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Epidemiology of Traumatic Spinal Cord Injury: A SAARC Perspective

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Abstract:

Background: This review is undertaken for an insight into the shadowy area of demography, incidence, prevalence as well as injury mechanisms associated with traumatic spinal cord injuries. Its main focus is on the data of developing worlds like India and other South Asian countries.

Material and method: Online literature search was undertaken in PUBMED library and PLOS ONE library with the key words "spinal cord injury (SCI) epidemiology, demography, mechanism of injury" etc. Journals with significant epidemiological information were selected. Articles from the Journal of Spinal Cord Medicine comprised the larger part of the information generated. One article from Journal of Association of Physicians of India was also selected.

However our main focus was on developing countries, but United States data was also reviewed from the latest publication of the National Spinal Cord Injury Statistical Center, Birmingham, Alabama. Few articles were selected from Indian Journal of Neurotrauma (IJNT), The Journal of the Norwegian Medical Association, Disability, CBR and Inclusive Development Journal, ASIA Pacific. This review strictly focused on demography, incidence, prevalence as well as injury mechanisms. A special publication from WHO was also taken into consideration.

Result and conclusion: Global prevalence rates of traumatic SCI varied from approximately 200 to 1000 per million and data on incidence varied from approximately 15 to 50 per million. The major cause of injury (leading etiology) in developed world is due to motor vehicle accidents when compared to two-wheeled accidents (e.g. motorcycles, scooters) which are predominant in Southeast Asia. Fall from height is the most common injury etiology in Southern Asia. Falls on level ground are an important injury etiology in regions with older populations, such as Japan and Western Europe. Traumatic SCI due to violence is more common in the regions of sub- Saharan Africa and Middle East. Gender involvement in spinal injuries reveals men are more prone to SCI. This is questionable as males to female gender ratios vary considerably in these regions; for example 1.73 in China to 7.55 in Pakistan, 0.9 in Taiwan, 12.0 in Nigeria to 13.5 in India. The average age at the time of injury varies from 26.8 years in Turkey to 55.5 years in the USA.

Indian estimates suggest incidence around 15-20 per million per year population. The commonest mode of injury is fall from height followed by weight turnover, hit by an animal, fire arm injuries and road traffic accidents. Overall the worldwide epidemiological data shows big geographical differences in incidence, prevalence and mechanism of spinal injury.

In all spinal trauma cases in developing countries, almost 90% people do not receive any primary medical care and pre hospital first aid during transportation to big hospital. Ambulances were used in very minimal 15% of cases. 33% cases of spinal cord trauma died within 1 year and 90% amongst them died enroute to the first hospital because of improper first onsite care and bad handling of transportation. Proper emergency care in developed world could decrease mortality from 33% to 4.2% and it reduced incidence of complete injuries from 62% to 1%.

Keywords: Traumatic Spinal Cord Injury, Paraplegia, Epidemiology, Demography, South Asian Association for Regional Cooperation (SAARC) countries.

Study Area: Traumatic Spinal cord injury.

Introduction:

Traumatic world of spinal cord injury (SCI) encompasses a great deal of misery due to disability for patients and their caregivers. This is due to the helplessness of medical fraternity for not being able to cure, carelessness of social sectors for not thinking of preventive, poor rehabilitative aspects and dilemma of researchers of not having exact epidemiological and pathological information. In order to fight with this dreaded situation, a deep understanding of its various aspects like management issues, complications, new developments etc is essential. One must remember that all the planning and investment of government for this disease depends on how well the epidemiological data has been collected. A correct demography will through light on its intensity, gravity and requirement of intensifying the management and research in that particular society.

World epidemiological data:

Reliable epidemiological data from developing world for traumatic SCI is scarcely reported **[1]**. The data from developed countries shows that incidence, prevalence, and mode of injury differ from region to region **[2, 3, 37]**. In the developed world, annual incidence of traumatic spinal cord injuries varies from 2.3 per million (as reported in a study from Canada) to 83 per million (in Alaska) [**9, 36, 37]**. According to a worldwide epidemiological study on spinal cord injury by Cripps et al. (2014) incidence in the North America was 39 per million, in the Western Europe 16 per million, and in Australia 15 per million, where four wheeled motor vehicle accidents are the leading etiology [**16, 9, 36, 37]**. Another study by Jackson AB, Dijkers M, et al. (2004) on new traumatic spinal cord injuries over 30 years revealed that incidence-prevalence of spinal injuries has been continuously on the rise with the incidence rate climbing up from 15 to 40 cases per million worldwide [**38]**. A study done by Fujieda et al. (2012) reported that in whole world incidence of SCI lies between 10 to 80 persons per million [**6]**.

It has been observed that the prevalence data has large variation over the continents with different authors reporting varying ranges. Prevalence ranged from 236 per million in India to 1800 per million in the USA [**9]**. Cripps et al. (2014) reported global prevalence rates ranging from 236 to 1009 per million [**16]**. Furlan JC, Krassioukov A et al. (2012) in the Spinal Cord Injury Rehabilitation Evidence calculated the prevalence of traumatic SCI varying from 50 to 906 cases per million populations worldwide **[14]**. In Sweden and Finland, prevalence was 227 and 280 individuals per million, respectively. Based on data from Nepal and India, the prevalence of ASCI (Acute Spinal Cord Injury) was 92.5 and 849.8 cases per million (Razdan et al. 1994; Lakhey et al. 2005), while in Australia, O'Connor et al. (2005) documented a prevalence of 681 individuals with traumatic SCI per million. In more recent studies, Correa et al. (2011) documented 112 cases per million populations in Chile, and Hagen et al. (2010) reported 35.1 to 41.9 cases per 1,00,000 populations in Norway [**7, 14, 15]**.

US epidemiological data:

As per US epidemiological data in the publication of National Spinal Cord Injury Statistical Center, Birmingham, Alabama in February 2013, the annual incidence of spinal cord injury (SCI) is approximately 40 cases per million population in the U. S. and approximately 12,000 new cases each year. The prevalence of SCI has been estimated to be approximately 273,000 persons in 2013, with a range of 238,000 to 332,000 persons. The National Spinal Cord Injury Database estimated 13% of new SCI cases in the U.S. since its inception in 1973 [**4, 22].**

South Asia epidemiological data:

In the developing countries like India, Pakistan, Bangladesh etc. there is an absence of national spinal injury programs or SCI registries resulting to population based data on SCI unavailability. A study by Thanni and Kehinde (2006) revealed that hospitals and nursing homes are unable to maintain proper medical records of cases for various reasons that are why researchers are not able to collect true data. It is clear from the studies by Chacko et al. (1986), Rathore et al. (2008) that the data which is available are just single center hospital based surveys representing far less than true picture of South Asia. Pre hospital trauma care, first aid at site and infrastructure for transport of spinal trauma patients are inadequate in larger regions of the South Asia [**7, 9, 25, 33, 34]**.

Bangaladesh is an underdeveloped, densely populated developing country in Asia, with 964 persons per square km (Bangladesh Bureau of Statistics, 2011) where people live in miserable conditions like buildings are unfit for human habitation by reason of overcrowding, faulty design of such buildings, narrowness or faulty streets, lack of ventilation, light, sanitation facilities etc [**28, 29]**. This makes these poor people vulnerable for traumatic spinal injuries. Although the magnitude of disease is high in Bangladesh but the proper demography data is not available. In Bangladesh one small institutional study by Hoque et al. (January 1994 to June 1995) studied 247 patients with spinal cord lesions and reviewed retrospectively **[30]**. In another study from the same place 407 persons with SCI were admitted between July 2011-June 2012 (CRP, 2012) [**8]**.

A study performed in Pakistan states that annual incidence of spinal column injuries ranges from 19-88/100,000 and prevalence is 480-813 per million. In another study done in various neurosurgical centers in Pakistan from July 1, 1995 to June 30, 1999 [Raja and Vohra et al. (2001)] 260,000 patients were admitted over a 4-year period of brain and spinal trauma **[26]**.

Lakhey S et al. (2005) have done a retrospective case study of 233 spinal injury patients admitted to the orthopaedic ward of BPKIHS, Nepal from May 1997 to April 2001. Bajracharya et al. (2007) have done an epidemiological study of spinal injuries in a predominantly rural population of eastern Nepal between 1996–2005 where details of 896 patients of spinal injury were recorded in the 10-year period of review **[14, 27, 31]**. As per information provided by European federation, demographic data gathered in Sri Lanka found approximately 1500 people suffer from SCIs annually **[34]**. As no population survey regarding this injury has been done,

literature lacks this data. The data is randomly available from the fewer studies conducted in South Asia.

Indian epidemiological data:

The WHO Global Burden of Disease Study predicts that trauma by road traffic injury will become the third ranked most disabling condition by 2020. As per report of the International Conference [Spinal Injuries Management, New Delhi, (1995)], the incidence of spinal injury was estimated at 15 new cases per million per year in India. This translates into 15,000 new cases per year and with a backlog of ten years, the prevalence exceeds 0.15 million. As per WHO estimates, the incidence of this disease is on the rise in developing countries like Brazil, China, Pakistan and India [**17, 19, 36, 34]**.

In India estimated incidence is 20 per million per year populations. Singh R et al. (2003) in an epidemiological study mention that approximately 20,000 new cases of SCI are added every year; 60-70% of them were illiterate, poor villagers [**17]**.

The mode of injury in India causing ASCI in a study conducted by Singh R et al. (2003) showed that fall from trees or roof constitute around 45% of ASCI followed by road traffic accidents (35%). These were accidental and could have been easily avoided. There are multiple small studies conducted to reveal similar results of ASCI, where fall from height is the commonest cause and this have been reported also by Bidre et al. (2007), Chako et al. and Shanmugasundaram (1986) [**14, 25]**. A list of most of the demographic epidemiological data related to SCI has been listed in **table below.**

Table: Summary of epidemiological data of SAARC countries.

	Ref. no.	**Data resource /Author/ Institute**	**Year of Publica-tion**	**Inciden-ce Data (per million)**	**Prevalence Data (per million)**	**Age (years)**	**Most commo-n Gender**	**Most common Mode of injury**
World	37	WHO & ISCI	2013	13 to 53	280 to 1298	20-40	male	Road traffic injuries
U.S.	4	NSCI Statistical Center, Alabama	2013	40	238 to 332	42.6	80.7% males	Vehicle crashes 36.5%
South Asia	12	Tidsskr Nor Laegeforen, Journal of Norway	2012	_	236	28.3 – 32.8	M:F ratio 1.8 – 7.6	Falls from a large height
India	12	Tidsskr Nor Laegeforen, Journal of Norway	2012	20	236	20-50	--	Fall from height 44.3 %

	32, 9, 36, 37	Lalwani *et al*., Indian J Med Res (single center study)	2014	_	_	25-64	84.5% males	Vehicle injury
		Chacko et al. Paraplegia (single center study)	1986	_	125 cases Studied	30-40	92.6% were men	Fall from height
		Singh et al. Indian J Community Med. (single center study)	2003	20	483 cases (year 2000-2001)	35.4	Men	Fall from height
		Agarwal et al., Spinal Cord (single center study)	2007	_	107 cases during 2003-2004	_	Men 83.4%	Fall from height
		Pandey et al., Indian J Orthop (single center study)	2007	_	60 cases (2005 and 2006)	Mean age was 34	85% were men	48.3% Fall from height
Pakistan	32	Rathore et al., Prospective, single rehabilitation Center	2006	_	83 cases	29.3 ± 12.4	M:F 4.5:1	Fall from height
	32	Raja et al., Retrospective multicenter	1995–1999	_	2,654 cases	21–30	2.6:1	Fall from height
Bangla-desh	30	Hoque et al., Retrospective, rehabilitation center	1994–1995	_	179 cases	20–30	7.5:1	_
Nepal	12	Lakhey et al., Retrospective, Orthopedic department	1997–2001	_	233 cases	20-50	2.6:1	Fall from height
	32, 9, 36, 37	Bajracharya S. et al., Indian J Orthop. 2007 (B. P. Koirala Institute of Health Sciences)	1996-2005	_	896 patients in the 10-year period of review	41.74 ± 16.53	76.35% male	Fall from height 39%

Age at injury:

The average age at the time of injury varies from 26.8 years in a study from Turkey to 55.5 years in Oklahoma, USA. There is a trend of increase in average age at the time of injury in recent decades. In the National Spinal Cord Injury Statistical Centre Database (US), the average age at the time of injury was 29 years in 1970 and 37 years in 2005 [**12**, **13]**. A study conducted in Bangladesh (2013) on 56 ASCI participants; mean age at injury was 33.02±13.5 years (range: 13–70 years). The age distribution peaked at the 16-30 years group which accounted for 46.43%. Children comprised 5.4% of the participants [**8]**. In one small institutional study [Hoque et al. (2012)] three-fourths (75%) of the injured were in the economically productive age group of 16-30 and 31-45 years [**30]**. A study undertaken in China reported that the average age at the time of Traumatic spinal cord injury (TSCI) ranged from 26.8 to

56.6 years. In the study fifteen reports on data of TSCI epidemiology from 16 Asian regions determined that the average age is less than 35 years **(36)**. A hospital-based study on spinal injury cases from India calculated maximum number of patients was in the age range of 20–39 years [**5**, **12, 36, 37]**. Study from All India Institute of Medical Sciences, New Delhi, India showed that among patients with spinal injuries 40.9% of them were in the third decade [**19]**. A recent WHO report said that the SCI incidence rate peaks in young adulthood and, to a lesser extent, in old age. As reported, while young males dominate the statistics, profile is in a changing state and will include older people and more women. Overall, age at time of injury was increasing [**13, 36, 37]**.

Gender:

The world health organization (WHO) has previously predicted that men are more prone to SCI in all countries, although the reported gender ratios vary considerably-1.73 in china to 7.55 in Pakistan **[10]**. Review by Guang-Zhi Ning et al. (2012) from china explained 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. In Taiwan, the gender ratio was 4.9:1 during 1978–1981 and 2.75:1 in 2002–2003. In Thailand, incidence rate was 11.1 times higher in men between 1985 and 1991, but only 5.6 times higher during 1989–1994 [**31, 36, 37]**.

In studies from Taiwan and Iran, spinal cord injuries occurred with equal frequency among both genders. The largest preponderance of men was found in studies from Sierra Leone in Nigeria (ratio 11 – 12: 1). The three studies from Norway show a male/female ratio of 4.7 to 5.0: 1 [**13, 35, 9]**. A study in US in 2013 revealed overall 80.7% of SCIs reported to the national database occurred among males [**4]**. In a study from Bangladesh in 2013 of the 56 participants, 84.0% were male and 16.0% were female [**8, 28, 29, 30]**. In one small institutional study, Hoque et al. (2012) found that males (84%) are predominantly affected by TSCI **[28, 29, 30]**. A study done in various neurosurgical centers in Pakistan from July 1, 1995 to June 30, 1999 [Raja and Vohra et al. (2001)] reported 1922 males (72%) and 732 (28%) females **[26]**.

A retrospective study in All India Institute of Medical Sciences India from January 1990 to May 2000 showed that among 440 patients with spinal injuries, females comprised 17.95% while 82.04% were males (M:F. 4.58:1) [**20]**.

Etiology:

SCI is primarily a disease of the young males. Motor vehicle accidents are the leading cause of death in the developed countries followed by falls [Divanoglou and Levi (2009)]. The reverse is true for most of the developing countries [Chacko et al. (1986), Maharaj (1996), Singh et al. (2003), Rathore et al. (2008)] [**7, 27]**.

Publication of national SCI statistical center, Birmingham, Alabama, US in 2013 revealed since 2010, motor vehicle crashes accounted for 36.5% of reported SCI cases. The next most common cause of SCI was falls, followed by acts of violence

(primarily gunshot wounds). The proportion of injuries due to sports decreased over time while the proportion of injuries due to falls increased. Violence caused 13.3% of SCIs prior to 1980, and peaked between 1990 and 1999 at 24.8% before declining to only 14.3% since 2010 [**2, 4]**.

Whereas, four wheeled motor vehicle accidents was the leading etiology in developed countries, two-wheeled accidents (e.g. motorcycles) predominated in Southeast Asia and falls from roof tops and trees were the most common injury etiology in Southern Asia and Oceania. Falls on level ground were an important injury etiology in regions with older populations, such as Japan (42%) and Western Europe (37%). Violence was a frequent cause of traumatic SCIs in South Africa, where it accounts for 61–62 % of the cases, whereas all studies from Europe reported less than 5% – with the exception of Greenland, where violence was the cause in 11% of the cases [**33**, **13, 15]**. TSCI due to violence was more common in the developing regions of sub- Saharan Africa (38%), North Africa/Middle East (24%), Latin America (22%) and North America (15%) having relatively high rates when compared with similar resource-rich, developed regions [**12, 9]**.

In most countries, road traffic accidents are the most common mechanism. The largest proportion was observed in West Africa and Nigeria at 89 % [**15]**. The lowest proportions were found in Greenland, at 4 % as well as in India, Pakistan and Nepal at around 7 %. Falls account for the other main mechanism of TSCIs. These included a broad range of incidents, from falls from a large height at the workplace or with suicidal intent, to patients slipping on the bathroom floor in their own homes. The lowest proportion is reported from South Africa at 3 % and the highest from Pakistan and Nepal both at 82 %. In Western Norway, the most frequent mechanisms of injury were falls (45.5 %) and traffic accidents (34.2 %).

In India with developing infrastructure, economy and social status around 45% cases of ASCI occurred because of fall from top of trees or roof or electricity pole or terraces followed by road traffic accidents (35%) as reported in a study conducted by Singh R et al. (2003) **(17)**. Similar results of ASCI where fall from height is the commonest cause have been reported by Bidre et al. (2007), Chako et al. and Shanmugasundaram, (1988) **[24, 25]**.

In Bangladesh the leading causes of injury were falls, accounting for 50% of the injured. This included low falls (<1 m) for 10.7%, high falls (1-5m) for 7.1%, and high energy falls (>5 m) for 82.2%. High energy falls consisted of falls from trees (64.3%), from roofs (12.2%), and from electric poles/construction work (23.5%). Road traffic accidents (RTA) were the second most common cause of TSCI at 23.2%, while carrying loads on the head was next at 12.5% [**8]**.

The fall from height could be due to fall from un-protected terrace, tree, electricity pole, well, overloaded bullock carts/ tractor /buses/ trucks/ trains/ other vehicle, construction site etc. Road traffic accidents were the second or third most common mode of injury and are on the increase **[3, 14]**.

In a study by Nobunaga et al. significant trends in changing demographics were observed. These included older ages at the time of injury, increasing proportions of injuries occurring in the racial and ethnic minority populations, and decreasing proportions of injuries because of motor vehicle crashes and sports [**5, 9, 36]**.

State of onsite emergency care and transfer to hospital:

The importance of onsite emergency medical care has been discussed widely. The data of western world reveals that in the 7th decade of 20th century, 33% cases of spinal cord trauma died within 1 year and 90% amongst them died enroute to the first hospital because of improper first onsite care and bad handling of transportation. This enlightens a lot about first medical care at first contact point. Proper emergency care could decrease mortality from 33% to 4.2% and it reduced incidence of complete injuries from 62% in 1972 to 1% in 1986 [**3**, **11, 37]**. Shooman and Rushambuza (2009) suggested that immobilization and log roll of a suspected SCI patient at the trauma site is of vital importance as it prevents further neurological deterioration and cord compression. Spinal boards were not available in poor countries. Spinal board has been developed as the standard of care in the developed world for evacuation and transport of a SCI patient [**10**, **22**, **35]**. Pre Hospital trauma care, first aid at site and infrastructure for transport of spinal trauma patients were negligible in most of the developing countries. Ambulance services, if any, were available in major cities only. Most of the patients were initially managed by the bystanders, with no training in first aid. All kind of transports (including buses, auto rickshaws, jeeps, carts, homemade hammocks and even animal backs) totally unsuitable for transport of a suspected SCI patient are used [Singh et al. (2003), Shrestha et al. (2007), Rathore et al. (2008)]. In many instances spinal immobilization and log roll was not performed even by the ambulance staff [Rathore et al. (2008)] [**7**, **16]**. Requirement comprised properly trained paramedical boys and girls who could give at least first aid and properly carryout the evacuation to the nearest capable hospital using an appropriate mode of transport. Requirement of adequate number of fully equipped ambulances round the clock on behalf of government was a necessity [**21]**.

Harrop JS et al. (2014) published an article in Neurosurgery which analyzed whether the diagnosis of spinal trauma affected patient transfer timing and patterns. The Pennsylvania Trauma database was retrospectively reviewed. One thousand one hundred sixty-two trauma patients were identified (1014 blunt injuries, 135 penetrating injuries and 12 other), with a mean transport time of 3.9 hours and a majority of patients arriving within 7 hours (>75%). Spine trauma patients had the longest mean arrival time (5.2 hours) most trauma patients arrived to a specialty center within 7 hours of injury. They suggested that 'earlier intervention may bring improved recovery' [**22]**. Around the same time another important study was done on Korean people by Kim JG et al. (2014 published in Ann Rehabil Med.) with the aim to investigate the accessibility of medical services for Korean people with SCI and to evaluate significantly related factors. Result showed that 16.5% patients in the SCI group had difficulties receiving medical services due to a lack of accessibility. Variables causing difficulties receiving medical services were lack of transportation (45%), lack of finances (40%), and difficulty scheduling hospital appointments (15%) in the SCI group [**23]**.

In India a study by Singh PK et al. published in Rural and Remote Health in 2011 reported that in SCI the method of the trauma, type of transportation, time taken to reach hospital and the resource level of the place of treatment chiefly determine SCI outcome. Limited resources and access to health care were found as

major challenges for SCI patients in rural India **[17]**. Rapid development of modern India has brought lifestyle changes in rural areas also, for instance an improvement in road infrastructure has increased vehicular accidents. It is estimated (Singh et al. 2011) that of 2 million hospitalizations and 7.7 million minor injuries, 6% of patients will have an SCI. Approximately 20% patients are reported to die before arrival at the hospital. These results reveals a gruesome truth of our health infrastructure in all spinal trauma cases studied here; almost 90 % people do not receive any primary medical care, pre hospital first aid during transportation to big hospital. Ambulances were used in very minimal 15% of cases. Even though it is crystal clear that transportation carelessness and time lost in hospital arrival destroys the patient's future survival still mean injury to hospital arrival time was found to be 75 hours **[24, 19, 25, 33]**.

Conclusion:

Worldwide road traffic accidents are the most common cause of spinal injuries. World prevalence of ASCI varies from 200 to 1000 per million and incidence of SCI lies between 10 to 100 persons per million populations. ASCI is going to be the biggest injury hazard in the future as world is developing so there are more buildings to be constructed, more cars on roads, traffic chaos, more population, more violence etc It is very important to form a world consensus on management of accidental injuries primarily spinal and brain injuries. India is having prevalence at range of 15,000-20,000 new cases per year and incidence at range of 20 per million per year population; the cause of injury being most commonly fall from height followed by road traffic accidents. Developing countries like India needs to solve the problem of both the prevailing and emerging trauma-care systems. A state-wide trauma-care system is urgently needed, including dedicated rural pre-hospital and SCI services. An SCI registry should also be developed to monitor the system and provide cost and epidemiological statistics.

It is also very important to make proper guidelines for triage of such patients and training of medical individual's. Identification of local problems in transportation and care is also taken in to consideration. In US and other developed nations there are proper guidelines of transportation and triage. There are also specialized spinal trauma center, they are trying to improve there already existing system of initial care. However, India and other developing countries lack even proper guidelines to tackle such situation. It is also important to focus on improvement of the transportation triage system for traumatic spinal patients. People with SCI in poor countries experienced limited accessibility to medical services, which was due to environmental as well as personal factors like lack of transportation, lack of finances, unavailability of hospital, untrained medical personal compared to that in developed countries. Therefore, development of social policies to reduce or rectify these problems is absolutely necessary.

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