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Epidemiology map of traumatic spinal cord injuries: A global overview

Angelo V. Vasiliadis, PhD (c)
Department of Physical Education and Sport Science at Serres, Aristotle University of Thessaloniki at Serres, Greece
Laboratory of Adapted Physical Activity, Laboratory of Exercise Physiology and Biochemistry, Department of Physical Education and Sport Science at Serres, Aristotle University of Thessaloniki at Serres, Greece
Medical student, Aristotle University of Thessaloniki, Greece

Corespondence: Angelo V. Vasiliadis, 3 Agias Sofias, 57010 Exochi, Thessaloniki
E-mail: vasiliadisvangelo@hotmail.com

Abstract

Background: Traumatic spinal cord injury (TSCI) represents a serious medical problem for society on all continents. This review provides the epidemiology of TSCI from 1978-2009. It explores the incidence, demography, aetiology of injury, secondary complications, length of stay and provides strategies for improved prevention.
Aim: This study summarizes the available data about the epidemiological data of traumatic spinal cord injuries worldwide.
Methods: A systematic review in PubMed was conducted.
Results: The incidence rates varied greatly among continents. Most of patients with TSCI are young men between 20 to 30 years with road accidents as the leading cause of injury worldwide. The majority of studies reported a high incidence of injury in cervical region.
Conclusions: There is a need for improved methods of registration of TSCI particularly from the lack of data from countries of Africa. To clarify regional differences, future epidemiological studies should carry out regional incidence. It is obvious the need for enforcement of laws and also for public awareness campaigns and education programmes.

Keywords: spinal cord injury, traumatic, epidemiology, incidence, rehabilitation

Introduction

Spinal cord injury (SCI) is an enormous devastating condition often affecting young and male healthy individuals and which result negatively at all the parameters of their life including physical, emotional, financial and social cost (Thuret et al., 2006; Ackery, Tator & Krassioukov, 2004; Burt, 2004). Traumatic SCI can result in paralysis or paresis of the affected areas of the body and the extent of this injury determined by how high or low on the spine the damage occurs, leading finally to tertaplegia or paraplegia (Thuret et al., 2006). There are many secondary complications that the individuals with SCI must face such as urinary infection, pulmonary complications and complications related to the skin (Montgomerie, 1997; Sugarman et al., 1982). Therefore prevention and rehabilitation programs for people with SCI are of paramount importance (Chen et al., 1985). SCI epidemiology has been studied extensively over the past 30 years. However, most investigations were limited to descriptive epidemiology, race and ethnicity, aetiology and mortality (Dollfus, 1990). It is however difficult to compare epidemiological data from one country or continent with another (Eng et al., 2006; Exner & Meinecke, 1997; Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991) due to differences in social structure, therapeutic procedures and data gathering systems. In this study we illustrate an epidemiological description of the group of SCI in a worldwide context. Specifically, we were interested in the incidence, the level of lesion, the aetiology, the gender predominance, the mean age of injury, secondary complications, and length of stay.

Prevention programs also were described according to the needs of countries.

Methods

An extensive search of Pub Med database was undertaken over the last three decades, published from 1979 to October 2009 in order to identify studies on epidemiology of TSCI from different countries throughout the five continents. The search terms were: 'epidemiology', 'SCI', 'traumatic', 'incidence' and 'rehabilitation'. The author also used all the 'related articles' option and all related articles were screened. Selected publications were analyzed as shown in Table 1.

Results

America (published data from 1992 to 2006)

Four manuscripts were analyzed, one study from USA (Jackson et al., 2004), two manuscripts from Canada because of the small reported number of patients and secondly because of total area (Pickett et al., 2006; Dryden et al., 2003) and one manuscript from Brazil (Campos da Paz et al., 1992). The two studies from Canada reported annual incidence per million, which was 41.8 and 52.5 for Eastern and Western Canada respectively. Individuals with SCI had a mean age varied from 30.3 to 42.2 and a male to female ratio varied from 2.5:1 (Dryden et al., 2003) to 4.2:1 (Jackson et al., 2004). Road accidents accounted for the majority between 35% and 56.4% of injuries and were the leading cause of injuries. A high percentage was presented for violence (27.9%) in Brazil. The manuscripts showed that TSCI predominantly occurred in cervical region. The main clinical complication was the pressure ulcers (54.1%) followed by urinary complications (31.9%) (Campos da Paz et al., 1992). The mean length of hospitalization in acute phase was 16.8 days in Eastern Canada, while in Brazil the median time of hospitalization was 126.7 days (Pickett et al., 2006; Campos da Paz et al., 1992). This difference may be due to the fact that in Brazil included the phase of rehabilitation.

Europe (published data from 1978 to 2009)

A total of 15 studies with TSCI were analyzed. The incidence of new TSCI reported to these studies varied widely from 5.3 new cases per year in Iceland (Knutsdottir, 2009) to 57.8 new cases per million inhabitants in Portugal (Martins et al., 1998). Martins (1998) included to their study, those who died on the way to the hospital. Two studies did not mention data of incidence (Aung & El Masry, 1997; Exner & Meinecke, 1997). The mean age of injury ranged between 37 to 50.5 in Portugal, with young males subject reported that they need more attention (Rekand et al., 2009; Aung & El Masry, 1997). Studies from France and Germany did not mention these data (Albert et al., 2005; Exner & Meinecke, 1997). TSCI in male is more common in the fourteen studies except France, ranged from 2.6:1 to 6.6:1 (O´Connor & Murray., 2005; Exner & Meinecke, 1997). Road accidents were the leading aetiology of injury in the most studies following by falls, which were the leading cause in Finland, Sweden, Estonia and Netherlands (Divanoglou & Levi, 2009; Rekand et al., 2009; Ahoniemi et al., 2008; Van Asbeck, Post & Pangalila, 2000). The areas of the spinal cord most susceptible to injury are the cervical region. Pressure sore seems to be the most frequent complication in the acute stage of hospitalization (Pagliacci et al., 2003; Aung & El Masry, 1997; Exner & Meinecke, 1997; Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991), also there are noteworthy percentages of urinary tract infection and respiratory disorders (Pagliacci et al., 2003; Exner & Meinecke, 1997; Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991). The average length of stay was between 26.67 and 138 days. Patients with motor complete lesions, tetraplegia and delay admission were hospitalised for longer period (Aung & El Masry, 1997; Biering-Sørensen, Pedersen & Clausen, 1990).

Africa (published data from 1994 to 2009)

Studies from Zimbabwe and Nigeria were retrospective. Only one manuscript of TSCI incidence was found in Africa and this annual incidence was 34 per million population (Obalum et al., 2009). The male to female ratio was ranged from 2.34:1 to 8.1:1. The majority of patients aged between 20 to 40 (Obalum et al., 2009; Gosselin & Coppotelli, 2005; Levy et al., 1998; Hart & Williams, 1994). Road accidents were the leading cause of SCI in three out four of studies, with South Africa reported violence as the most predominant cause of injury (56%) (Hart & Williams, 1994). Two studied reported that cervical region was more common for injury (Gosselin & Coppotelli, 2005; Levy et al., 1998), while one study reported lumbar region (Obalum et al., 2009) and study from South Africa reported thoracic region (Hart & Williams, 1994). The most frequently complication was
pressure sores, which were present in 47 cases in South Africa (7.6%) and in 163 cases in Nigeria

(59.9%). The inpatient care were about of 75 days in Sierra Leone and in Nigeria patients were discharged after an average duration of hospital stay of 84 days, while the duration of patients` stay in the unit ranged from 90-180 days in South Africa (Obalum et al., 2009; Gosselin & Coppotelli, 2005; Hart & Williams, 1994).

Asia (published data from 1985 to 2005)

Eleven studies reviewed from the continent of Asia and roughly half of them, they do not mention estimations of incidence. Estimations of TSCI incidences varied from 7.8 per million (Raibulet et al., 2001) to 20.5 per million (Nak-Su, Cheen-Kyung & Won-Chul, 1999). The average TSCI age in studies ranged from 20.6 to 35.4 (Singh et al., 2003; Raibulet et al., 2001). The study from Nepal showed that the sixth decade of life was the major decade of injury (Lakhey et al., 2005). The majority of studies showed that the forth decade was the most prevalent decade (Kuptniratsaikul, 2003; Singh et al., 2003; Catz et al., 2002; Mena Quinones et al., 2002; Karacan et al., 2000; Nak-Su, Cheen-Kyung & Won-Chul, 1999; Otom et al., 1997; Chen & Lien, 1985). The male to female ratio ranged from 2.5:1 (Karacan et al., 2000) to 8.3:1 (Mena Quinones et al., 2002). The main cause of TSCI was the road accidents. Three studies reported as main cause falls (Lakhey et al., 2005; Singh et al., 2003; Fazlul Hoque, Grangeon & Reed, 1999). As reviewed, percentages of cervical spine injury ranged widely from 25.3 (Kuptniratsaikul, 2003) to 63.2 (Nak-Su, Cheen-Kyung & Won-Chul, 1999) and was the most common region of injury among thoracic and lumbar. Urinary tract infection was the major complication present in 62% and 59.57% of all cases in Bangladesh and Kuwait respectively (Raibulet et al., 2001; Fazlul-Hoque, Grangeon & Reed, 1999). The average length of hospital stay varied between 39.5 and 152.7 days (Singh et al., 2003; Raibulet et al., 2001), depends on the severity of injury (paraplegic or tetraplegic) and the duration of rehabilitation period.

Oceania (published data from 1996 to 2006)

It has been reported that the annual incidence of SCI varies between 15.4 and 18.7 cases per million people in the three countries of Oceania. Studies from Fiji and Papua New Guinea were retrospective (Maharaj, 1996; Gee & Sinha, 1982). The highest incidences of SCI were reported in persons between 15 and 30 years of age. All the studies reported that SCI in males is more prevalent than in females, displayed ratios of 4:1, 4.5:1 and 8:1 (Cripps, 2006; Maharaj, 1996; Gee & Sinha, 1982). Falls were the main cause of injury in two studies except study from Australia where the leading cause of injury reported road accidents (Cripps, 2006). Fiji reported a high percentage (32%) of TSCI for sport injuries (Maharaj, 1996). Thoracic and lumbar injuries seem to be the dominant level of injury in Papua New Guinea and Fiji, while in Australia, 51.8% had cervical injuries. In the Fiji Islands, a rate of 48.8% of patients spent less than 28 days in acute hospitals with only 7.3% spending more than 168 days, whereas 15.7% of patients spent less than 28 days in rehabilitation unit with 33.6% spending more than 168 days. Pressure sores and urinary tract infection were the major complications in Fiji Islands and Papua New Guinea (Maharaj, 1996; Gee & Sinha, 1982). The average duration of initial care for tetraplegics and paraplegics was 144 days in Oceania, while in Papua New Guinea was 240 days.

Discussion

From the 37 studies, 24 studies indicated an annual incidence of SCI. The reported annual incidence varied between 5.3 and 57.8 per million people (Knutsdottir & Thorisdottir, 2009; Martins et al., 1998). North America reported high incidence of over 40 per million population (Table 1a). Obalum (2009) found an incidence of 34 cases per million population in Nigeria, having made efforts to include those who included the following: age, gender, aetiology, injury characteristics, severity, complications and outcome. Rates of 7.8-20.5 per million per year are quoted in Asia. In Australia and Fiji an annual incidence of 15.4 and 18.7 per million was found between 2004-2005 and 1985-1994 respectively (Table 1a & 1b). Portugal and Western Canada had the highest reported annual incidence 57.8 and 52.5 respectively but unlike other studies included preadmission deaths. In contrast, Ireland had the lowest reported incidence of 5.3 which increased to 7.6 per year in 2001-2008 (Table 1a). Europe has a wide variation from the very low incidence of 5.3 to incidence of 57.8. In order to obtain more reliable evidence, the data were segregated for Europe in countries of Mediterranean and rest of Europe. The annual incidences between countries are shown in Table 2.

Annual incidence for the Mediterranean countries now ranged 8 to 57.8 cases of SCI per million

population. In contrast it varied between 5.3 and 34.1 cases per million population for the rest of Europe. Estonia reported incidence of 34.1. The higher incidence of SCI in Mediterranean countries was reported from increased road accidents. These results strongly suggest the necessity for implementing more effective prevention and educational programmes about road culture, aiming to change their destructive driving culture.

The highest incidence of SCI was reported for ages between 20 and 40 years. Although, there are two studies which were reported that over 50 years of age were at greatest risk. Nepal reported 26.6 percent of patients with SCI more than 50 years (Raibulet et al., 2001). In Portugal, the distribution according to age presents a bimodal curve, with the 55-74 age group was at greatest (Martins et al., 1998). Also, Divanoglou & Levi (2009) stated a mean age of 47 years with the majority of patients (28%) found between 61 to 75 years. These differences may be due to high predominance of falls which affect all age groups and lead to be the main cause of injury, while road accidents which affect the younger population stay in low level.

It has been well documented previously that men seem to be still more at risk for spinal cord injury (Wyndaele & Wyndaele, 2006; Ackery, Tator & Krassioukov,2004). This review confirms this global trend, despite geographic calculations. Africa seems to have a gender distribution (men/women) of spinal cord injury of 10:1 (Obalum et al., 2009; Gosselin & Coppotelli, 2005; Levy et al., 1998; Hart & Williams, 1994) and took to the first place with the highest predominance. Oceania has the second place with a male to female ratio of 5.5:1 (from 4:1 to 8:1) (Cripps, 2006; Maharaj, 1996; Gee & Sinha, 1982) following by Asia with a male to female ratio of 4.7:1 (from 2.5:1 to 8.3:1) (Lakhey et al., 2005; Kuptniratsaikul, 2003; Singh et al., 2003; Catz et al., 2002; Mena Quinones et al., 2002; Raibulet et al., 2001; Karacan et al., 2000; Fazlul-Hoque, Grangeon & Reed, 1999; Nak-Su, Cheen-Kyung & Won-Chul, 1999; Otom et al., 1997; Chen & Lien, 1985). Europe has a male to female ratio of 4.1:1 (range between 2.6:1 and 7:1) (Divanoglou & Levi, 2009; Knutsdottir & Thorisdottir, 2009; Rekand et al., 2009; Ahoniemi et al., 2008; O'Connor & Murray, 2006; Pagliacci et al., 2003; Van Asbeck, Post & Pangalila, 2000; Martins et al., 1998; Aung & El Masry, 1997; Exner & Meinecke, 1997; Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991; Biering-Sørensen, Pedersen & Clausen, 1990; Gjone & Nordlie, 1978-79) and America 3.45:1 (range between 2.5:1 and 4.2:1) (Pickett et al., 2006; Jackson et al., 2004; Dryden et al., 2003; Campos da Paz et al., 1992). All the studies mention male to female ratios except on study from France (Albert et al., 2005). Ravaud (2000) reported a male to female ratio of 4:1, a study which conducted in France and included only tetraplegic spinal cord injured persons. These calculations showed that the male to female ratio is greater in developing than developed countries. This predominance may be determined or influenced by the social structure, economic and cultural differences in developing countries, explained by the fact that women stay at home as housewives, while men performed high risk activities at work environment (Fazlul-Hoque, Grangeon & Reed, 1999). The majority of all studies worldwide showed a male to female ratio of approximately 3:1 to 4:1.

Table 3 shows the comparison of aetiology of traumatic spinal cord injury between continents. Literature data show that in the most studies, road accidents is the leading aetiology of TSCI rather than falls. Only three studies from Europe (Divanoglou & Levi, 2009; Ahoniemi et al., 2008; Van Asbeck, Post & Pangalila, 2000), three studies from Asia (Lakhey et al., 2005; Singh et al., 2003; Fazlul-Hoque, Grangeon & Reed, 1999) and two studies from Oceania (Maharaj, 1996; Gee & Sinha, 1982) report that falls are the most predominant aetiology of injury. Violence was the most frequent aetiology of TSCI in South Africa which estimated 56% and also in Jordan, violence was the second cause of injury with a prevalence of up to 27.8% (Otom et al., 1997). Two studies from Europe, Sweden and Iceland, report high percentages of sports related injuries including diving accounted for 17% and 21% respectively (Divanoglou & Levi, 2009; Knutsdottir & Thorisdottir, 2009). Finally, sport injuries in Fiji island accounted for 32% of all the injuries (Gee & Sinha, 1982).

SCI results in dramatic changes mainly in sensory and motor signals below the level of lesion (Biering-Sørensen et al., 2009). Injury to the cervical area of spinal cord results in tetraplegia and injury to the thoracic, lumbar and sacral areas of the cord result in paraplegia. The areas of the spinal cord most susceptible to injury are the lower cervical segments (O'Connor & Murray, 2006; Biering-Sørensen, Pedersen & Clausen,

1990) and the thoracolumbar region (Raibulet et al., 2001; Fazlul-Hoque, Grangeon & Reed, 1999). There are studies which show roughly equivalent numbers of cervical versus thoracic and lumbar injuries (Divanoglou & Levi, 2009; Cripps, 2006; Jackson et al., 2004; Raibulet et al., 2001; Nak-Su, Cheen-Kyung & Won-Chul, 1999; Biering-Sørensen, Pedersen & Clausen, 1990) and three studies from Asia which reported equivalent percentages between cervical, thoracic and lumbar injuries (Lakhey et al., 2005; Catz et al., 2002; Karacan et al., 2000).

As reviewed within our study, percentages of cervical spine injury ranged from 22 (Gee & Sinha, 1982) to 75 (Pickett et al., 2006), whereas it ranged from 10 (Pickett et al., 2006) to 63 (Hart & Williams, 1994) in the thoracic spine and from 7.8 (Martins et al., 1998) to 59.4 (Obalum et al., 2009) to the lumbar spine (Table 4). These percentages varied widely worldwide. The majority of studies, with the exception of South Africa, reported a high incidence of SCI at the cervical region. There were not differences in the variation of percentages between the studies among continents. There were few studies which provided more detailed information on the levels of SCI, such as the evaluation of upper and lower cervical injuries (Cripps et al., 2006; Pickett et al., 2006; Catz et al., 2002; Raibulet et al., 2001; Fazlul-Hoque, Grangeon & Reed, 1999). The French study focused only on the cervical SCI (Ravaund et al., 2000).

Persons with SCI are particular risk for certain types of problems in the acute and chronic phases. Immediately after admission to hospital, nursing problems become paramount (Levy et al., 1998). Late admission from SCI indicates different secondary complications (Aung & El Masry, 1997). Urinary tract infection seems to be reported as the main complication in most studies (Raibulet et al., 2001; Fazlul-Hoque, Grangeon & Reed, 1999; Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991) followed by pressure sores. Respiratory disorders related to a high injury level on spinal cord and especially in persons with tetraplegia (Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991). Hart (1994) and also Gee & Sinha (1982) reported that the main complications in patients with SCI were pressure sores. There is a significantly greater prevalence of pressure sores on admission compared to hospitalization while urolological complications are most frequent during stay in hospital (Pagliacci et al., 2003).

According to hospitalization, the duration of stay is differentiated as the initial admission in the surgery department and admission to the initial rehabilitation period as well as readmission to the initial rehabilitation clinic (Raibulet et al., 2001). The length of stay was significantly associated with the severity and level of injury (Pickett et al., 2006), patients with complete SCI were hospitalised for longer periods than those with incomplete injury and the average stay in hospital was also longer for those with cervical injury than those with thoracolumbar injury (Biering-Sørensen, Pedersen & Clausen, 1990).

The mean length of stay in acute care institution, for people with TSCI, varies from 15 days (Dryden et al., 2003) to 64.37 days in a surgery department (Raibulet et al., 2001). It is difficult to compare the length of hospitalization between countries and grouped all together because of the different system of admission. Although, the duration of hospitalization varied widely from 30.9 days (Van Asbeck, Post & Pangalila, 2000) to 539 days (Martins et al., 1998). Patients with at least one medical complication on admission have a significantly longer stay than patients with complete injury and cervical injury (Pagliacci et al., 2003). Also, the long hospital stay may be due to the incorporation of acute, sub acute and chronic care in the hospitalization.

The goal of rehabilitation is to prevent medical complications and maximize the functional capability of the people with SCI, ultimately improving their quality of life. For this reason, in the first instance rehabilitation has to be started by the medical doctor who slowly built up a team of concerned people (Levy et al., 1998). Rehabilitation following SCI is more effectively undertaken with a multidisciplinary, team-based approach. Physiotherapist, occupational therapist, rehabilitation nurses, psychologists, speech language pathologists, social workers and doctors is intensive for the management of SCI person during the first month post injury (Van Langeveld et al., 2009; Burt, 2004).

The development of prevention programs could decrease the incidence of SCI, especially in countries without the suitable education. In Africa countries such as Nigeria and Zimbabwe (Obalum et al., 2009; Levy et al., 1998), where road accidents are highly prevalent aetiology of SCI, the reinforcement of use of seat belts as well as laws could have a beneficial effect. In Eastern Nepal education about the risks of trekking in high altitude could also have beneficial results in

order to prevent falls (Lakhey et al., 2005). It is of great importance the education about prevention measures in high altitude activities. In addition, education in elderly population about the risk of falls could also have the same beneficial results (Pickett et al., 2006; Martins et al., 1998; Garcia-Reneses, Herruzo-Cabrera & Martinez-Moreno, 1991). In this population, the learning of the correct way of move is fundamental importance. Finally, sports, recreational activities and especially diving cause SCI in young population. Many countries must recognize the need of educational programs and awareness campaigns in sports-related SCI in order to reduce high incidences of SCI (Divanoglou & Levi, 2009; Knutsdottir & Thorisdottir, 2009; Cripps, 2006; Jackson et al., 2004; Exner & Meinecke, 1997; Maharaj, 1996).

Thirty seven manuscripts were found and evaluated during the preparation of this review in order to create a worldwide perspective on the epidemiology of traumatic spinal cord injury. Although the selected manuscripts that contained epidemiological data of traumatic spinal cord injury, the majority of the studies also addressed other aspects of spinal cord injury such as secondary complications and therapeutic approaches. Prevention measures should be focused mainly on these types of trauma (road accidents, falls, sports) in order to reduce the frequencies of SCI.

Finally, it was recommended that manuscripts of international incidence reports should at least include data from defined geographical area for each country, age, gender, neurological level and completeness of injury and aetiology of injury. Comparisons between epidemiological studies of traumatic spinal cord injuries and correlations of the results are problematic and difficult because of the lack of international uniformity in methodology and data collection. This survey shows the need for improved registration of spinal cord injury and the need for publication of the findings in many countries of the world.

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Table 1a: Comparative analysis of traumatic spinal cord injury in different countries of the world

Country	*Reference*	*Years*	*Num. of patients*	*Mean age (years)*	*Incidence per million people*	*Male to female ratio*
America						
United States	**Jackson et al.-Arch Phys Med Rehab (2004)**	**1973-2003**	**30,532**	**33.3**	**Not mentioned**	**4.2 to 1**
Western Canada	**Dryden et al.-Can J Neurol Sci (2003)**	**1997-2000**	**450**	**35 (median)**	**52.5**	**2.5 to 1**
Eastern Canada	**Pickett et al.-Spine (2006)**	**1997-2001**	**151**	**42.2**	**41.8 aged 15-64**	**3 to 1**
Brazil	**Campos da Paz et al.-Paraplegia (1992)**	**1988**	**108**	**30.3**	**Not mentioned**	**4.1 to 1**
Europe						
Portugal	**Martins et al.-Spinal Cord (1998)**	**1989-1992**	**398**	**50.5**	**57.8**	**3.4 to 1**
Italy	**Pagliacci et al.-Arch Phys Med Rehabil (2003)**	**1997-1999**	**581**	**38.5**	**18-20**	**4 to1**
Germany	**Exner and Meinecke-Spinal Cord (1997)**	**1976-1996**	**16,659**	**Not mentioned**	**Not mentioned**	**2.6 to 1**
United Kingdom	**Aung and El Masry-Spinal Cord (1997)**	**1985-1988**	**219**	**Male 35.5, female 44.2**	**Not mentioned**	**3.76 to 1**
France	**Albert et al.-Spinal Cord (2005)**	**2000**	**793**	**Not mentioned**	**19.4**	**Not mentioned**
The Netherlands	**Van Asbeck et al.-Spinal Cord (2000)**	**1994**	**113**	**Majority aged 21-30**	**10.4**	**3.3 to 1**
Denmark	**Biering-Sørensen et al.-Paraplegia (1990)**	**1975-1984**	**268**	**Majority aged 15-24**	**9.2**	**3.3 to 1**
Spain	**Garcia-Reneses et al.-Paraplegia (1991)**	**1984-1985**	**616**	**41.8**	**8**	**2.6 to 1**
Norway	**Gjone and Nordlie-Paraplegia (1978-79)**	**1974-1975**	**131**	**37**	**16.5**	**4.9 to 1**
Finland	**Ahoniemi et al.-Spinal Cord (2008)**	**1976-2005**	**1,647**	**Male 42.4, female 40.4**	**13.8**	**4.8 to 1**
Ireland	**O'Connor and Murray-Spinal Cord (2005)**	**2000**	**46**	**37 (median)**	**13.1**	**6.6 to 1**
Greece	**Divanoglou and Levi-Spinal Cord (2009)**	**Sep 2006(1year)**	**81**	**43**	**33.6**	**7 to 1**
Sweden	**Divanoglou and Levi-Spinal Cord (2009)**	**Sep 2006(1year)**	**47**	**47**	**19.6**	**3 to 1**
Estonia	**Rekand et al.-48th ISCoS (2009)**	**2003-2007**	**191**	**Male 37.8, female 43.3**	**34.1**	**4.9 to 1**
Iceland	**Knutsdottir and Thorisdottir-48th ISCoS (2009)**	**1973-2008**	**191**	**37**	**5.3**	**2.7 to 1**
Africa						
Zimbabwe	**Levy et al.-Spinal Cord (1998)**	**1988-1994**	**136**	**Majority aged 20-40**	**Not mentioned**	**8.1 to 1**
Sierra Leone	**Gosselin and Coppotelli-Int Orthop (2005)**	**2002-2004**	**24**	**30**	**Not mentioned**	**11 to 1**
Nigeria	**Obalum et al.-Spinal Cord (2009)**	**1992-2006**	**468**	**Majority aged 20-40**	**34**	**2.34 to 1**
South Africa	**Hart and Williams-Paraplegia (1994)**	**1988-1993**	**616**	**Majority aged 20-29**	**Not mentioned**	**4 to 1**
Asia						
Turkey	**Karacan et al.-Spinal Cord (2000)**	**1992**	**684**	**35.5**	**12.7**	**2.5 to 1**

Table 1b: Comparative analysis of traumatic spinal cord injury in different countries of the world

Country	*Reference*	*Years*	*Num. of patients*	*Mean age (years)*	*Incidence per million people*	*Male to female ratio*
Kuwait	**Raibulet et al.-Kuw Med J (2001)**	**1991-1999**	**90**	**20.6**	**7.8**	**7.2 to 1**
Thailand	**Kuptniratsaikul-J Med Assoc Thai (2003)**	**1997-2000**	**83**	**33.2**	**Not mentioned**	**3.9 to 1**
Nepal	**Lakhey et al.-Trop Doct (2005)**	**1997-2001**	**233**	**Majority aged 50+**	**Not mentioned**	**2.6 to 1**
Taiwan	**Chen and Lien-Paraplegia (1985)**	**1978-1981**	**560**	**Male 36.3, female 33.7**	**14.6**	**4.9 to 1**
Israel	**Catz et al.-Spinal Cord (2002)**	**1959-1992**	**250**	**34.5**	**Not mentioned**	**3.1 to 1**
Jordan	**Otom et al.-Spinal Cord (1997)**	**1993**	**151**	**33**	**18**	**5.8 to 1**
Bangladesh	**Fazlul-Hoque et al.-Spinal Cord (1999)**	**1994-1995**	**179**	**Majority aged 20-30**	**Not mentioned**	**7.5 to 1**
India	**Singh et al.-Ind J Comm Med (2003)**	**2000-2001**	**483**	**35.4**	**Not mentioned**	**2.96 to 1**
Qatar	**Mena Quinones et al.-Mid East J Emerg Med (2002)**	**1987-1996**	**75**	**32.3**	**12.5**	**8.3 to 1**
South Korea	**Nak-Su et al.-Kautpt (1999)**	**1995**	**204**	**Majority aged 40th years**	**20.5**	**3.5 to 1**
Oceania						
Australia	**Cripps-Inj Res Stat (2006)**	**2004-2005**	**251**	**Majority aged 15-24**	**15.4**	**4.5 to 1**
Papua New Guine	**Gee and Sinha-PNG Med J (1982)**	**1978-1981**	**36**	**26**	**Not mentioned**	**8 to 1**
Fiji	**Maharaj-Spinal Cord (1996)**	**1985-1994**	**75**	**Majority aged 16-30**	**18.7**	**4 to 1**

Table 2: Segregation of Europe

	Countries	*Incidence*
Mediterr	**Greece, Divanoglou and Levi-Spinal Cord (2009)**	**33.6**
	Italy, Pagliacci et al.-Arch Phys Med Rehabil (2003)	**18-20**
	France, Albert et al.-Spinal Cord (2005)	**19.4**
	Spain, Garcia-Reneses et al.-Paraplegia (1991)	**8**
	Portugal, Martins et al.-Spinal Cord (1998)	**57.8**
Rest of Europe	**The Netherlands, Van Asbeck et al.-Spinal Cord (2000)**	**10.4**
	Denmark, Biering-Sørensen et al.-Paraplegia (1990)	**9.2**
	Norway, Gjone and Nordlie-Paraplegia (1978-79)	**16.5**
	Sweden, Divanoglou and Levi-Spinal Cord (2009)	**19.6**
	Finland, Ahoniemi et al.-Spinal Cord (2008)	**13.8**
	Ireland, O'Connor and Murray-Spinal Cord (2005)	**13.1**
	Iceland, Knutsdottir and Thorisdottir-48th ISCoS (2009)	**5.3**
	Estonia, Rekand et al.-48th ISCoS (2009)	**34.1**

Table 3: Comparison of aetiology of TSCI between continents

	Country	RA	Fall	Violence	Sport		Country	RA	Fall	Violence	Sport
America	United States	45.6	19.6	17.8	10.7	Africa	Zimbabwe	56	11	15	-
	Canada	35-56.4	19.1-31	5	11.3		Sierra Leone	50	41.7	-	-
	Brazil	42	15	27.9	-		Nigeria	77.4	9.4	11.1	1.7
Europe	Portugal	57.3	37.4	-	-		South Africa	25	2.5	56	-
	Italy	53.8	22.6	1.9	7.9	Asia	Turkey	48.8	36.5	5.2	1.2
	Germany	46.2	6.5	1.4	10.3		Kuwait	63.3	16.9	8.4	-
	United Kingdom	50.2	42.5	-	7.3		Thailand	74.7	16.9	8.4	-
	The Netherlands	31	48.7	-	8.9		Nepal	6.9	77.6	-	-
	Denmark	47	34	2	12		Taiwan	44.5	29.9	2.7	3.4
	Spain	52.2	27.4	3.2	3.2		Israel	32.8	30.4	10.4	
	Finland	39.5	41.2	2.7	6.6		Jordan	44.4	21.9	27.8	2.6
	Ireland	50	37	-	9		Bangladesh	18	43	6	
	Greece	51	37	2	4		India	34.7	44.5	2.7	3.9
	Sweden	23	47	2	17		Qatar	72	13.3	-	-
	Estonia	-	42	-	-		South Korea	42.2	39.2		
	Iceland	44	31	-	21	Oceania	Australia	49	29	10	9
							Papua New Guinea	34	40	6	6
							Fiji	25.3	38.7	-	32

Abbreviations: TSCI = traumatic spinal cord injury; Numbers uppercase right from the countries cite reference number; RA = road accidents; All the number represent percentages (%).

Table 4: Number of TSCI by level of injury

	Country	Cervical	Thoracic	Lumbar
America	United States	54.1	45.9	
	Canada	61.5-75	17.3-10	17.1-9
Europe	Portugal	51.2	41	7.8
	Italy	43.3	56.7	
	Germany	38	62	
	United Kingdom	53	33.3	13.7
	The Netherlands	57.5	42.5	
	Denmark	51	49	
	Spain*	38	34	16
	Finland	50.6	49.4	
	Ireland	50	41	9
	Greece	48	52	
	Sweden	45	55	
	Norway	53	26	12
Africa	Zimbabwe	51	49	
	Sierra Leone	29.4	70.6	
	Nigeria	30.3	10.3	59.4
	South Africa	25	63	12
Asia	Turkey	31.8	26.6	28.1
	Kuwait	43.98	56.02	
	Thailand	25.3	74.7	
	Nepal	37.8	30	30.9
	Taiwan	46.8	53.2	
	Israel	36.4	32.4	31.2
	Jordan	31.8	68.2	
	Bangladesh	40	60	
	India	34	59	
	Qatar	57.3	42.7	
	South Korea	63.2	21.1	15.7
Oceania	Australia	51.8	37	10
	Papua New Guinea	22	78	
	Fiji*	31	69	

Abbreviations: TSCI = traumatic spinal cord injury; Numbers uppercase right from the countries cite reference number; * regarding traumatic and non-traumatic aetiology; All the number represent percentages (%); Injuries refer as tetraplegia grouped as cervical injuries and injuries refer as paraplegia grouped as thoracic and lumbar injuries.

Figure 1: Incidence of new traumatic spinal cord injury cases by country