2011

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International Spinal Cord Society

Spinal Cord (2011) 49, 874–879

www.nature.com/sc

ORIGINAL ARTICLE

Incidence and epidemiology of spinal cord injury within a closed American population: the United States military (2000–2009)

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Study design: Cohort study
Objectives: The objective of this study was to characterize the incidence of spinal cord injury (SCI) within the population of the United States military from 2000–2009. This investigation also sought to define potential risk factors for the development of SCI.
Setting: The population of the United States military from 2000–2009.
Methods: The Defense Medical Epidemiology Database was queried for the years 2000–2009 using the International Classification of Diseases, Ninth Revision, Clinical Modification codes for SCI (806.0, 806.1, 806.2, 806.3, 806.4, 806.5, 806.8, 806.9, 952.0, 952.1, 952.2, 952.8, 952.9). The raw incidence of SCI was calculated and unadjusted incidence rates were generated for the risk factors of age, sex, race, military rank and branch of service. Adjusted incidence rate ratios were subsequently determined via multivariate Poisson regression analysis that controlled for other factors in the model and identified significant independent risk factors for SCI.
Results: Between 2000 and 2009, there were 5928 cases of SCI among a population at-risk of 13 813 333. The raw incidence of SCI within the population was 429 per million person-years. Male sex, white race, enlisted personnel and service in the Army, Navy or Marine Corps were found to be significant independent risk factors for SCI. The age groups 20–24, 25–29 and >40 were also found to be at significantly greater risk of developing the condition.
Conclusions: This study is one of the few investigations to characterize the incidence, epidemiology and risk factors for SCI within the United States. Results presented here may represent the best-available evidence for risk factors of SCI in a large and diverse American cohort.
Spinal Cord (2011) **49,** 874–879; doi:10.1038/sc.2011.18; published online 8 March 2011

Keywords: spinal cord injury; incidence; epidemiology

Introduction

Spinal cord injury (SCI) represents a significant public health issue due to the long-term consequences that result from the condition. Although estimated to be relatively rare in its occurrence, SCI has lasting effects beyond the precipitating event at both the individual and the societal levels.[1–4] Long-term disability resulting from SCI not only translates into personal and financial losses for the affected individual, but also exerts a significant loss on the economy and healthcare system through lost productivity, revenue, and the substantial costs associated with long-term care and ancillary issues that arise in the setting of SCI.[1–4]

The most effective means of combating SCI is preventing its occurrence, through targeted programs and education aimed at populations-at-risk.[4] However, the concept of at risk populations, as well as the epidemiology of SCI itself, remains incompletely explored, particularly within the United States. Challenges to the effective study of the incidence and risk factors for SCI in the American population include those inherent to all epidemiological investigations, such as selection bias, population cachement and definition of injury. Studies within the United States are further hampered, however, by an ethnically, culturally and socioeconomically heterogeneous population, as well as the absence of a closed healthcare system that is capable of tracking all diagnoses and medical conditions. As a result, a wide range of incidences have been reported for SCI in the United States[5–9] and North American[1–4] populations, with conflicting data regarding risk factors for the condition. For

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Received 4 December 2010; revised 24 January 2011; accepted 29 January 2011; published online 8 March 2011

example, Griffin *et al.*[7] found that white males were at greatest risk of SCI in Minnesota, while several studies reported black males to be at greater risk within Arkansas,[5] Oklahoma[8] and parts of Kentucky/Indiana.[6] These findings may be confounded by the ethno-cultural composition of the locales under study, and inhibit generalization to the American population as a whole.

In several studies conducted outside the United States, a variety of approaches have been utilized to determine incidence rates and risk factors for SCI.[1–4,10–13] Of these, the most effective appear to be nationalized databases capable of capturing all individuals with SCI within a set population, as well as the number at-risk.[1,2,3,10] Although the absence of a national health-care system obviates such a possibility within the United States, a comparable data set may exist within the Defense Medical Epidemiological Database (DMED) maintained by the Department of Defense (DoD).[14]

This investigation sought to employ the DMED as a means to characterize the incidence of SCI within the population of the United States military from 2000–2009. This study also endeavored to define potential risk factors for SCI among the demographic variables available within the DMED system. Results presented here may represent the best-available evidence for SCI within an American population, as our data is drawn from a diverse demographic but not confined to one particular region or state.

Materials and methods

Study population

This investigation received Investigational Review Board and ethics approval from our institution. The DMED is a de-identified data set that contains the following information for servicemembers: medical condition categorized by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code, sex, race, rank, branch of service and age. All active duty military personnel serving within the DoD are prospectively enrolled in the DMED at the time of enlistment. The system can be used to accurately define the entire population, and demographic characteristics, of those serving within the four military branches (Army, Navy, Air Force and Marine Corps) during any given time period. The data set may also be queried using ICD-9-CM code to identify individuals diagnosed with any specific medical condition. The DMED is linked to the DoD Composite Health Care System (CHCS) and Ambulatory Data System, and prospectively collects ICD-9-CM diagnoses for servicemembers, as they are entered into the electronic record. As the DMED is linked to both DoD healthcare-tracking systems, accurate medical information is captured within the database for all servicemembers, even those who do not receive treatment at military facilities. As such, the DMED most closely approximates the type of closed system healthcare data set encountered in countries with nationalized healthcare registries. In addition, previous research has demonstrated the efficacy of the DMED in defining the epidemiology of traumatic[15] and spinal conditions[16] among servicemembers in the American military.

The population-at-risk for this study was defined as the entire population of the four branches of the United States military from 1 January 2000 through 31 December 2009. The DMED was initially queried to provide demographic characteristics and total number of servicemembers in the armed forces during this time period.

Identification of SCI

The DMED was then queried to identify all individuals diagnosed with SCI during the period under investigation. The ICD-9-CM codes for SCI, with and without associated spine fracture, were used in the query (806.0, 806.1, 806.2, 806.3, 806.4, 806.5, 806.8, 806.9, 952.0, 952.1, 952.2, 952.8, 952.9). The query was limited to first-time diagnosis only so that subsequent diagnoses of the same SCI, made for the individual as they received further treatment, did not result in overestimation. Injuries to the spinal column in regions distal to the spinal cord (that is, sacrum and coccyx) were excluded as were diagnoses of cauda equina syndrome.

The sex, age, race, military rank and branch of service for all individuals recorded as having sustained a SCI in the DMED were also obtained. Sex was classified as male or female. An individual's racial determination within the DMED occurs through self-report, but the system categorizes servicemembers as white, black or other, where other includes those reported to be Hispanic, Native American, Alaskan native, Pacific Islander, Asian, mixed race or no race reported. Age in the data set is reported for personnel within one of the following pre-determined age groups: <20, 20–24, 25–29, 30–34, 35–39 and >40. Similarly, rank is also reported in a pre-determined manner as Junior Enlisted (private to specialist/corporal), Senior Enlisted (sergeant to sergeant major), Junior Officers (second lieutenant to captain and warrant officers) and Senior Officers (major to lieutenant general). Military branch is documented as Army, Navy, Air Force or Marine Corps, but individual occupational specialties, such as Special Forces, airborne ranger, infantryman or cavalry scout, are not available.

Risk factors for SCI that were felt to be represented within the model included sex, race, age, activity level/occupational demands[15,16] and socioeconomic status. Previous studies involving the DMED have used rank and branch of service as indicants of physical activity, as well as occupational demands. In general, enlisted personnel and members of the Army and Marine Corps have been assumed to engage in more rigorous activities, and have greater physical occupational demands relative to officers and the Navy or Air Force.[15,16] Previous research has also used military rank as an indicator of socioeconomic status, both during military service and before enlistment.[17] Enlisted personnel, particularly Junior Enlisted, are paid less than officers, are less likely to have obtained higher education, and frequently originate from a lower socioeconomic class.[17] Enlisted servicemembers are also felt to be at risk for many of the same medical conditions that afflict members of lower socioeconomic strata, even in spite of their service in the military.[17]

Statistical analysis
The raw incidence of SCI was calculated by comparing the number of individuals identified with the condition in the DMED to the total population-at-risk. Incidence is expressed as the rate per million person-years, where one person-year indicates a calendar year of exposure to service in the military for a single individual. The unadjusted incidence rate (IR) was then determined for all subcategories within the risk factors included in the model. Multivariate Poisson regression analysis was subsequently used to generate adjusted incidence rate ratios with 95% confidence intervals for individual risk factors, while controlling for others present in the model. All adjusted incidence rate ratios were calculated for risk factors using the subcategory with the lowest unadjusted IR as a referent. For the risk factor of race, only white or black were felt to be viable candidates for the referent, as the subcategory of other included multiple, heterogeneous groups. Statistical calculations were performed with the use of Statistical Analysis Software (SAS 9.2, Cary, NC, USA).

Results

Incidence
In the time period under investigation, 5928 servicemembers were identified as having sustained a SCI within a population-at-risk of 13 813 333. The demographic characteristics of those individuals diagnosed with SCI are presented in Table 1. The overall incidence of SCI within the population was 429 per million person-years. Cervical SCI occurred in approximately 38% of the cohort, while thoracic SCI was diagnosed in 24% (Table 2). Unadjusted IRs that exceeded the raw incidence for the population as a whole were encountered among males, whites, Junior Enlisted, those serving in the Army or Marines, and individuals aged <20 and 20–24 years of age (Tables 3 and 4). The greatest unadjusted IR for SCI was found among members of the Marine Corps at 533 per million person-years.

Risk factors
On the basis of lowest unadjusted IR, the subcategories of female, black, senior officers, Air Force service and aged 30–34 were used as the referents in multivariate Poisson regression analysis. Subsequently, male sex, white race, enlisted personnel and service in the Army, Navy or Marine Corps were found to be significant independent risk factors for SCI (Table 3). The age groups 20–24, 25–29 and >40 were also found to be at significantly greater risk of SCI when compared with those aged 30–34 (Table 4). Adjusted incidence rate ratios that exceeded 1.5 relative to the referent were Junior Enlisted rank, and service in the Army or Marines. Junior Enlisted rank maintained the highest adjusted incidence rate ratio at 1.61 (95% confidence interval 1.38–1.89, $P=0.0001$).

Discussion

Although at present, revolutionary advances in medical and surgical technology are improving the lives and minimizing the physical limitations of those with SCI, there is still no means of reversing this condition. The most effective approach to limiting the effects of SCI is prevention through targeted educational programs aimed at at-risk individuals.[4] However, relatively few epidemiological studies have attempted to define at-risk populations,[1–3,5–9,18] and what work has been conducted may not be applicable to the American population as a whole. This investigation sought to characterize the incidence of SCI within the population of the United States military over a 10-year period and highlight potential risk factors for its development.

Results presented here demonstrate that, between 2000 and 2009, 5928 individuals in the military sustained a SCI. The raw incidence for SCI within this population was 429 per million, and male sex, white race, enlisted positions within the rank structure, service in the Army, Navy or Marine

Table 1 Demographic characteristics of spinal cord injury among 5928 US military servicemembers, 2000–2009

Category	*Total number*	*Total (%)*	*Male*	*Male (%)*	*Female*	*Female (%)*
Total	5928	100	5181	100	747	100
Race						
Black	970	16.36	757	14.61	213	28.51
Other	701	11.83	599	11.56	102	13.65
White	4257	71.81	3825	73.83	432	57.83
Rank						
Junior Enlisted	3004	50.67	2578	49.76	426	57.03
Junior Officers	404	6.82	338	6.52	66	8.84
Senior Enlisted	2267	38.24	2040	39.37	227	30.39
Senior Officers	253	4.27	225	4.34	28	3.75
Service						
Army	2442	41.19	2122	40.96	320	42.84
Navy	1441	24.31	1255	24.22	186	24.90
Air Force	1084	18.29	896	17.29	188	25.17
Marines	961	16.21	908	17.53	53	7.10
Age (years)						
<20	508	8.57	412	7.95	96	12.85
20–24	2292	38.66	1994	38.49	298	39.89
25–29	1249	21.07	1102	21.27	147	19.68
30–34	705	11.89	627	12.10	78	10.44
35–39	628	10.59	571	11.02	57	7.63
40+	546	9.21	475	9.17	71	9.50

Table 2 ICD-9-CM codes used to identify spinal cord injury among 5928 US military servicemembers, 2000–2009

Codes	*Number of cases*	*% of cases*
806.0–806.1 Cervical	942	15.89
806.2–806.3 Dorsal (thoracic)	1129	19.05
806.4–806.5 Lumbar	523	8.82
806.8–806.9 Unspecified	192	3.24
952.0 Cervical	1307	22.05
952.1 Dorsal (thoracic)	271	4.57
952.2 Lumbar	491	8.28
952.8 Multiple sites of spinal cord	48	0.81
952.9 Unspecified site of spinal cord	1025	17.29

Abbreviation: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

Table 3 Unadjusted incidence rates (IR) and adjusted incidence rate ratios (IRR) of spinal cord injury among the US military servicemembers, 2000–2009

Category	*Number of cases*	*Person-years*	*Unadjusted IR*[a]	*Adjusted IRR (95% CI)*	P-*value*
Male	5181	11 795 305	439	1.11 (1.03–1.20)[b]	0.0086
Female	747	2 018 028	370	1	ref.
Black	970	2 567 557	377	1	ref.
Other	701	1 759 176	398	1.07 (0.97–1.18)[c]	0.1978
White	4257	9 486 600	448	1.23 (1.14–1.32)[c]	0.0001
Junior Enlisted	3004	6 077 634	494	1.61 (1.38–1.89)[d]	0.0001
Junior Officers	404	1 354 332	298	1.06 (0.89–1.25)[d]	0.5251
Senior Enlisted	2267	5 506 970	412	1.49 (1.30–1.72)[d]	0.0001
Senior Officers	253	874 397	289	1	ref.
Army	2442	4 976 608	491	1.56 (1.45–1.68)[e]	0.0001
Navy	1441	3 549 191	406	1.29 (1.19–1.39)[e]	0.0001
Air Force	1084	3 484 086	311	1	ref.
Marines	961	1 803 448	533	1.58 (1.44–1.72)[e]	0.0001

Abbreviation: CI, confidence interval.
ref., this category was used as the referent category for calculations.
[a]Incidence rate is per 1 000 000 person-years.
[b]Adjusted for age, race, rank group and service.
[c]Adjusted for age, sex, rank group and service.
[d]Adjusted for age, sex, race and service.
[e]Adjusted for age, sex, race and rank group.

Table 4 Incidence rate ratio (IRR) of spinal cord injury among servicemembers in the US military, 2000–2009, by age group

Age group	*No. of cases*	*Person-years*	*Incidence rate*[a]	*Adjusted IRR (CI)*[b]	P-*value*
<20	508	1 084 882	468	1.09 (0.95–1.24)	0.2078
20–24	2292	4 613 200	497	1.21 (1.09–1.33)	0.0002
25–29	1249	2 919 000	427	1.15 (1.05–1.26)	0.0037
30–34	705	1 996 712	353	1	ref.
35–39	628	1 773 252	354	1.04 (0.93–1.15)	0.5286
40+	546	1 426 287	383	1.21 (1.07–1.36)	0.0019

Abbreviation: CI, confidence interval.
ref., this category was used as the referent.
[a]Incidence rate is per 1 000 000 person-years.
[b]Adjusted for sex, service, rank group and race.

Corps, and ages 20–29 and >40 were found to represent significant independent risks for developing the condition.

In the terms of the population-at-risk, the 13 813 333 servicemembers captured in the closed DMED system represent one of the largest cohorts used to estimate the incidence and epidemiology of SCI to date. One of the most difficult challenges in epidemiological investigations is a valid determination of all individuals diagnosed with a condition, as well as the enumeration of the at-risk population. Investigations that focus on patients who already sustained spinal trauma,[13,18] or derive their cohorts from the registries of tertiary referral centers,[4,6,11,12] in most instances are unable to accurately define the population from which their cases are drawn. Other methods, such as regional or national surveys,[13] provide useful information but cannot account for an entire population, and reported findings may be inaccurate. As a result, a wide range of SCI incidence has been reported throughout the literature and proposed risk factors remain equally variegated, if not contradictory.

In most large series throughout the world, the incidence of SCI has been reported in the range of 12–68 per million.[10–12,19] A recent population based study in Iran, however, revealed a much higher incidence of 2.2 per 10 000.[13] In North America, the SCI incidence has been documented at 24–93 per million.[1–9] Canadian investigations, conducted within definable populations-at-risk, have maintained that the incidence of SCI is 24–53 per million.[1–3] However, it should be noted that most of these results represent findings among relatively homogenous populations, such as that of Manitoba.[3] Additionally, in most studies, the incidence is calculated based on a relatively small number of actual cases of SCI. For example, Dryden *et al.*[2] derived their data for SCI in Alberta from 322 cases, and Burke *et al.*[6] made estimations for the Northern Kentucky/Southern Indiana region based solely on 161 instances of the condition.

Within American populations, reports of SCI incidence range from 27–93 per million.[5–9] Griffin *et al.*[7] maintained that the SCI incidence in Olmsted County, Minnesota was 54.8 per million over a 66-year period, while Surkin *et al.*[9] documented an incidence of 93 per million in Mississippi. Our incidence of 429 per million is admittedly higher than that of most other studies. However, comparison is limited due to the fact that the present investigation addresses a racially and socioeconomically diverse demographic, drawn from the American military population. As no previous research has been conducted with regard to the effect of military training and service on the incidence of SCI, we cannot rule out the fact that participation in the military elevates the risk of SCI relative to civilian populations.

Additionally, for 90% of the time period under investigation, the US armed forces have been engaged in conflicts in Iraq and/or Afghanistan. The DMED system was not designed to capture injuries sustained in the combat environment, but rather focuses on conditions developed by personnel over the course of their service in the military. As such, we are unable to define the degree to which SCI sustained during combat impacted our estimation of the overall incidence.

In terms of risk factors postulated to influence the development of SCI, results presented here are largely commensurate with those reported in previous research. Most works have reported young, white males to be the demographic at greatest risk of SCI,[2,3,18] although some reports with regional limitations have found black males to have a higher risk than whites.[5,6,8] Similarly, our findings of elevated risk for the age groups 20–29 are in keeping with previous studies, although we also found significant increased risk for servicemembers aged >40. Some recent investigations have documented a bimodal incidence of SCI among young individuals and the elderly.[1,4] As the DMED does not stratify age beyond 40 we cannot evaluate the effect that SCI among personnel of a more advanced age had on skewing the results for this subcategory.

Some novel findings presented in this study include the effect of military rank and branch of service on the risk of SCI. All enlisted individuals and Junior Enlisted in particular, were found to have an elevated risk of SCI. This may reflect the impact of socioeconomic factors, as proposed by Hu *et al.*,[3] on the incidence of SCI. Additionally, although service in the Army, Navy and Marines all were found to have significant independent risks of SCI relative to the Air Force, only personnel in the Army and Marines demonstrated IRs above the cohort average. Moreover, the Marine Corps maintained the highest unadjusted IR for SCI. These findings may represent the type of training employed by the Army and Marines, as well as the degree of exposure to the combat environment.

This study suffers from limitations. Foremost, although the DMED represents a prospectively collected healthcare data system, it still suffers from limitations inherent to databases. For example, the determination of SCI was made using information imparted to the database and its accuracy cannot be independently verified. The DMED does contain failsafe measures to limit the potential for inaccurate data being entered into the system,[14] and previous research has reported incidence sensitivities of 77–94% when relying on coding data.[4] Nonetheless, we cannot quantify the degree of under- or over-coding in this cohort.

Additionally, the DMED does not provide robust patient-specific data, such as mechanism of injury, treatment or final outcome. Such information would have been useful in discerning the degree to which the combat environment contributed to the number of SCIs, relative to motor vehicle accidents, falls or sport injuries that occur more commonly in the civilian setting. Furthermore, the determination of injury etiology could have also potentiated more robust comparisons to other previously published works. Such facts limit our ability to determine the degree to which our findings translate to the civilian sector.

Lastly, the population itself could be seen as a possible limitation in terms of generalizing results to all American adults. When compared with recent census data, although reflective of the general American populace on racial grounds, the composition of the United States military would only be representative of 58% of the nation as a whole.[20] Specifically, women are under-represented within our cohort and those greater than 55 years of age are not included in large numbers. This is potentially important as those 65 years of age and over have been heralded as being at increased risk of SCI in several recent studies.[1,4]

While acknowledging these limitations, it should be recognized that this is one of the few investigations to characterize the incidence, epidemiology and risk factors for SCI within a large and diverse American cohort. Additionally, our estimations, made using close to 6000 documented cases of SCI, exceed the number of individuals with this condition in most other epidemiological research. As a result, the information presented here may represent the best-available evidence for risk factors of SCI in the American population.

Conflict of interest

The authors declare no conflict of interest.

Disclaimer: All authors are employees of the US federal government and the United States Army. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or United States government.

References

1 Couris CM, Guilcher SJT, Munce SEP, Fung K, Craven BC, Verrier M *et al*. Characteristics of adults with incident traumatic spinal cord injury in Ontario, Canada. *Spinal Cord* 2010; **48**: 39–44.
2 Dryden DM, Saunders LD, Rowe BH, May LA, Yiannakoulias N, Svenson LW *et al*. The epidemiology of traumatic spinal cord injury in Alberta, Canada. *Can J Neurol Sci* 2003; **30**: 113–121.
3 Hu R, Mustard CA, Burns C. Epidemiology of incident spinal fracture in a complete population. *Spine* 1996; **21**: 492–499.
4 Pickett GE, Campos-Benitez M, Keller JL, Duggal N. Epidemiology of traumatic spinal cord injury in Canada. *Spine* 2006; **31**: 799–805.
5 Acton PA, Farley T, Freni LW, Ilegbodu VA, Sniezek JE, Wohlleb JC. Traumatic spinal cord injury in Arkansas, 1980 to 1989. *Arch Phys Med Rehabil* 1993; **74**: 1035–1040.
6 Burke DA, Linden RD, Zhang YP, Maiste AAC, Shields CB. Incidence rates and populations at risk for spinal cord injury: a regional study. *Spinal Cord* 2001; **39**: 274–278.
7 Griffin MR, Opitz JL, Kurland LT, Ebersold MJ, O'fallon WM. Traumatic spinal cord injury in Olmstead County, Minnesota, 1935–1981. *Am J Epidemiol* 1985; **121**: 884–895.
8 Price C, Makintubee S, Hernodon W, Istre GR. Epidemiology of traumatic spinal cord injury and acute hospitalization and rehabilitation charges for spinal cord injuries in Oklahoma, 1988–1990. *Am J Epidemiol* 1994; **139**: 37–47.
9 Surkin J, Gilbert BJ, Harkey III HL, Sniezek J, Currier M. Spinal cord injury in Mississippi. Findings and evaluation, 1992–1994. *Spine* 2000; **25**: 716–721.
10 Divanoglou A, Levi R. Incidence of traumatic spinal cord injury in Thessaloniki, Greece and Stockholm, Sweden: a prospective population-based study. *Spinal Cord* 2009; **47**: 796–801.
11 Hagen EM, Eide GE, Rekand T, Gilhus NE, Gronning M. A 50-year follow-up of the incidence of traumatic spinal cord injuries in Western Norway. *Spinal Cord* 2010; **48**: 313–318.
12 Ning GZ, Yu TQ, Feng SQ, Zhou XH, Ban DX, Liu Y *et al*. Epidemiology of traumatic spinal cord injury in Tianjin, China. *Spinal Cord* 2011; **49**: 386–390.

13 Rahimi-Movaghar V, Saadat S, Rasouli MR, Ganji S, Ghahramani M, Zarei MR *et al*. Prevalence of spinal cord injury in Tehran, Iran. *J Spinal Cord Med* 2009; **32**: 428–431.
14 Army Medical Surveillance Activity. Defense Medical Epidemiological Database (DMED) Users Guide. Version 3.6.4. March 2004. http://www.afhsc.mil/viewDocument?file=DMED_Userguide/DMEDUsersGuide364.pdf Accessed 7 March, 2010.
15 Owens BD, Dawson L, Burks R, Cameron KL. Incidence of shoulder dislocation in the United States military: demographic considerations from a high-risk population. *J Bone Joint Surg Am* 2009; **91**: 791–796.
16 Knox J, Orchowski J, Belmont Jr PJ, Scher D, Burks R, Owens B. Incidence and risk factors for low back pain in active duty military over a 10 year period. *Spine J* 2009; **9** (10S): 118S–119S.
17 Clark JY, Thompson IM. Military rank as a measure of socioeconomic status and survival from prostate cancer. *South Med J* 1994; **87**: 1141–1144.
18 Jackson AB, Dijkers M, DeVivo M, Poczatek RB. A demographic profile of new traumatic spinal cord injuries: change and stability over 30 years. *Arch Phys Med Rehabil* 2004; **85**: 1740–1748.
19 van den Berg ME, Castellote JM, Mahillo-Fernandez I, de Pedro-Cuesta J. Incidence of spinal cord injury worldwide: a systematic review. *Neuroepidemiology* 2010; **34**: 184–192.
20 United States Census Bureau. Population and Household Economic Topics. http://www.census.gov/population/www/ Accessed 7 September, 2010.