Review article

Epidemiology of traumatic spinal cord injury in Asia: A systematic review

Guang-Zhi Ning, Qiang Wu, Yu-Lin Li, Shi-Qing Feng

Department of Orthopaedics, Tianjin Medical University General Hospital, Tianjin, PR China

Study design: A systematic review.
Background: The number of traumatic spinal cord injury (TSCI) reports grows annually, especially in China and Korea. The epidemiological characteristics of TSCI in Asia differ from those in other countries. Thus, we compiled epidemiological factors from Asia to compare with those from other countries.
Method: We searched articles published in any language between January 1980 to December 2011 using the terms "spinal cord injury", "traumatic spinal cord injury", "epidemiology", and "Asia". The articles were reviewed for information regarding TSCI incidence, total cases, case criteria, case source, causes of injury, male/female ratio, mean age, prospective or retrospective, neurological level of injury, extent of injury, and America Spinal Injury Association Impairment Scale (AIS)/grade.
Results: Epidemiological data were extracted from 39 reports in the published literature that met the inclusion criteria. Only two studies reported prevalence rates. Incidence rates ranged from 12.06 to 61.6 per million. The average age ranged from 26.8 to 56.6 years old. Men were at higher risk than women. Motor vehicle collisions (MVCs) and falls were the main causes of TSCI. However, several countries reported war wounds as the major cause. The neurological level and extent of injury were mixed, and most patients were categorized as AIS/Frankel grade A.
Conclusion: TSCI is an important public health problem and a major cause of paralysis. We must understand the epidemiology to implement appropriate preventative measures. Asian epidemiology is different from that in other regions, so intervention measures must be established according to population-specific characteristics.

Keywords: Spinal cord injuries, Tetraplegia, Paraplegia, Epidemiology, Asia, Injury prevention

Introduction

Traumatic spinal cord injury (TSCI) is one of the most devastating types of injury, and it results in varying degrees of paralysis, sensory loss, and bladder/bowel dysfunction. The effects of TSCI are not limited to an individual's health; it also creates an enormous financial burden for families and society at large.[1] As there is no cure for TSCI, prevention is critical. A thorough epidemiological understanding is vital for implementing preventative measures and planning clinical services. Numerous articles on TSCI epidemiology have come out of Europe, North America, and Australia[2–4] because most Western countries have implemented TSCI registries or databases that provide convenient systems for collecting patient information and facilitate the comparison of epidemiological characteristics from different time periods. However, with the exceptions of Taiwan and Japan, most Asian countries do not have TSCI registries; therefore, it is difficult to accurately assess epidemiological data and TSCI characteristics in Asia. While the number of studies from Asian countries has increased in recent years, especially reports from China[5–7] and Korea,[8] a systematic review on TSCI epidemiology in Asia has not been published to date.

The aim of this review was to compile epidemiological characteristics of TSCI in Asia in order to increase prevention awareness. In addition, we gave recommendations for future epidemiological studies to improve comparisons with other countries and enriched worldwide epidemiological data regarding this important subject.

Methods

Search strategy

PubMed, EBSCO, MEDLINE, EMBASE, and Google Scholar™ databases were queried for TSCI articles

Correspondence to: Shi-Qing Feng, Department of Orthopaedics, Tianjin Medical University General Hospital, Tianjin Heping District Anshan Road 154,Tianjin 300052, PR China. Email: fengsq321@gmail.com

DOI 10.1179/2045772312Y.0000000021

published from January 1980 through December 2011 with the following key indexing and MeSH terms: "spinal cord injury", "traumatic spinal cord injury", "epidemiology", "incidence", and "Asia". These terms were linked using combinations of "epidemiology" or "incidence" plus "spinal cord injury" or "traumatic spinal cord injury" and "Asia". No language restrictions were used. References from the retrieved reports were reviewed to find additional relevant articles that may have been omitted from the database search. We also collected relevant abstracts from conference proceedings (Fig. 1).

Inclusion criteria

Two reviewers independently assessed the titles and abstracts of the publications produced by the initial search strategy. To be eligible for inclusion, studies had to meet the following criteria: (1) describe an original study involving TSCI and (2) report Asian TSCI epidemiological data. General population studies were eligible for inclusion.

Data extraction

Available methodological information and data were extracted from the articles, including country (region), number of patients, source population, case criteria, incidence period, male/female ratio and incidence, causes of TSCI, mean age, prospective or retrospective, and America Spinal Injury Association Impairment Scale (AIS)/Frankel grade. In addition, the extent level of neurological injury (tetraplegia or paraplegia) and extent of injury (complete or incomplete) were recorded. If these data were not fully reported, we contacted the corresponding author and requested the missing information.

Results

We identified 39 reports with data on TSCI epidemiology from 16 Asian regions in the published literature. Of those, 15 reports were from east Asia, 2 from southeast Asia, 9 from south Asia, and 13 from west Asia. Study characteristics including country (region), authors, year of publication, source population, case source, case criteria, and prospective or retrospective design are listed in Table 1, and incidence, gender ratio, cause of injury, and mean age are summarized in Table 2. A comparison of these parameters revealed marked variation in study years, inclusion criteria, case source, and methods employed. Concerning study design, 35 reports were retrospective and 4 were prospective. Regarding case criteria, 7 studies made use of International Classification of Diseases codes, 4 used the definition of Kraus *et al.*[9] and the remaining 28 did not mention specific criteria. Case-finding

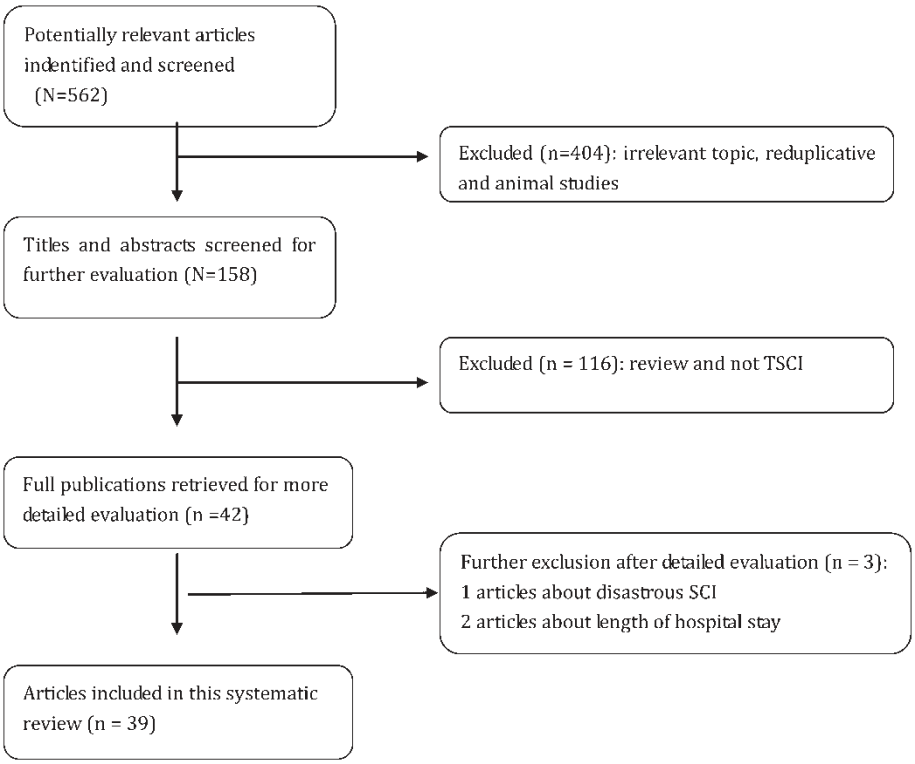

Figure 1 Flow diagram of the systematic literature review.

Table 1 Profile of traumatic spinal cord injury in Asian countries and regions

	Study author(s) (year) (ref.)	Country (region)	Incidence period	Source population	Case source	Case criteria	Prospective/ retrospective
East Asia	Ning *et al.* (2011) [20][5]	Tianjin, China	2004–2008	All TSCI patients aged 15 years or older who were admitted to tertiary hospitals in Tianjin	Records data from hospitals	ICD-10 codes for hospital admitted patients	Retrospective
	Li *et al.* (2011) [35][6]	Beijing, China	2002	All TSCI patients admitted to sample hospital in Beijing	Records data from hospitals	N	Retrospective
	Feng *et al.* (2011) [26][7]	Tianjin, China	1998–2009	TSCI patients admitted to a Tianjin Medical University General Hospital	Records data from hospitals	Diagnostic code T09.302	Retrospective
	Yang *et al.* (2008) [29][10]	Taiwan	2000–2003	Patients hospitalized with a spinal trauma in Taiwan from the National Health Insurance entire inpatient database	National register	ICD9-CM 805.00–805.9, 806.00–806.9, 952.00–952.9	Retrospective
	Chen and Lien (1985) [10][11]	Taipei, Taiwan	1978–1981	Patients admitted to general hospitals with acute SCI	Records data from hospitals	ICD codes 806.0–806.9 or 968.0–968.9	Retrospective
	Ye *et al.* (2009) [20]**[12]	Beijing, China	1993–2006	Patients in four general hospitals and two rehabilitation institutions	Records data from hospitals	N	Retrospective
	Chen *et al.* (1997) [27][13]	Taiwan	1992–1996	Patients attended by physicians from various medical centers and general hospitals in Taiwan	National register	SCI was defined according to Kraus *et al.*[9]	Prospective
	Chen and Boore (2008) [41][14]	Taiwan	2002–2003	Patients in a rehabilitation hospital in Taiwan	Semi-structured, tape-recorded interview and observation of a group discussion	N	Retrospective
	Lan *et al.* (1993) [13][15]	Hualin county, Taiwan	1986–1990	Patients in four local general hospitals in Taiwan	Records data from hospitals	ICD codes 806.0–806.9 or 968.0–968.10	Retrospective
	Yeh *et al.* (1993) [13][16]	Taiwan, China	1977–1989	Admitted to the Chang Gung Memorial Hospital in Taiwan	Records data from hospitals	N	Retrospective
	Yang *et al.* (2011) [28][8]	Korea	2006–2009	Patients at the hospitals of six Universities	Questionnaire	N	Retrospective
	Shingu *et al.* (1995) [17][17]	Japan	1990–1992	All patients with SCI admitted to the 47 prefectures	Mailing survey	N	Retrospective
	Ide *et al.* (1993) [5][18]	Okayama, Japan	1988–1989	The registration lists contained in the Law for the Welfare of the Physically Disabled	Register	N	Retrospective
	Suyama *et al.* (1997) [10][19]	Japan	1980–1994		Records data from hospitals	N	Retrospective
	Shingu *et al.* (1994) [10][20]	Japan	1990	SCI patients at nationwide rehabilitation institutions	Mail study	ICD.806.0–9:ICD952.0–9	Retrospective
Southeast Asia	Pajareya *et al.* (1996) [16][21]	Thailand	1989–1994	All patients with traumatic SCI who were admitted to Siriraj Hospital, Bangkok	Records data from hospitals	According to Kraus *et al.*[9]	Retrospective
	Kovinpha *et al.* (1993) [12][22]	Chiang Mai, Thailand	1985–1991	Spinal cord injured patients admitted at Maharaj Nakorn Chiang Mai Hospital	Records data from hospitals	N	Retrospective

Continued

Table 1 ***Continued***

	Study author(s) (year) (ref.)	Country (region)	Incidence period	Source population	Case source	Case criteria	Prospective/ retrospective
South Asia	Qureshi *et al.* (2010) [20][23]	Pakistan	2001–2008	Non-disaster spinal injury patients admitted to the Spine Unit of a tertiary care hospital in Pakistan	Records data from spinal unite	N	Retrospective
	Rathore *et al.* (2008) [24][24]	Pakistan	2006	Admitted at Armed Forces Institute of Rehabilitation Medicine	Records data from spinal unite and patients	N	Prospective
	Masood *et al.* (2008) [21][25]	Pakistan	2003–2007	Admitted to the Department of Neurosurgery at Civil Hospital Karach	Specially designed proforma	N	Retrospective
	Singh *et al.* (2003) [9][26]	Haryana, India	2000–2001	All the patients with traumatic spinal injuries reporting to accident and emergency department and outdoor and indoor patients of orthopaedics department	N	N	Prospective
	Chacko *et al.* (1986) [7][27]	India	1980–1986	Patients with spinal injuries at the Kasturba Medical College Hospital, Manipal	Records data from hospitals	N	Retrospective
	Hoque *et al.* (1999) [10][28]	Bangladesh	1994–1995	All patients with SCI admitted to the The Centre for the Rehabilitation of the Paralysed during 1994–1995	Records data from hospitals	SCI was defined according to Kraus *et al.*[9]	Retrospective
	Islam *et al.* (2011) [19][29]	Bangladesh	2009	Patients admitted at the Centre for the Rehabilitation of the Paralysed	Face-to-face interview	N	Retrospective
	Lakhey *et al.* (2005) [13][30]	Eastern Nepal	1997–2001	Admitted to the orthopaedic ward of BP Koirala Institute of Health Sciences	Records data from hospitals	N	Retrospective
	Shrestha *et al.* (2007) [10]***[31]	Dharan, Nepal	2001–2004	Patients with suspected cervical spine injuries presented in emergency and accident department of BP Koirala institute of Health Sciences	N	N	Prospective
West Asia	Deconinck (2003) [30][32]	Kabul and Herat, Afghanistan	March–July 2001	The residents of Kabul and Herat ($N = 311$) with traumatic SCI	A standardized questionnaire and interview	N	Retrospective
	Rahimi-Movaghar *et al.* (2009) [18][33]	Tehran, Iran	2003–2008	Cases with definite traumatic SCI in Tehran	Interview	N	Retrospective
	Gur *et al.* (2005) [31][34]	Anatolia, Turkey	1990–1994, 1995–1999	SCI patients registered between 1990 and 1999	Records data from hospitals	ICD codes 806.0–806.9 or 968.0–968.9	Retrospective
	Karacan *et al.* (2000) [21][35]	Turkey	1992	TSCI cases during 1992 in Turkey	Postal questionnaires	N	Retrospective
	Karamehmetoğlu *et al.* (1995) [17][36]	Istanbul, Turkey	1992	Patients with a traumatic spinal cord in all of the hospitals of Istanbul	Records data from hospitals	N	Retrospective
	Ones *et al.* (2007) [29][37]	Turkey	2002–2005	Patients treated in Training and Research Hospital 3rd Clinic of	Records data from hospitals	N	Retrospective

Continued

Table 1 ***Continued***

Study author(s) (year) (ref.)	Country (region)	Incidence period	Source population	Case source	Case criteria	Prospective/ retrospective
			Physical Medicine of Physical Medicine			
Cosar *et al.* (2010) [20][38]	Turkey	1996–2008	In-patient rehabilitation program at the rehabilitation unit of a tertiary research hospital	Records data from hospitals	N	Retrospective
Karamehmetoğlu *et al.* (1997) [17][39]	Southeast Turkey	1994	TSCI was conducted in all the hospitals in Southeast Turkey	Records data from hospitals	N	Retrospective
Dincer *et al.* (1992) [19][40]	Turkey	1974–1985	Patients with TSCI in the rehabilitation program at the Ankara Rehabilitation Centre	Records data from hospitals	N	Retrospective
Otom *et al.* (1997) [16][41]	Amman-Jordan	1988–1993	Patients at the Ankara Rehabilitation Centre at the Royal Jordanian Rehabilitation Centre (RJRC) King Hussein Medical Centre (KHMC) Amman-Jordan	Records data from hospitals	Defined according to Kraus *et al.*[9]	Retrospective
Al-Jadid and Robert (2010) [33][42]	Saudi Arabia	2005–2008	Patients who completed the TSCI and NTSCI rehabilitation program at Sultan Bin Abdulaziz Humanitarian	Records data from hospitals	N	Retrospective
Mena *et al.* (2002) [15][43]	Qatar	1987–1996	City, Riyadh, Saudi Arabia All patients with TSCI admitted to Hamad	Records data from the Medical Record Department.	N	Retrospective
Ronen *et al.* (2004) [18][44]	Raanana, Israel	1962–2002	Medical Hospital during 1987–1996, SCI patients admitted to Loewenstein Rehabilitation Hospital	From hospital charts and from the Population Registry of the Israel Ministry of Internal Affairs	N	Retrospective

N, not mentioned.
**This article reported sport-related SCI.
***This article reported cervical spinal cord injuries.

Table 2 Incidence, gender ratio, cause and mean age of TSCI in Asian countries and regions

	Study author(s) (year) (ref.)	Country (region)	Incidence period	Total Cases	Incidence	Leading causes	Second causes	Gender ratio	Mean age
East Asia	Ning *et al.* (2011) [20][5]	Tianjin, China	2004–2008	869	23.7	Fall	MVCs	5.63:1	46
	Li *et al.* (2011) [35][6]	Beijing, China	2002	1079	60.6	Fall	MVCs	3.1:1	41
	Ye *et al.* (2009) [20][12]*	Beijing, China	1993–2006	57	N	Water sports	Gymnastics	3.3:1	24.49
	Feng *et al.* (2011) [26][7]	Tianjin, China	1998–2009	239	N	Fall	MVCs	4.6:1	45.4
	Yang *et al.* (2008) [29][10]	Taiwan	2000–2003	54484	61.6	N	N	0.99:1	N
	Chen and Lien (1985) [10][11]	Taipei, Taiwan	1978–1981	560	14.6	MVCs	Fall	4.9:1	36.2
	Chen *et al.* (1997) [27][13]	Taiwan	1992–1996	1586	18.8	MVCs	Fall	3:1	46.1
	Chen and Boore (2008) [41][14]	Taiwan	2002–2003	15	N	MVCs	Fall	2.75:1	31
	Lan *et al.* (1993) [13][15]	Hualin, Taiwan	1986–1990	99	56.1	MVCs	Fall	4:1	M44F46
	Yang *et al.* (2011) [28][8]	Korea	2006–2009	47	N	Fall	MVCs	2.4:1	48.4
	Shingu A *et al.* (1995) [17][17]	Japan	1990–1992	7471	40.2	MVCs	Fall	4:1	48.6
	Ide *et al.* (1993) [5][18]	Okayama, Japan	1988–1989	92	28.6	MVCs	N	3.2;1	56.6
	Suyama *et al.* (1997) [10][19]	Japan	1980–1994	1047	N	MVCs	Fall	7.5:1	33
	Shingu *et al.* (1994) [10][20]	Japan	1990	3645	50.5	MVCs	Fall	4.3:1	48.5
Southeast Asia	Pajareya *et al.* (1996) [16][21]	Thailand	1989–1994	219	N	MVCs	Fall	5.6:1	32.8
	Kovinpha *et al.* (1993) [12][22]	Chiang Mai, Thailand	1985–1991	398	23	MVCs	Fall	11:1	N
South Asia	Qureshi *et al.* (2010) [20][23]	Pakistan	2001–2008	521	N	Fall	MVCs	3.35:1	39.1
	Rathore et al. (2008) [24][24]	Pakistan	2006	83	N	Fall	MVCs	4.53:1	28.3
	Masood *et al.* (2008) [21][25]	Pakistan	2003–2007	214	N	Fall	MVCs	7.56:1	32.7
	Singh *et al.* (2003) [9][26]	Haryana, India	2000–2001	483	N	Fall	MVCs	2.96:1	35.4
	Chacko *et al.* (1986) [7][27]	India	1980–1986	218	N	Fall	MVCs	13.5:1	N
	Hoque *et al.* (1999) [10][28]	Bangladesh	1994–1995	179	N	Fall	MVCs	7.5:1**	N
	Islam *et al.* (2011) [19][29]	Bangladesh	2009	99	N	Fall	MVCs	5:1**	31
	Lakhey S *et al.* (2005) [13][30]	Eastern Nepal	1997–2001	233	N	Fall	MVCs	2.64:1	N
	Shrestha D *et al.* (2007) [10][31]***	Dharan Nepal	2001–2004	149	N	Fall	MVCs	4:1	40
West Asia	Deconinck (2003) [30][32]	Kabul and Herat, Afghanistan	March–July 2001	311	N	War wound	Fall	10.1:1	34
	Rahimi-Movaghar *et al.* (2009) [18][33]	Tehran, Iran	2003–2008	4	44	MVCs	Fall	1:1	N
	Gur *et al.* (2005) [31][34]	Anatolia, Turkey	1990–1999	539	12.06	MVCs	Wounds/Fall	3.38:1	30.62
	Karacan *et al.* (2000) [21][35]	Turkey	1992	581	12.7	MVCs	Fall	2.5 : 1	35.5
	Karamehmetoğlu *et al.* (1995) [17][36]	Istanbul, Turkey	1992	152	21	Fall	MVCs	3 : 1	33
	Ones *et al.* (2007) [29][37]	Turkey	2002–2005	131	N	MVCs	Fall	2.28:1	35.82
	Cosar *et al.* (2010) [20][38]	Ankara, Turkey	1996–2008	127	N	MVCs	Fall	2.1:1	37.81
	Karamehmetoğlu *et al.* (1997) [17][39]	Southeast Turkey	1994	75	16.9	Fall	wounds	5.8:1	31.3
	Dincer *et al.* (1992) [19][40]	Turkey	1974–1985	1694	N	MVCs	Fall	3.1:1	26.8
	Otom *et al.* (1997) [16][41]	Amman-Jorda	1988–1993	151	18	MVCs	Gunshot	5.8:1	33
	Maher S. *et al.* (2010) [33][42]	Saudi Arabia	2005–2008	495	N	MVCs	N	4.44:1	34.3
	Mena *et al.* (2002) [15][43]	Qatar	1987–1996	75	12.5	MVCs	Fall	8.35:1	32.26
	Ronen *et al.* (2004) [18][44]	Raanana, Israel	1962–2002	250	N	MVCs	Work accident	3.3:1	34.5

N, not mentioned; M, male; F, female.
*This article reported sport-related SCI.
**These data included non-TSCI.
***This article reported cervical spinal cord injuries.

procedures varied: 25 studies reviewed hospital data, 5 used mailing surveys and questionnaires, 3 patient interviews, 5 used information from national registries, and 1 did not describe the methodology.

Prevalence

Prevalence is defined as the number of persons with TSCI who are currently alive, which has a significant impact on health care systems. Because there are limited data registry systems in most Asian countries, only two reports summarized available findings on TSCI prevalence in Asia. Both of these utilized different methods to measure prevalence. In an Afghan study by Deconinck,[32] the reported prevalence rates were 128.5 and 108.7 per million in Kabul and Herat, respectively. In an Iranian study, Rahimi-Movaghar[33] estimated that the point prevalence of TSCI was 44 per million during 2007–2008.

Incidence

TSCI incidence was only mentioned in 17 reports, which included 71 860 cases in total. Just one south Asian country reported TSCI incidence. The studies included in this review employed different inclusion criteria. Most published incidences only included TSCI patients who were admitted to hospitals and excluded patients who died before reaching hospitals. Several incidences included persons with suspected TSCI in emergency departments but who were not admitted to hospitals. Therefore, we found that incidence rates ranged considerably; the highest value was 61.6 per million in Taiwan,[10] which was more than five times the rate for Anatolia, Turkey (a low of 12.06 per million).[34]

Gender and age

As demonstrated in Table 2, we found that men were at higher risk of TSCI than women; the gender ratio ranged considerably, from 0.99:1 in Taipei, Taiwan to 13.5:1 in India. However, the percentage of new injuries in women had increased slightly. In Taiwan, the gender ratio was 4.9:1 during 1978–1981 and 2.75:1 in 2002–2003. A similar trend was found in Thailand, where the incidence rate was 11.1 times higher in men between 1985 and 1991, but only 5.6 times higher during 1989–1994. The average age at the time of TSCI ranged from 26.8 to 56.6 years. Fifteen reports determined that the average age was less than 35 years.

Causes

The causes of TSCI are summarized in Table 2. The largest contributors were motor vehicle collisions (MVCs; 59.5%) and falls (37.8%). War wounds surpassed MVCs and falls as the primary cause of injury in an Afghan study.[32] Conversely, Otom *et al.*,[41] Gur *et al.*[34] and Karamehmetoğlu *et al.*[39] reported that war wounds were the second most common cause of TSCI.

Severity

Overall TSCI severity is usually measured by neurological level of injury (tetraplegia or paraplegia) and injury extent (complete or incomplete). In the included studies, 25 reports distinguished between paraplegia and tetraplegia and incomplete and complete (Table 3). The findings were inconsistent; the proportion of paraplegic individuals varied between 18 and 91.97%, and that of quadriplegic individuals ranged from 8.03 to 82%. Most countries reported more paraplegic than quadriplegic individuals, with the exceptions of China, Japan, and Thailand, where the situation was reversed. The percentage of complete injuries ranged from 25.2 to 89.96% and incomplete injuries from 10.04 to 74.8%. Most of the articles reported a higher percentage of complete injuries, with the exceptions of China, Korea, Pakistan, Nepal, and Israel.

The AIS/Frankel grades are also listed in Table 3. We extracted data from 12 studies and found that nearly 95% of TSCI patients showed neurological deficits. In most countries, most patients were classified as grade A, except in China[5,7] and Japan.[18] Grade B patients accounted for approximately 10–30%, and a similar proportion of patients were grade C.

Discussion

This is the first systematic review of TSCI in Asia. We compiled epidemiological characteristics of TSCI in Asia for comparison with other world regions. We found that this type of data was insufficient in some Asian countries, and the reported epidemiological data varied among the articles we assessed.

We were unable to establish universal case criteria to gather the cases. Therefore, it is impossible to precisely state how frequently TSCIs occur in Asia, so we reported ranges instead. The range of incidence was between 12.06 and 61.6 per million. In comparison, the European TSCI incidence was between 10.4 and 29.7 per million, and the incidence in North America ranged from 27.1 to 83 per million.[2] These estimates suggest that the incidence of TSCI in Asia was lower than that in North America. Such a difference might be attributable to economic and social development. In Asia, the number of developing countries is much higher than that in North America. Chiu *et al.*[45] reported that developing countries had lower incidence rates compared to developed ones. Population structure

Table 3 AIS, neurological level of injury and extent of injury of TSCI in Asian countries and regions

	Study author(s) (year) (ref.)	Country	*T* (%)	*C* (%)	AIS A (%)	AIS B (%)	AIS C (%)	AIS D (%)	AIS E (%)
East Asia	Ning *et al.* (2011) [20][5]	Tianjin, China	71.6	25.2	25.2	18.2	14.7	41.9	0
	Ye *et al.* (2009) [20][12]*	Beijing, China	89	54.5	N	N	N	N	N
	Feng *et al.* (2011) [26][7]	Tianjin, China	82	32.6	32.6	12.1	16.3	38.9	0
	Chen and Lien (1985) [10][11]	Taipei, Taiwan	46.8	58	N	N	N	N	N
	Chen *et al.* (1997) [27][13]	Taiwan	49	58.7	N	N	N	N	N
	Chen and Boore (2008) [41][14]	Taiwan	46.7	46.7	N	N	N	N	N
	Lan *et al.* (1993) [13][15]	Hualin, Taiwan	69.7	51.5	N	N	N	N	N
	Yeh *et al.* (1993) [13][16]	Taiwan, China	N	N	N	N	N	N	N
	Yang *et al.* (2011) [28][8]	Korea	N	40	40.4	N	N	26	N
	Shingu *et al.* (1995) [17][17]	Japan	N	N	25.8(33.7)**	12.4(16.2)**	20.3(26.6)**	18.1(23.6)**	23(0)**
	Ide *et al.* (1993) [4][18]	Okayama, Japan	68.5	N	31.5	3.3	12	53.2	0
	Suyama *et al.* (1997) [10][19]	Japan	N	76	N	N	N	N	N
	Shingu *et al.* (1994) [10][20]	Japan	N	N	26.2(34.6)**	12.5(16.2)**	20(30.0)**	17.9(23.2)**	22.8(0)**
Southeast Asia	Pajareya *et al.* (1996) [16][21]	Thailand	50.2	52.5	N	N	N	N	N
	Kovinpha *et al.* (1993) [12][22]	Chiang Mai, Thailand	53	32.4	40.5	11.3	26.4	21.9	0
South Asia	Qureshi *et al.* (2010) [20][23]	Pakistan	N	43	43(56.6)**	4(5.1)**	15(20.3)**	14(18.0)**	24(0)**
	Rathore *et al.* (2008) [24][24]	Pakistan	26.5	57.8	N	N	N	N	N
	Masood *et al.* (2008) [21][25]	Pakistan	N	36	N	N	N	N	N
	Singh *et al.* (2003) [9][26]	Haryana, India	40	N	N	N	N	N	N
	Chacko *et al.* (1986) [7][27]	India	N	41.7	N	N	N	N	N
	Hoque *et al.* (1999) [10][28]	Bangladesh	40	N	78	7	7	7	0
	Islam *et al.* (2011) [19][29]	Bangladesh	45.8	78	N	N	N	N	N
	Lakhey *et al.* (2005) [13][30]	Eastern Nepal	N	46.8	46.8(62.6)**	5.1(6.9)**	11.6(15.5)**	11.2(14.9)**	25.3(0)**
	Shrestha *et al.* (2007) [10][31]***	Dharan, Nepal	92.4	N	36.2(47.0)**	13.4(17.4)**	14.8(19.1)**	12.8(16.5)**	22.8(0)**
West Asia	Deconinck (2003) [30][32]	Kabul and Herat, Afghanistan	N	80	N	N	N	N	N
	Gur *et al.* (2005) [31][34]****	Anatolia,	30.62	51.79	N	N	N	N	N
		Turkey	23.4	68.53	N	N	N	N	N
	Karacan *et al.* (2000) [21][35]	Turkey	32.18	N	N	N	N	N	N
	Karamehmetoğlu *et al.* (1995) [17][36]	Istanbul, Turkey	33	N	N	N	N	N	N
	Ones *et al.* (2007) [29][37]	Turkey	25.95	63.35	N	N	N	N	N
	Cosar *et al.* (2010) [20][38]	Turkey	32.1	74	74	14.2	6.3	5.5	0
	Karamehmetoğlu *et al.* (1997) [17][39]	Southeast Turkey	41.3	N	N	N	N	N	N
	Dincer *et al.* (1992) [19][40]	Turkey	8.03	89.96	N	N	N	N	N
	Otom *et al.* (1997) [16][41]	Amman-Jorda	32	N	53.6	10	22.5	13.9	0
	Mena *et al.* (2002) [15][43]	Qatar	57.3	58.7	N	N	N	N	N
	Ronen *et al.* (2004) [18][44]	Raanana, Israel	N	46	N	N	N	N	N

T, Tetraplegia; C, Complete; N, not mentioned; AIS, America Spinal Injury Association Impairment Scale.
*This article reported sport-related SCI.
**Original date were from all spinal injury, including injury without SCI (AIS E), and the data in brackets was re-calculated excluding AIS E by authors of this review.
***This article reported cervical spinal cord injuries.
****This study described epidemiology of two periods, the former data was during 1990–1994, and the latter was between 1995 and 1999.

also plays an important role in variable incidence in different countries. Asia is home to an estimated 60% of the world's population and has an enormous aging population. Elderly people are more prone to injury because of degenerative spine conditions, such as stenosis, spondylolisthesis, and degenerative disc disease. As the population ages, the number of TSCIs in elderly patients also increases.

Regarding age at TSCI, the highest incidences in all countries were reported in persons between 20 and 50 years old. In North America,[46–52] the average age was between 32 and 55.4 years, and European studies[53–57] reported an average range between 37 and 47.9 years. Asian articles reported average ages that ranged from 26.8 to 56.6 years. This estimate is similar worldwide, which indicates that the majority of TSCI occurs in adults because they are the most active, socially productive members of society.

Although there were almost equal numbers of men and women in the populations, men were at higher risk for TSCI than women, which has been reported previously.[46,53,55,56,58–63] This review confirmed the global trend, despite geographic and demographic differences. The disparate gender ratio may be due to differences in socioeconomic and cultural backgrounds. In most countries,[5,7,28,29,35,37,41] women historically stayed home and were protected from many outside dangers, whereas men were more likely to be engaged in dangerous work to earn money to support a family. Certain occupations, such as truck driving and construction, take place in dangerous environments. This was the major reason that men were more vulnerable to injury. In addition, violence and alcohol are important potential reasons for the high incidence observed in men versus women.[11,21] However, as societies develop, an increasing number of women work in high-risk jobs. This is the likely reason for the slightly increased percentage of TSCI in women.

With regard to cause, traffic accidents are the most common cause of TSCI in North America,[49,63–65] Europe[53,66–68] and sub-Saharan Africa.[69] In western Norway,[70] falls were the most common cause. In this review, MVCs and falls were the main causes. It is not surprising that the proportion of new TSCI due to falls has been increasing steadily as Asian societies age.[5,7] The relative distribution of causes reflects the lifestyles of the people in different countries. In Asia, most areas are underdeveloped, and motor vehicle usage is not as common as in North America and Europe. In addition, TSCI causes are influenced by lifestyle and political environment. For example, in some regions of Turkey, the most common cause of TSCI was falling from a great height, which could be associated with the fact that most falls occurred in the summer when people sleep on the top of their houses. In China,[5,7] there was an enormous number of elderly patients with degenerative cervical spine changes who were more vulnerable to a slight damage (e.g. a low fall), so the number of low falls-induced TSCI would increase gradually; in Bangladesh,[28,29] falls while carrying heavy loads on neck or back is a common cause. In Afghanistan,[32] Jordan,[41] and southeast Turkey,[39] the frequency of firearm wounds, a specific problem to these countries, was higher than in other regions. In Jordan, the majority of firearm accidents happened during wedding celebrations, a common cultural habit in rural areas. In other regions, where the political situation was stable and firearms were strictly controlled, such injuries were rare.

The assessment of TSCI severity varied. The AIS/Frankel grade is a standard tool for evaluating TSCI patients in North America and Europe. In other countries,[55,56,59,60,62,63,71,72] AIS/Frankel grade A was most frequently observed. In this review, most Asian studies agreed with this trend, although grade D was dominant in China.[7] This difference was attributed to elderly people, whose cervical spine is a degenerative change vulnerable to slight damage. Still, the Chinese data were in accordance with that from other countries, showing increasing numbers of elderly people sustaining incomplete TSCI from falls.[58,62,73,74]

With respect to the neurological level of injury, there is substantial variability in the proportion of TSCI resulting in tetraplegia and paraplegia. In the USA,[62] tetraplegic injuries (54.1%) were more common than paraplegic injuries over a 30-year period. The Netherlands[75] reported that tetraplegic injuries accounted for 39.8% and paraplegic for 60.2%. In China,[7] tetraplegic injuries were as high as 82%. As mentioned above, China[7] has an enormous number of elderly patients with degenerative cervical spine changes who are susceptible to incomplete tetraplegia following a minor fall. Similarly, there is no meaningful trend in the proportion of persons with complete and incomplete injuries. The reasons for this difference are multiple and include improved initial care, awareness of the importance of emergency treatment after injury, and injury mechanisms.

Recommendations

Despite a growing body of TSCI literature, we found several limitations of Asian epidemiology: (1) most reports were retrospective studies; (2) a large proportion of studies only reported a subset of TSCI patients, so the

epidemiological data could not be used to infer a national trend; (3) the studies focused on TSCI survivors. Persons who died before they arrived at hospital or in the emergency department were not included; and (4) there were a number of important differences regarding case definitions, including case criteria and variable study periods.

Conclusion

Because of the above limitations, it is difficult to acquire accurate epidemiological data for TSCI in Asia. To correct these methodological shortcomings, it is proposed that national registries and international methodological uniformity be established over the next several years. Asian countries should also consider collaborating in future studies. In addition, to clarify differences in TSCI among countries, future studies should be prospective and collect large amounts of data in order to provide valid comparative data.

Acknowledgements

This study was supported by the grants from Key Technology Foundation of Tianjin Health Bureau (07KG2), National Natural Science Foundation of China (81070982), and Research Foundation of Tianjin Health Bureau (09kz104).

References

1 Pickelsimer E, Shiroma EJ, Wilson DA. Statewide investigation of medically attended adverse health conditions of persons with spinal cord injury. J Spinal Cord Med 2010;33(3):221–31.
2 Wyndaele M, Wyndaele JJ. Incidence, prevalence and epidemiology of spinal cord injury: what learns a worldwide literature survey. Spinal Cord 2006;44(9):523–9.
3 Cripps RA, Lee BB, Wing P, Weerts E, Mackay J, Brown D. A global map for traumatic spinal cord injury epidemiology: towards a living data repository for injury prevention. Spinal Cord 2011;49(4):493–501.
4 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(3):184–92.
5 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(3):386–90.
6 Li J, Liu G, Zheng Y, Hao C, Zhang Y, Wei B, *et al.* The epidemiological survey of acute traumatic spinal cord injury (ATSCI) of 2002 in Beijing municipality. Spinal Cord 2011;49(7):777–82.
7 Feng HY, Ning GZ, Feng SQ, Yu TQ, Zhou HX. Epidemiological profile of 239 traumatic spinal cord injury cases over a period of 12 years in Tianjin, China. J Spinal Cord Med 2011;34(4):388–94.
8 Yang JY, Shim DM, Kim TK, Moon ES, Sohn HM, Hong CH, *et al.* Epidemiology of the spinal cord and cauda equina injury in Korea – multicenter study. J Korean Soc Spine Surg 2011; 18(3):83–90.
9 Kraus JF, Franti CE, Riggins RS, Richards D, Borhani NO. Incidence of traumatic spinal cord lesions. J Chronic Dis 1975; 28(9):471–92.
10 Yang NP, Deng CY, Lee YH, Lin CH, Kao CH, Chou P. The incidence and characterisation of hospitalised acute spinal trauma in Taiwan – a population-based study. Injury 2008;39(4):443–50.
11 Chen CF, Lien IN. Spinal cord injuries in Taipei, Taiwan, 1978–1981. Paraplegia 1985;23(6):364–70.
12 Ye C, Sun T, Li J, Zhang F. Pattern of sports- and recreation-related spinal cord injuries in Beijing. Spinal Cord 2009;47(12): 857–60.
13 Chen HY, Chiu WT, Chen SS, Lee LS, Hung CI, Hung CL. A nationwide epidemiological study of spinal cord injuries in Taiwan from July 1992 to June 1996. Neurol Res 1997;19(6):617–22.
14 Chen HY, Boore JR. Living with a spinal cord injury: a grounded theory approach. J Clin Nurs 2008;17(5A):116–24.
15 Lan C, Lai JS, Chang KH, Jean YC, Lien IN. Traumatic spinal cord injuries in the rural region of Taiwan: an epidemiological study in Hualien county, 1986–1990. Paraplegia 1993;31(6): 398–403.
16 Yeh YS, Lee ST, Lui TN, Fairholm DJ, Chen WJ, Wong MK. Features of spinal cord injury in Taiwan (1977–1989). Changgeng Yi Xue Za Zhi 1993;16(3):170–5.
17 Shingu H, Ohama M, Ikata T, Katoh S, Akatsu T. A nationwide epidemiological survey of spinal cord injuries in Japan from January 1990 to December 1992. Paraplegia 1995;33(4):183–8.
18 Ide M, Ogata H, Tokuhiro A, Takechi H. Spinal cord injuries in Okayama Prefecture: an epidemiological study "88-"89. J UOEH 1993;15(3):209–15.
19 Suyama T, Nihei R, Kimura T, Yano H, Tobimatsu Y, Hatsuyama Y, *et al.* Rehabilitation of spinal cord injury in the national rehabilitation center for the disabled of Japan: profile of a spinal service. Spinal Cord 1997;35(11):720–4.
20 Shingu H, Ikata T, Katoh S, Akatsu T. Spinal cord injuries in Japan: a nationwide epidemiological survey in 1990. Paraplegia 1994;32(1):3–8.
21 Pajareya K. Traumatic spinal cord injuries in Thailand: an epidemiologic study in Siriraj Hospital, 1989–1994. Spinal Cord 1996; 34(10):608–10.
22 Kovinpha A. A retrospective study of spinal cord injuries at Maharaj Nakorn Chiang Mai Hospital, during 1985–1991. Chiang Mai Med Bull 1993;32(2):85–92.
23 Qureshi MA, Khalique AB, Pasha IF, Asad A, Malik AS, Shah MQ, *et al.* Epidemiology of non-disaster spinal injuries at a spine unit. J Coll Physicians Surg Pak 2010;20(10):667–70.
24 Rathore MF, Hanif S, Farooq F, Ahmad N, Mansoor SN. Traumatic spinal cord injuries at a tertiary care rehabilitation institute in Pakistan. J Pak Med Assoc 2008;58(2):53–57.
25 Masood Z, Wardug GM, Ashraf J. Spinal injuries: Experience of a local neurosurgical centre. Pak J Med Sci 2008;24(3):368–71.
26 Singh R, Sharma SC, Mittal R, Sharma A. Traumatic spinal cord injuries in Haryana: an epidemiological study. Indian J Community Med 2003;28(4):184–6.
27 Chacko V, Joseph B, Mohanty SP, Jacob T. Management of spinal cord injury in a general hospital in rural India. Paraplegia 1986; 24(5):330–5.
28 Hoque MF, Grangeon C, Reed K. Spinal cord lesions in Bangladesh: an epidemiological study 1994–1995. Spinal Cord 1999;37(12):858–61.
29 Islam MS, Hafez MA, Akter M. Characterization of spinal cord lesion in patients attending a specialized rehabilitation center in Bangladesh. Spinal Cord 2011;49(7):783–6.
30 Lakhey S, Jha N, Shrestha BP, Niraula S. Aetioepidemiological profile of spinal injury patients in Eastern Nepal. Trop Doct 2005;35(4):231–3.
31 Shrestha D, Garg M, Singh GK, Singh MP, Sharma UK. Cervical spine injuries in a teaching hospital of eastern region of Nepal: aclinico-epidemiological study. JNMA J Nepal Med Assoc 2007; 46(167):107–11.
32 Deconinck H. The health condition of spinal cord injuries in two Afghan towns. Spinal Cord 2003;41(5):303–9.
33 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(4):428–31.
34 Gur A, Kemaloglu MS, Cevik R, Sarac AJ, Nas K, Kapukaya A, *et al.* Characteristics of traumatic spinal cord injuries in southeastern Anatolia, Turkey: a comparative approach to 10 years' experience. Int J Rehabil Res 2005;28(1):57–62.
35 Karacan I, Koyuncu H, Pekel O, Sümbüloglu G, Kirnap M, Dursun H, *et al.* Traumatic spinal cord injuries in Turkey: a nation-wide epidemiological study. Spinal Cord 2000;38(11): 697–701.

36 Karamehmetoğlu SS, Unal S, Karacan I, Yílmaz H, Togay HS, Ertekin M, *et al.* Traumatic spinal cord injuries in Istanbul, Turkey. An epidemiological study. Paraplegia 1995;33(8):469–71.
37 Ones K, Yilmaz E, Beydogan A, Gultekin O, Caglar N. Comparison of functional results in non-traumatic and traumatic spinal cord injury. Disabil Rehabil 2007;29(15):1185–91.
38 Cosar SN, Yemisci OU, Oztop P, Cetin N, Sarifakioglu B, Yalbuzdag SA, *et al.* Demographic characteristics after traumatic and non-traumatic spinal cord injury: a retrospective comparison study. Spinal Cord 2010;48(12):862–6.
39 Karamehmetoğlu SS, Nas K, Karacan I, Sarac AJ, Koyuncu H, Ataoğlu S, *et al.* Traumatic spinal cord injuries in southeast Turkey: an epidemiological study. Spinal Cord 1997;35(8):531–3.
40 Dincer F, Oflazer A, Beyazova M, Celiker R, Basgoze O, Altioklar K. Traumatic spinal cord injuries in Turkey. Paraplegia 1992;30: 641–6.
41 Otom AS, Doughan AM, Kawar JS, Hattar EZ. Traumatic spinal cord injuries in Jordan – an epidemiological study. Spinal Cord 1997;35(4):253–5.
42 Al-Jadid M, Robert AA. An analysis of the length of stay in traumatic and non-traumatic spinal cord injured patients. A rehabilitation unit experience in Saudi Arabia. Saudi Med J 2010;31(5): 555–9.
43 Mena QPO, Nassal M, Al Bader KI, Al Muraikhi AE, Al Kahlout SR. Traumatic spinal cord injury in Qatar: an epidemiological study. Middle East J Emergency Med 2002;2(1):35–40.
44 Ronen J, Itzkovich M, Bluvshtein V, Thaleisnik M, Goldin D, Gelernter I, *et al.* Length of stay in hospital following spinal cord lesions in Israel. Spinal Cord 2004;42(6):353–8.
45 Chiu WT, Lin HC, Lam C, Chu SF, Chiang YH, Tsai SH. Review paper: epidemiology of traumatic spinal cord injury: comparisons between developed and developing countries. Asia Pac J Public Health 2010;22(1):9–18.
46 Calancie B, Molano MR, Broton JG. Epidemiology and demography of acute spinal cord injury in a large urban setting. J Spinal Cord Med 2005;28(2):92–6.
47 Couris CM, Guilcher SJ, Munce SE, Fung K, Craven BC, Verrier M, *et al.* Characteristics of adults with incident traumatic spinal cord injury in Ontario, Canada. Spinal Cord 2010;48(1):39–44.
48 Krassioukov AV, Furlan JC, Fehlings MG. Medical co-morbidities, secondary complications, and mortality in elderly with acute spinal cord injury. J Neurotrauma 2003;20(4):391–9.
49 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(2):113–21.
50 Tator CH, Duncan EG, Edmonds VE, Lapczak LI, Andrews DF. Changes in epidemiology of acute spinal cord injury from 1947 to 1981. Surg Neurol 1993;40(3):207–15.
51 McColl MA, Charlifue S, Glass C, Savic G, Meehan M. International differences in ageing and spinal cord injury. Spinal Cord 2002;40(3):128–36.
52 Nobunaga AI, Go BK, Karunas RB. Recent demographic and injury trends in people served by the Model Spinal Cord Injury Care Systems. Arch Phys Med Rehabil 1999;80(11):1372–82.
53 Knútsdóttir S, Thórisdóttir H, Sigvaldason K, Jónsson H, Jr, Björnsson A, Ingvarsson P. Epidemiology of traumatic spinal cord injuries in Iceland from 1975 to 2009. Spinal Cord. 2012; 50(2):123–6.
54 Dahlberg A, Kotila M, Leppänen P, Kautiainen H, Alaranta H. Prevalence of spinal cord injury in Helsinki. Spinal Cord 2005; 43(1):47–50.
55 Amin A, Bernard J, Nadarajah R, Davies N, Gow F, Tucker S. Spinal injuries admitted to a specialist centre over a 5-year period: a study to evaluate delayed admission. Spinal Cord 2005; 43(7):434–7.
56 O'Connor RJ, Murray PC. Review of spinal cord injuries in Ireland. Spinal Cord 2006;44(7):445–8.
57 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(11):796–801.
58 O'Connor PJ. Forecasting of spinal cord injury annual case numbers in Australia. Arch Phys Med Rehabil 2005;86(1):48–51.
59 Obalum DC, Giwa SO, Adekoya-Cole TO, Enweluzo GO. Profile of spinal injuries in Lagos, Nigeria. Spinal Cord 2009; 47(2):134–7.
60 Maharaj JC. Epidemiology of spinal cord paralysis in Fiji: 1985–1994. Spinal Cord 1996;34(9):549–59.
61 Price C, Makintubee S, Herndon 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(1):37–47.
62 Jackson AB, Dijkers M, Devivo MJ, Poczatek RB. A demographic profile of new traumatic spinal cord injuries: change and stability over 30 years. Arch Phys Med Rehabil 2004;85(11):1740–8.
63 Pickett GE, Campos-Benitez M, Keller JL, Duggal N. Epidemiology of traumatic spinal cord injury in Canada. Spine (Phila Pa 1976) 2006;31(7):799–805.
64 Surkin J, Gilbert BJ, Harkey HL, 3rd, Sniezek J, Currier M. Spinal cord injury in Mississippi. Findings and evaluation, 1992–1994. Spine (Phila Pa 1976) 2000;25(6):716–21.
65 Pirouzmand F. Epidemiological trends of spine and spinal cord injuries in the largest Canadian adult trauma center from 1986 to 2006. J Neurosurg Spine 2010;12(2):131–40.
66 Silberstein B, Rabinovich S. Epidemiology of spinal cord injuries in Novosibirsk, Russia. Paraplegia 1995;33(6):322–5.
67 Martins F, Freitas F, Martins L, Dartigues JF, Barat M. Spinal cord injuries – epidemiology in Portugal's central region. Spinal Cord 1998;36(8):574–8.
68 van Asbeck FW, Post MW, Pangalila RF. An epidemiological description of spinal cord injuries in The Netherlands in 1994. Spinal Cord 2000;38(7):420–4.
69 Draulans N, Kiekens C, Roels E, Peers K. Etiology of spinal cord injuries in Sub-Saharan Africa. Spinal Cord 2011;49(12): 114–54.
70 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(4):313–8.
71 van Den Berg M, Castellote JM, Mahillo-Fernandez I, de Pedro-Cuesta J. Incidence of traumatic spinal cord injury in Aragon, Spain (1972–2008). J Neurotrauma 2011;28(3):469–77.
72 Sekhon LH, Fehlings MG. Epidemiology, demographics, and pathophysiology of acute spinal cord injury. Spine (Phila Pa 1976) 2001;26(24 Suppl.):S2–12.
73 Ahoniemi E, Alaranta H, Hokkinen EM, Valtonen K, Kautiainen H. Incidence of traumatic spinal cord injuries in Finland over a 30-year period. Spinal Cord 2008;46(12):781–4.
74 Pickett W, Simpson K, Walker J, Brison RJ. Traumatic spinal cord injury in Ontario, Canada. J Trauma 2003;55(6):1070–6.
75 Post MW, Dallmeijer AJ, Angenot EL, van Asbeck FW, van der Woude LH. Duration and functional outcome of spinal cord injury rehabilitation in the Netherlands. J Rehabil Res Dev 2005; 42(3):75–85.