



Original Article

Incidence rates and populations at risk for spinal cord injury: A regional study

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Study Design: A 6 year retrospective study was conducted.

Objectives: The populations at risk for spinal cord injury (SCI) in the northwestern Kentucky (KY) and southern Indiana (IN) regions were identified following examination of the causes and factors associated with SCI.

Setting: The database included patients primarily from the surrounding KY and IN counties admitted to the University of Louisville (U of L) Hospital.

Method: Specification of SCI patient demographics, injury causes and related factors was achieved utilizing the hospital's trauma institute database and an extensive review of patient medical records.

Results: An adjusted average incidence rate of 27.1 cases per million per year was obtained for this region. A high rate of SCI was found for the youngest age group, 14–24 year olds, and for African Americans. A high frequency of injuries was also observed for adults between the ages of 25–39 years. Motor vehicle accidents (MVA) were the leading cause of SCI. Contributing factors included alcohol and widespread non-use of vehicle safety precautions.

Conclusions: In addition to the high proportion of youth at risk for SCI, a higher proportion of older adults with SCI was observed for this region compared to other studies. Because the primary source of transportation in this area is the use of private vehicles, rather than public transportation, greater effort is warranted in emphasizing the potential risks of combining driving with alcohol consumption and non-use of seatbelts.

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Introduction

Spinal cord injuries leading to neurological deficits often produce long-term effects that persist over a lifetime. Estimates of SCI incidence rates are based on the number of new cases per population size (i.e., per 100 000 or million) over a given period of time (e.g., per year). Extensive reviews of spinal cord injury incidence rates have yielded values ranging from 28.0–50.0 cases per million per year in the United States (US) and 2.5–46.8 cases per million per year among other countries.^{1,2}

The creation and utilization of databases, such as Regional Model Spinal Cord Systems, have increased the reporting of SCI occurrences and related injury information.³ Although a limitation of utilizing SCI surveillance database systems and trauma registries for calculating incidence rates is its inclusion of only

survival (hospitalized) patients, there are two important advantages to this data collection methodology. First, the data collected encompass a broad range of information that is based on established parameters. Second, these rates are therefore comparable at regional, state and national levels. Moreover, the accuracy and comparability of incidence rates increase when they are adjusted to correct for underestimation.^{4–6}

Establishing the relevant factors related to SCI as they pertain to the characteristics of a specified region and population is a prerequisite to determining strategies to reduce the occurrence of SCI. The purpose of the present epidemiological study is to ascertain the incident rate of SCI, the factors associated with the injuries and the population at risk for this specified region of KY and IN. This study identifies the demographic characteristics of SCI patients, injury types and

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causes, and the risk factors that characterize this region's population of SCI patients. In addition to estimates of the spinal cord incidence rates for the region overall, incidence rates were also determined for subset populations related to pertinent demographic factors.

Method

The University of Louisville Hospital SCI Trauma Registry and patient medical records were used to identify and validate instances of SCI from May, 1993 through December, 1998. Patients were included in the database using the International Classification of Diseases (ICD) handbook codes.⁷ Codes from 806–806.9 (fracture of vertebral column with spinal cord injury) or 952–952.9 (spinal cord injury without evidence of spinal bone injury) were included.⁸ Severity of injury was defined by complete or incomplete lesion, as specified by ICD coding (i.e., injury codes within the 806 and 952 classifications ending in 1 and 6 (806.01, 806.06 . . . 952.16). Patient records were routinely reviewed to both verify demographic and injury data (e.g., cause, severity, safety) and resolve cases of missing, ambiguous or contradictory information.

Average SCI incidence rates for this time period were calculated based on the US Census Bureau population estimates for 1995,^{9,10} the middle time-point of the study. Population estimates were calculated based on each of the surrounding counties (18 KY and 11 IN counties; KY: Breckinridge, Bullitt, Grayson, Green, Hardin, Hart, Henry, Jefferson, Larue, Marion, Meade, Nelson, Oldham, Shelby, Spencer, Taylor, Trimble, Washington. IN: Clark, Crawford, Floyd, Harrison, Jackson, Jefferson, Jennings, Lawrence, Orange, Scott, Washington), encompassing a radius of approximately 50 miles surrounding the hospital. Population values were adjusted for age to exclude children under 14 years old and corrected for underestimation of missed SCI cases, estimated at approximately one-third of cases.^{1,2,4}

Injury assessment measures included the Injury Severity Scale (ISS),¹¹ American Spinal Injury Association (ASIA) impairment score¹² and the Frankel grades of motor function.¹³ Values for the injury assessment measures were extrapolated from information within patient's medical records.

Because only partial data (8 months) was obtained for 1993, the number of SCI cases for 1993 was weighted in order to enable comparisons among all the years. Means were compared using one-way ANOVA, followed by Student Newman-Keuls *post-hoc t*-tests. Ratios were compared with binomial proportion tests and frequency counts were analyzed using appropriate chi square analyses (one sample and Pearson) when sample size allowed.¹⁴ Data were analyzed using the statistical software program Statistical Package for the Social Sciences (SPSS).¹⁵ Averages are expressed as mean ± SD.

Results

Incidence

There were 161 SCI cases admitted to the University of Louisville Hospital from May, 1993 through December, 1998. Of these, the percentage of patients with ICD codes 806 and 952 equaled 81 and 19%, respectively. Based on the US Census Bureau's population estimates for the region's surrounding counties, an average incidence rate of 25.2 cases per million per year for residents of this region was estimated for this time period. After correcting for age and potential underestimation due to missed cases, an adjusted average incident rate of 27.1 cases per million per year was determined.

Although there was a relatively high number of SCI from 1995–1996, followed by a decline of nearly 50% in 1998, the frequency of SCI each year from 1994 through 1998 did not differ significantly ($\chi^2=7.7$, $df=4$, $P>0.05$) (see Table 1). After hospitalization the survival rate was very high, with 94% of patients surviving their injury. Compared to survivors, non-survivors were more likely to have a cervical injury (86 vs 48%; $z=2.7$, $P<0.01$) and were less likely to have used safety precautions (ie, seatbelt or helmet) (100 vs 77%; $z=4.8$, $P<0.001$). One-third of the fatalities suffered injury due to a fall. No relationship was

Table 1 Frequency of SCI by year

Year	Count	%
1993*	12	7.5
1994	28	17.4
1995	35	21.7
1996	40	24.8
1997	24	14.9
1998	22	13.7
Total	161	

*May – December

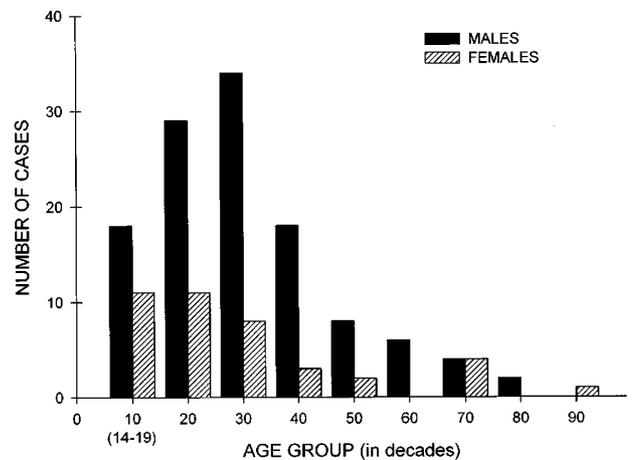


Figure 1 Number of injuries for males and females by age group

observed among other demographic (e.g., gender, race) or injury factors (eg, cause, severity) with survival.

Demographics

Ninety-five percent of the SCI patients were residents of KY or IN. The ratio of males to females with SCI was 3:1. The number of males compared to females was considerably higher at all ages below 70 years, as illustrated in Figure 1. Ethnic groups within the present study were represented primarily by Caucasians, comprising 84% of injury patients, while all of the remaining cases were African American. Within these categories, Caucasian males comprised approximately three-quarters of all SCI patients, while 12% were African American males. Incidence rates based on race were inversely related to the observed percentages. Although the proportion of injuries within the African American population was much smaller compared to Caucasians, the average incident rate was much higher (35.3) compared to 21.3 cases per million for Caucasians. The adjusted rates for the Caucasian and African American populations equaled 28.3 and 46.9 cases, respectively, per million per year.

Most of the SCI patients (59.5%) were single. Smaller percentages of patients were married (29.4%), divorced (5.6%), separated (4.0%) or widowed (1.6%) ($\chi^2=154.6$, $df=4$, $P<0.001$). The median age of SCI patients equaled 31.6 years ($n=160$, range=14–90 years) where females tended to be slightly younger than males (33.8 ± 19.4 years, 36.1 ± 15.9 years, respectively). When patients' ages were divided into four age groups, a significant difference in the number of injuries within age groups was observed ($\chi^2=28.2$, $df=3$, $P<0.001$). Based on the 1995 US Census bureau age group population estimates for 18–24 year olds, a very high incident rate of 78.3 cases per million per year was obtained for this group compared to a rate of 25.4 for patients 25–44 years of age.

Injury

Detailed information regarding the level of injury pertaining to cervical, thoracic or lumbar regions was ascertained for nearly all patients (95%). Overall, nearly half (49%) of SCI involved the cervical region, while over one-third were thoracic level injuries (see Table 2).

Over half (55%) of all SCI were the result of vehicle-related accidents (motor vehicle (MVA),

Table 2 Frequency and percent of injury by level

Level	Count	%	Subtotal
C1-C4	31	20.3	
C5-C7	45	29.4	49.7
T1-T6	17	11.1	
T7-T12	37	24.2	35.3
Lumbar	23	15.0	
Total	153		

Table 3 Frequency and percent of SCI causes

Cause	Count	%	Subtotal	%
MVA	75	46.6		
MCA	10	6.2		
MPA	3	1.9	88	54.7
GSW	21	13.0		
Fall	37	23.0		
Assault	2	1.2		
Other	13	8.1	73	45.3
Total	161			

motorcycle (MCA), pedestrian (MPA)) (see Table 3), with falls representing the next most likely cause (23%). Over two-thirds of injuries from MVA and MCA occurred to drivers (71%). While most vehicle-related accidents (MVA, MCA, MPA) resulted in cervical injuries (56.5%), the level of injury associated with gunshot wounds (GSW) was highest in the thoracic (48%) region. Comparing lesion severity and injury causes, a higher percentage of complete injuries was observed following a fall (15/35=43%) or GSW (9/21=43%) compared to the number of complete injuries for vehicle-related accident patients (24/85=28%) ($\chi^2=7.1$, $df=2$, $P<0.05$).

The mean age of patients injured as a result of a fall was higher (45.6 ± 17.0 years, $n=37$) than vehicle-related accident patients (34 ± 17.0 years, $n=87$) or GSW victims (28.8 ± 11.6 years, $n=21$) ($F=9.1$, $df=2$, $P<0.001$, $t=34.8$, $P<0.05$). In addition, when patients' ages were grouped and compared with the frequency of injury causes, a significant relationship was observed between cause of injury (vehicle-related, GSW, fall, other) and age group of the SCI patient ($\chi^2=25.6$, $df=9$, $P<0.005$): a high percentage of vehicle-related accidents (61%) compared to all other causes (GSW: 20%, fall: 7%, other: 11%) was observed for patients ≤ 24 years old.

The distribution of patients by race within injury causes was similar to the distribution of race for all SCI cases (ie, Caucasian: 84%, African American: 16%), with the exception of GSW. The proportion of African Americans injured by GSW (35%) was twice the rate of African Americans injured in vehicle-related accidents and falls (14.5 and 13.5%, respectively).

Head injuries accompanied SCI 39.4% of the time. Eight-two percent of head injuries were concussions: 67.6% were mild, 18.9% moderate and 13.5% severe. Head injuries occurred in over half (51%) of MVA and MCA (56%) incidents, as well as in two of three MPA injuries. In MVA and MCA where seatbelts and helmets were not worn, 77% of SCI patients had an accompanying head injury.

Potential contributing factors

Only 22% of SCI patients injured in MVA and MCA used safety precautions (ie, seatbelt, motorcycle

helmet). Although the percentage of non-use of safety measures was largest for the age group under 25 years (85%), the percentages were also high (76, 77 and 70%) among the remaining age groups (25–39, 40–54, ≥ 55 years, respectively). While the presence of alcohol (45/95 tested) was likely to be a contributing factor in nearly 50% of cases tested, drug usage (18/130 = 14% tested) was not common among the SCI patients.

Injury assessment measures

ASIA scores were documented for 123 patients, with an average score of 44 (± 30.2 , $n=123$). An average Injury Severity Scale (ISS) score of 26 (± 11.1 , $n=156$) was observed indicating that most patients had a traumatic injury to only one area. A Frankel grade of 'A' (major impairment to normal motor ability function) was the most frequent grade observed, 58%. The percentages of grades B, C and D equaled 17, 7 and 15%, respectively ($n=119$). Three percent had a normal (E) Frankel score. Frankel scores were similar among the various causes of injury ($\chi^2=12.5$, $df=12$, $P>0.05$) and whether or not safety precautions were used ($\chi^2=9.2$, $df=12$, $P>0.05$).

Discussion

There were 161 SCI cases admitted to the University of Louisville Hospital from May, 1993 through December, 1998 and after adjusting for age and correcting for missed cases, an average incidence rate of 27.1 cases per million per year for this region was determined. This overall incidence rate is lower than adjusted rates of most state surveillance systems (between 25 and 50 million per year^{4,5,16–18}), and considerably lower than incidence rates from other trauma registries such as Alaska¹⁹ (83/mil/yr) or Mississippi⁶ (93/mil/yr) in which multiple sources of data collection were utilized. However, the incident rate for the population within the present study is only slightly less than national incidence rates of approximately 30–40 cases per million per year as reported by Go²⁰ for Model Systems around the country.

In general, the demographic characteristics of the SCI patients of this region are similar to other studies with respect to age,^{4,5,16,19,21} race^{4,5} and marital status,²² although values regarding the latter are less frequently reported. Incidence rates by race were disproportionately high for African Americans with respect to their population size in this region compared to the incidence rate of Caucasians. This rate is not as high as reported by Price⁴ and Acton,⁵ who reported African Americans' SCI rates at twice the rate of Caucasians. The observed ratio for gender (3:1) was slightly lower when compared to other trauma centers' findings that ranged from 4 to 5:1.^{19,21,23}

MVA was the most likely cause of SCI, as also observed in many studies,^{4,5,16,17} with over 50% of the patients within the 14–24 and 25–39 year age groups. The second leading cause of injury, however, was

different for the two groups. The younger age group's second most likely cause of SCI was GSW (21%), while for 25–39 year olds, a fall was the next likely cause of injury (24%).

The demographic characteristics of those with the highest risk factors for this region were those who were unmarried, male, African American and under 25 years of age. The risk factors associated with SCI were primarily related to vehicular accidents, particularly when safety measures were not used. The use of alcohol was also a contributing factor. The usage of alcohol (47%) was slightly higher in the present population compared to other reports.^{4,17,19}

The preponderance of alcohol and non-use of safety measures among youths <21 years old who were injured in vehicle accidents is particularly pertinent for the regional population since private vehicles are the primary source of transportation.

While the combination of alcohol and driving without the use of a seatbelt enhances the probability of injury, when associated with youth and driving inexperience, the chances of SCI can be increased more than threefold. Since the present findings revealed head injury accompanied SCI nearly 80% of the time when safety measures were not used, the condition of SCI patients may be exacerbated further with an additional injury from head trauma. Tyroch²¹ found that a stunning 72% of injuries were preventable. Most of these injuries could be prevented through education and increased awareness regarding the risk factors and potential consequences. Elimination of these risk factors could conceivably result in a substantial decrease in the number of SCI, in this and comparable regions, to as few as 8–11 cases per year.

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