Epidemiology of Traumatic Spinal Cord Injury in Developing Countries: A Systematic Review

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Key Words

Spinal cord injury · Developing countries · Incidence · Epidemiology · Etiology

Abstract

Background/Aims: To describe the epidemiology of spinal cord injury (SCI) in the developing world. **Methods:** Developing countries were selected based on the definition proposed by the International Monetary Fund. A literature search was performed in July 2012 in Medline and Embase. Further article procurement was obtained via the reference lists of the identified articles, websites, and direct contact with the authors of the identified studies. We designed search strategies using the key words: SCI, epidemiology, incidence, and prevalence. According to the inclusion criteria, 64 studies from 28 countries were included. **Results:** The incidence of SCI in developing countries is 25.5/million/year (95% CI: 21.7–29.4/million/year) and ranges from 2.1 to 130.7/million/year. Males comprised 82.8% (95% CI: 80.3–85.2) of all SCIs with a mean age of 32.4 years (95% CI: 29.7–

35.2). The two leading causes of SCI were found to be motor vehicle crashes (41.4%; 95% CI: 35.4–47.4) and falls (34.9%; 95% CI: 26.7–43.1). Complete SCIs were found to be more common than incomplete injuries (complete SCI: 56.5%; 95% CI: 47.6–65.3; incomplete SCI: 43.0%; 95% CI: 34.1–52.0). Similarly, paraplegia was found to be more common than tetraplegia (paraplegia: 58.7%; 95% CI: 51.5–66.0; tetraplegia: 40.6%; 95% CI: 33.3–48.0). **Conclusion:** Through an understanding of the epidemiology of SCI in developing countries, appropriate preventative strategies and resource allocation may decrease the incidence and improve the care of these injuries.

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Introduction

Spinal cord injury (SCI) is a devastating condition which occurs with an annual incidence of 12.1–57.8 cases per million [1]. SCI is associated with permanent disability and decreased life expectancy [2]. Although more than

Fig. 1. Flow diagram of studies based on the PRISMA statement.

80% of the world's population live in the more than 100 developing countries, little information is available regarding the epidemiology of SCI in these countries [3].

Since there is no curative treatment for SCI, prevention of SCI is paramount. Investigating the epidemiological pattern of SCI is the first step in planning for preventive strategies [4]. The epidemiology of SCI varies in different countries and the results of epidemiological studies from developed countries are not applicable to developing countries [5, 6]. Given the poorly elucidated epidemiological pattern of SCI in developing countries, this systematic review aims to pool all available data to elucidate epidemiological patterns of SCI in these countries.

Materials and Methods

We designed search strategies using the following key words: SCI, epidemiology, incidence, and prevalence. The search strategy was repeated several times by our team and performed on July 16, 2012, with the help of an experienced research librarian (online

supplementary material; for all online supplementary material, see www.karger.com/doi/10.1159/000350710). We pooled papers from Embase (via Ovid SP) and Medline (through Pubmed) in the End Note X3 software (Thomson Reuters 1988–2009 – Bld 4094). We reviewed the reference lists of the identified articles and identified papers describing the epidemiology of SCI in developing countries. We also searched reported data by the National Spinal Cord Injury Statistical Center (<https://www.nscisc.uab.edu>) [7] and International Spinal Cord Society (ISCoS) (<https://www.iscos.org.uk>) [8] websites. The 112 authors of the papers identified using the above search strategy were directly contacted via e-mail in search of any further published data. In total, 15 manuscripts were identified from these authors (fig. 1). Duplicated records were removed manually.

Our definition for developing countries in this paper is based on the International Monetary Fund's World Economic Outlook Report, April 2012 [9]. The International Monetary Fund uses a flexible classification system that considers (1) per capita income level, (2) export diversification – so oil exporters that have high per capita gross domestic product would not make the advanced classification because around 70% of its exports are oil – and (3) degree of integration into the global financial system.

Titles of 1,441 records were reviewed in the integrated End Note file. In total, 1,296 articles were found to have irrelevant titles.

Fig. 2. SCI incidence in developing countries.

However, 145 articles were found to be related to the epidemiology of SCI in both developing and developed countries and were thus further screened by evaluating their abstracts. Fifty-six papers were excluded, most of which due to their focus on epidemiology of SCI in developed countries. Eighty-nine full publications were retrieved for detailed evaluation. We evaluated all papers carefully to include papers that measured incidence, age, sex, complete/incomplete injuries, paraplegia/tetraplegia, or mechanism of injury. We excluded low-quality and heterogeneous studies in order to draw more precise conclusions. Further exclusion after detailed evaluation was performed for review articles, articles with data on pediatric or geriatric patients, articles describing a specific etiology for SCI, articles without any data, letters, and articles with an unrelated focus (SCI patients who have pressure ulcers, employment problem, pain, satisfaction/quality of life, morbidity, urology, and economy). We excluded articles with mixed data for spinal fractures and SCIs unless the data for spinal cord-injured patients was independently reported.

Further, we excluded those papers with mixed traumatic and nontraumatic SCIs unless the traumatic SCI patient data was independently reported. For non-English papers (2 Portuguese papers, 2 Russian papers and 1 Polish paper), the manuscripts were

translated into English prior to review. Two independent researchers (V.R.-M., M.K.S.) performed data extraction separately, and the results were compared.

The flow diagram for various stages of studies based on the PRISMA statement [10] is shown in figure 1. Data on demographics, incidence or prevalence of SCI (if reported), level of SCI (cervical, thoracic and lumbar), etiology of SCI, type of SCI (incomplete tetraplegia, complete tetraplegia, incomplete paraplegia and complete paraplegia) and classification of SCI were extracted from the articles by the reviewers. The study protocol was reviewed and approved by the Sina Trauma and Surgery Research Center ethical review board.

Meta-analysis was performed for pooled data for percentages of paraplegics versus tetraplegics, complete versus incomplete SCI and mechanism of injury [motor vehicle crashes (MVCs) and falls] using STATA software version 9.1 (Stata Corp., College Station, Tex., USA). A moment-based random model was used for estimating pooled measures because of heterogeneity of studies. We used metaregression for adjusting study period, male sex percent, mean age, relative frequency of MVC and fall-related SCI.

Table 1. Comparative analysis of SCIs in developing countries

Study No.	Country	First author	Years of study	Number of patients	Male-to-female ratio	Mean age years	Incidence cases/million people	Method	ALS or Frankel score	Complete para-plegia, %	In-complete para-plegia, %	In-complete tetra-plegia, %	SCI level, %	thoracic	lumbarsacral	
1	Afghanistan (Kabul)	Deconinck [11]	2001	257	9:1	25 ± 11.5	128.5 (P)	Cohort interview, observation, clinical examination with a standardized questionnaire	–	80	19	6.7	47	46.3		
2	Afghanistan (Herat)	Deconinck [11]	2001	54	9.4:1	28 ± 12.4	108.7 (P)	Cohort interview, observation, clinical examination with a standardized questionnaire	–							
2	Bangladesh	Hoque [12]	1994–1995	179	7.5:1	Peak 20–30: 42%	–	Retrospective, rehabilitation center	–	60	40	–	40	60		
3	Brazil	Brasil [13]	1986–1995	164	4.4:1	–	–	–	Frankel A: 38% B: 10% C: 36% D: 16%	64.9	35.1	–	61	39		
		Leal-Filho [14]	1995–2002	386	6.3:1	–	–	Prospective, reference-based hospital	Frankel A: 50% B: 3.4% C: 16.3% D: 14.8% E: 15.5%	–	–	–	51	27, L ₁ = 13.0	22	
		Brito [15]	2008–2009	87	4.4:1	34.0 ± 13.6		Retrospective hospital database	–	–	–	–	26.4	37.9	10.3 TL/25.4	
		Greve [16]	1986–2007	3,289	5.0:1	–	17.3	–	–	–	–	–	–	–	–	
		Barros Filho [17]	1982–1987	428	16.8:1	–	10.1	Retrospective chart search, hospital database	–	–	–	–	–	–	–	
		da Paz [18]	1988	108	4.1:1	30.3 ± 1.1 (6–56)	–	Hospitalized cord-injured patients, prevalence study	56.5	30.5	13.0					
		Masini [19]	1997–1998	93 (population 159,884,278)	9:1	30.4 ± 15.5	71	Questionnaires to public hospital of national insurance system	–	–	–	–	–	–	–	
		Souza [20]	2002–2003	250	8.3:1	–	–	Reference-based hospitals	–	–	–	–	35.6	–	–	
4	Bulgaria	Stavrev [21]	1983–1992	980	–	–	130.7	Retrospective hospital database	–	–	–	–	–	–	–	
5	Chile	Correa [22]	1986–2005	173	–	38.2 ± 12.1	7.8 ± 3.6	Workers with SCI/total work force in the same year	–	–	–	–	–	–	–	
6	China	Ning [23]	2004–2008	869	5.6:1	46 ± 14.2	23.7	Retrospective hospital database	ALS A: 25.2% B: 18.2% C: 14.7% D: 41.9%	10.7	14.5	17.8	57	13.3	LS: 15.2	
		Feng [24]	1998–2009	239	4.6:1	45.4 ± 14.1	–	Retrospective hospital database	–	–	22.6	–	59.4	82	–	–
		Li [25]	1982–2002	1,079	3.1:1	41	60.6 (9 times – >20 years)	–	–	–	–	–	4.9	28.0	65.9	

Table 1 (continued)

Study No.	Country	First author	Years of study	Number of patients	Male-to-female ratio	Mean age years	Incidence cases/million people	Method	AIS or Frankel score	Complete para-plegia, %	In-complete para-plegia, %	In-complete tetra-plegia, %	SCI level, %	thoracic	lumbal/sacral	
		Wang [26]	1982–1986	No data	–	–	6.7	Retrospective	–	51	49	51	19	18 TL, 12 L		
7	Fiji Islands	Maharaj [27]	1985–1994	75	6.5:1	38.3 ± 17.3	Average: 10 cases/million people 1986: 5.6 1991: 17.9 Fiji male: 41.85 Fiji females: 12.34 Indian females: 3.47	Retrospective, rehabilitation center	AIS 53.3% quadriplegia, 46.7% paraplegia	Complete: 61.3	Incomplete: 38.7	53.3	46.7			
8	Greenland	Pedersen [28]	1965–1986	27	2.9:1	–	26	–	–	–	–	–	–	–	–	
9	India	Singh [29] Manjeet [30]	2000–2001 2006–2008	483 403 spine, 314 SCI	3:1 3:1	35.4 Peak: 20–30	–	Prospective hospital database Hospital database	– Frankel A: 52 (12.9%) B: 62 (15.4%) C: 98 (24.3%) D: 102 (25.3%) E: 89 (22.1%)	58.6 Complete: 16.6	33.9 Incomplete: 83.4	– 100 (24.8%)	– 303 TL	–	–	
10	Iran	Rahimi-Movaghgar [31, 32] Yousefzadeh [33]	2007–2008 2005–2006	496 44	2.2:1 –	– 38.2	72.4 –	Population-based plus DisMod software Hospital database	AIS Complete: 34.1% Incomplete: 65.9%	56 9.1	19.9 25	14.7 65.9	7.8 –	18.5 –	33.3 –	48.2
11	Jordan	Fakharian [34] Otom [35]	1995–1999 1988–1993	39 151	3.9:1 5.8:1	39 ± 18 33	30 18	Hospital database Retrospective hospital database	– Frankel A: 53.6% B: 10% C: 22.5% D: 13.9%	– 68.2	– 31.8	– –	– 31.8	– 68.2		
12	Kuwait	Raibulet [36]	1991–1999	90	7.1:1	20.6	7.8	Retrospective hospital database	Frankel A: 29% B: 22.7% C: 38.3% D: 9.9%	56.02	43.98	–	–	–	–	–

Table 1 (continued)

Study No.	Country	First author	Years of study	Number of patients	Male-to-female ratio	Mean age years	Incidence cases/million people	Method	AIS or Frankel score	Complete para-plegia, %	In-complete para-plegia, %	In-complete tetra-plegia, %	SCI level, %	thoracic	lumbar/sacral
13	Myanmar	Toe [37]	1975–1976	24	–	–	–	Hospital for rehabilitation	–	Complete: 62.5	Incomplete: 37.5	16.7	50	33.3	cauda equina
14	Nepal	Bajracharya [38]	1996–2005	374	–	–	–	Retrospective hospital database	Frankel A: 47.3% B: 7.8% C: 24.9% D: 20.0%	–	–	–	–	–	–
		Lakhey [39]	1997–2001	233	2.6:1	–	–	Retrospective, orthopedic department	–	–	–	–	–	–	–
15	Nigeria	Olasode [40]	2004–2006	71	2:1	30	–	Prospective	–	28.8	23.7	–	–	–	–
		Obalum [41]	1992–2006	468	2.3:1	Majority: 30–40	–	Retrospective, university hospital	AIS A: 91.9% B: 1.3% C: 2.6% D: 3.8% E: 0.4%	70	30	–	30.3	10.3	59.4
		Udosen [42]	2005–2006	14	4:1	36	–	Prospective, university hospital	AIS Complete: 71.4% Incomplete: 21.4% Spinal shock: 7.1%	78.6	14.3	–	35.7	21.4	43
		Iwegbu [43]	1973–1982	48	7:1	–	–	–	–	–	–	–	–	–	–
		Igun [44]	1984–1997	68	10.3:1	–	–	Retrospective hospital database	–	77	–	33	–	–	–
		Solagberu [45]	1995–1999	39	12:1	–	–	Retrospective hospital database	Complete: 69% Incomplete: 31%	54	46	–	–	–	–
		Nwankwo [46]	1996–2000	74	–	–	–	–	–	–	–	–	–	–	–
		Nwadinigwe [47]	1996–2001	104	5.5:1	–	–	–	–	–	–	–	–	–	–
16	Pakistan	Rathore [48]	2006	83	4.5:1	29.3 ± 12.4	–	Prospective, single rehabilitation center	AIS A: 57.9% B: 21.7% C: 10.8% D: 7.2% E: 2.4%	53	4.8	18.1	21.7	25.6	70.8
		Masood [49]	2003–2007	214	7.6:1	Peak (72/214): 33.6% 21–30 years	–	Retrospective, single hospital	–	77/196 = 39.3%	119/196 = 60.7%	101/224 = 45.1%	64/224 = 28.6%	59/224 = 26.3%	–

Table 1 (continued)

Study No.	Country	First author	Years of study	Number of patients	Male-to-female ratio	Mean age years	Incidence cases/million people	Method	AIS or Frankel score	Complete para-plegia, %	In-complete para-plegia, %	In-complete tetra-plegia, %	SCI level, %		
													cervical	thoracic	lumbar/sacral
		Raja [50]	1995–1999	2,654	2.6:1	Peak 25.2% 21–30 years	–	Retrospective multicenter	Complete: 29.4% Incomplete: 70.6%	32	68	–	68	7	TL = 25
		Qureshi [51]	2001–2008	521 spine, 394 SCI	Data for spine not saved	–	–	Retrospective single hospital database	A: 223 (43%) B: 20 (4%) C: 80 (15%) D: 71 (14%) E: 127 (24%)	Complete: 56.6%	Incomplete: 43.4%	–	–	–	–
17	Papua New Guinea	Gee [52]	<1982	36	4:1	26	–	Hospital database	–	–	–	–	–	–	–
18	Poland	Jankowski [53]	1979–1992	511	7.2:1	–	–	–	Tetraplegia: 50.3% Paraplegia: 49.7%	–	–	–	–	–	–
19	Qatar	Mena Quinones [54]	1987–1996	75	8.3:1	32	12.5	Retrospective hospital database	AIS Complete: 58.7% Incomplete: 41.3%	28	30.7	14.7	26.6	57.3	TL: 42.7
20	Romania	Soopramanien [55]	1975–1993	262	3.3:1	–	28.5	Retrospective 1975–1992 Prospective 1992–1993, hospital/rehabilitation	Frankel A: 33% B: 6% C: 6% D: 18% E: 37%	122/219 = 55.7%	97/219 = 44.3%	60	60	40	
21	Russia	Silberstein [56]	1989–1993	196	3.5:1	Male: 34.7 Female: 32.3	29.7	Hospital database	Frankel A: 32.7% B: 11.2% C: 34.2% D: 21.9%	51	49	–	–	49.0	27.5 23.5
		Kondakov [57]	1994–1996	105	2.26:1	Spine data not saved	44, 64 male, 28 female	–	–	–	–	–	–	–	–
		Fromovich-Amit [58]	Before 2008	50	5.25:1	30.8 ± 11.5	–	Hospital for rehabilitation	AIS A: 76% B: 4% C: 2% D: 18%	–	–	–	48	52	52
22	Saudi Arabia	Alshahri [8] Al-Arabi [59]	2003–2008 1979–1984	307 377	7.5:1 46.1:1	– –	2.1 –	– Hospital database	– –	48	52	–	–	–	–

Table 1 (continued)

Study No.	Country	First author	Years of study	Number of patients	Male-to-female ratio	Mean age years	Incidence cases/million people	Method	AIS or Frankel score	Complete paraplegia, %	In-complete paraplegia, %	In-complete tetraplegia, %	SCI level, %	thoracic	lumbar/sacral
23	Sierra Leone	Gosselin [60]	2002–2004	24	11:1	30	3.4	Retrospective hospital database	–	87.5	12.5	41.7	58.3		
24	South Africa	Velmahos [61]	1988–1992	551	3.4:1	28	48.5	Retrospective hospital database	–	90.3	9.7	–	26	59	15
		Key [62]	1963–1967	300	9:1	–	–	–	–	–	–	–	–	–	–
		Hart [63]	1988–1993	616	40:1	28	–	Retrospective rehabilitation database	–	75	25	–	–	–	–
25	Thailand	Pajareya [64]	1989–1994	219	5.6:1	32.8	5.8	–	–	28.8	23.7	21	26.5	50.2	49.8
		Kovindha [65]	1985–1991	398	11.1:1	23	–	–	–	–	–	–	–	–	–
		Kuptniratsaikul [66]	1997–2000	83	4:1	33.2 ± 11.7	–	Prospective hospital database	–	33.7	25.3	41 AIS D	50.2	TL: 49.8	
26	Turkey	Karacan [67]	1992	581	2.5:1	35.5 ± 15.1	12.7	Retrospective cohort, rehabilitation centers	Paraplegics: 54.7% Tetraplegics: 6.8% Paraparesis: 28.1% Tetraparesis: 10.4%	67.8	32.2	–	31.7	26.6	28.1
		Dincer [68]	1974–1985	1,694	3.1:1	26.8	–	Retrospective cohort, rehabilitation center	–	–	–	–	–	–	–
		Karamehmetoglu [69]	1992	152	3:1	33	21.1	Retrospective cohort hospital database	–	–	–	–	33	67	
		Gur [70]	1990–1999	539	3.4:1	30.6 ± 13.2	12.06	Retrospective cohort hospital database	–	45	13.9	27.4	13.7	C = 25.4 CT = 2.4	T = 34.0 TL = 36.7 L = 1.5%
		Karamehmetoglu [71]	1994	75	5.8:1	31.3 ± 12.8	16.9	Retrospective cohort hospital and rehabilitation database, rural	–	–	–	–	–	–	–
27	Vietnam	Weerts [72]	2006–2007	247	–	–	13.9 (I) 464 (P)	–	–	–	–	–	–	–	–
28	Zimbabwe	Levy [73]	1988–1994	136	8.1:1	Majority: 20–40	11.7	Retrospective, national rehabilitation center	AIS A: 58.7% B: 0% C + D: 36.5% E: 4.8%	27	31.7	25.4	11.1	51	49

AIS = American Spinal Injury Association impairment scale; P = prevalence; TL = thoracolumbar (T₁₀–L₁); LS = lumbosacral; L = lumbar; C = cervical; CT = cervicothoracic; T = thoracic; I = incidence.

Table 2. Etiology and age distribution of SCI in developing countries (%)

Study No.	Country	First author	Cause (etiology)				Age groups, years										
			motor vehicle accident	falls	gunshot injuries	violence/ stab injuries	sports injuries	other/unrecognized	0-9	10-19	20-29	30-39	40-49	50-59	≥60		
1	Afghanistan	11	26	15	2	-	-	Shelling: 38 Mine: 5 Others: 3	-	-	-	-	-	-	-	-	
2	Bangladesh	18	63	-	-	-	-	Falls: 43 Falling while carrying a heavy load: 20 Other/unknown: 19	-	-	-	-	-	-	-	-	
3	Brazil	Brasil [13]	37.8	25.6	11.6	-	7.3	17.7	0.6	14.1	26.2	25	15.2	12.2	6.7	6.7	
		Leal-Filho [14]	31.1	38.3	-	2.1	-	Local trauma on the body: 6.2 Firearm: 11.9 Diving: 6.5 Run over: 3.9	-	-	-	-	-	-	-		
		Greve [16]	31	39	16	14	-	Firearm: 12.6 Diving in shallow waters: 3.4	1.1	9.2	39.1	23	11.5	12.6			3.5
		Barros Filho [17]	26.9	22.4	36.7	7.9	7.9	Other: 6.1	0.6	15.7	20.8	27.1	7.7	1.9			1.3
		da Paz [18]	41.7	14.8	27.8	9.2	9.2	Other: 6.5	-	-	-	-	-	-			-
	Masini [19]	Transit accidents, diving, fall, gunshot injury				-	-	-	-	-	-	-	-	-	-		
	Souza [20]	8.4	39.6	24.4	24.4	Diving: 7.2	Others	Peak: 20-40									
4	Bulgaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
5	Chile	-	-	-	-	-	-	-	Peak: 25-34								
6	China	Ning [23]	34.1	56.9	-	1.4	0.2	Struck by object: 6.3 Work accident: 0.8	-	-	-	-	-	-	-		
		Feng [24]	36.4	52.3	-	-	0.4	Others	15-24: 9.2 25-34: 12.1 35-44: 26.4 45-54: 26.8 55-64: 15.1 ≥65: 10.5	-	-	-	-	-	-		
		Li [25]	26.9	Height: 37.5 Ground: 8.3	-	-	-	Struck by object: 16.3 Others	-	-	-	-	-	-	-		
		Wang [26]	<10	36	-	-	-	>54	-	-	-	-	-	-	-		
7	Fiji Islands	25.3	38.7	-	-	28	8	-	-	-	-	-	-	-	-		
8	Greenland	4	33	-	11	4	Self-harm: 26 Other/unknown: 22	-	-	-	-	-	-	-	-		

Table 2 (continued)

Study No.	Country	First author	Cause (etiology)		Age groups, years										
			motor vehicle accident	falls	gunshot injuries	violence/ stab injuries	sports injuries	other/unrecognized	0–9	10–19	20–29	30–39	40–49	50–59	≥60
9	India	Singh [29]	34.8	44.5	–	2.7	4	Cave-in: 6.4 Others: 7.6	0.41	6.21	42.03	26.5	15.53	6.83	2.48
		Manjeet [30]	30.3	50		2.7	0.7	Fall of heavy weight on back: 9.2 Cave in: 6.9 Fall into well: 0.2	0.5	4.2	47.1	22.8	15.4	8.4	1.7
10	Iran	Rahimi-Movaghar [31, 32] Yousefzadeh [33]	64 52	12 43	– –	– –	– –	24 Falling heavy object: 2.4 Others: 2.4	0.6	6.6	26.8	23.8	21	21.2	
		Fakharian [34]	–	–	–	–	–	–				<20: 7.7 20–50: 69.2 >50: 23.1			
11	Jordan		44.4	21.2	25.8	2	2.6	Suicide attempts: 0.7 Others: 3.3	24.5	35.8	15.9			23.8	
12	Kuwait		63.3	24.7	–	2.2	–	Hit by falling object: 6.7 Diving: 2.2	–	–	–	–	–	–	–
13	Myanmar		12	70	3	–	6	Industrial accident: 6 Tunnel digging: 3				<20: 8.3 20–30: 33.3 30–40: 27.8 40–50: 25 >50: 5.6			
14	Nepal	Bajracharya [38] Lakhey [39]	– 7	– 82	–	–	–	Other/unknown: 11				–			
15	Nigeria	Olasode [40]	88.8	–	1.4	–	–	Strangulation: 2.8 Hanging: 1.4 Others: 5.6	–	–	–	–	–	–	–
		Obalum [41]	77.4	9.4	7.3	2.1	1.7	Assault: 1.7 Domestic accidents: 0.4				0–10: 0.4 11–20: 8.1 21–30: 29.1 31–40: 28.6 41–50: 21 51–60: 7.7 >60: 5.1			
		Iwegbu [43]	75	8	–	–	17		–	–	–	–	–	–	–
		Igun [44]	57	22	3	–	Work-related: 18		–	–	–	–	–	–	–
		Solagberu [45]	67	23	–	–	10		–	–	–	–	–	–	–
		Nwankwo [46]	–	–	–	–	–		–	–	–	–	–	–	–

Table 2 (continued)

Study No.	Country	First author	Cause (etiology)		falls	gunshot injuries	violence/stab injuries	sports injuries	other/unrecognized	Age groups, years						
			motor vehicle accident							0-9	10-19	20-29	30-39	40-49	50-59	≥60
16	Pakistan	Nwadinigwe [47]	58	24	12	-	6			-	-	-	-	-	-	-
		Udosen [42]	85.7		-	-				-	-	-	-	-	-	-
		Rathore [48]	25.2	57.8	8.4	-	Hit by falling object: 7.3 Others: 1.3	2		-	-	-	-	-	-	-
17	Papua New Guinea	Masood [49]	23.4	67.7	6	1	2		33.3	-	-	-	-	-	-	-
		Raja [50]	7	82	-	-	-			-	-	-	-	-	-	-
		Qureshi [51]								-	-	-	-	-	-	-
18	Poland		33.3	33.3	-	-	-	-		-	-	-	-	-	-	-
			41	-	-	-	19		Work-related: 15 Other/unknown: 25	-	-	-	-	-	-	-
			72	13.3	-	-	-		Falling heavy object: 9.3 Penetrating wound: 2.7 Others: 2.7	-	-	-	-	-	-	-
19	Qatar															
20	Romania		72	-	-	-	7		Work-related: 13 Others: 8	41.3					58.7	
21	Russia	Silberstein [56]	25.1	40.4	1.6	33	Diving: 23.2			-	-	-	-	-	-	-
		Kondakov [57]	16	34	-	-	2		Work-related: 5 Other/unknown: 43	-	-	-	-	-	-	-
		Fromovich-Amit [58]	-	-	-	-	-			-	-	-	-	-	-	-
22	Saudi Arabia	Alshahri [8]	85	9	-	5	1			-	-	-	-	-	-	-
		Gosselin [60]	50	41.7	-	-	-		Crushed by collapsed wall: 8.3	-	-	-	-	-	-	-
23	Sierra Leone															
24	South Africa	Valmahos [61]	30		61		9			3	62	32				3
		Key [62]	34	12.3	25.3		5.3		24.0	-	-	-	-	-	-	-
		Hart [63]	28	3	62		7			-	-	-	-	-	-	-
25	Thailand	Pajareya [64]	51	30.6	-	8.2	0.5		Hit by moving objects: 7.8 Suicide: 0.5 Others: 1.4	-	-	-	-	-	-	-
26	Turkey	Kovindha [65]	47	48	-	4	1			-	-	-	-	-	-	-
		Kuptniratsaikul [66]	Car: 49.4 Motorcycle: 25.3	16.9	Gun-shot: 8.4		-			-	-	-	-	-	-	-
27	Turkey	Karacan [67]	48.8	36.5	1.9	3.3	-		Diving: 1.2 Others: 8.3	1.5	9.8	30.9	21.9	15	11.8	8.7
		Dincer [68]	35.4	29.5	29.5	-	-		Stab wound: 0.49	-	-	-	-	-	-	-

Table 2 (continued)

Study No.	Country	First author	Cause (etiology)		Age groups, years											
			motor vehicle accident	falls	gunshot injuries	violence/ stab injuries	sports injuries	other/unrecognized	0-9	10-19	20-29	30-39	40-49	50-59	≥60	
		Karamehmetoglu [69]	40.8	42.8	-	Being struck by an object: 7.2	2.6	6.6	Self-harm: 3 Other: 5	35.5	23	13.2	8	7.2	41	43
		Gur [70]	37.1	31.9	-	23	-	-		-	-	-	-	-	-	
		Karamehmetoglu, rural [71]	25	37	-	31	-	7		-	-	-	-	-	-	
27	Vietnam		45	-	-	1	2	Work-related: 17 Other/unknown: 36	-	-	-	-	-	-	-	-
28	Zimbabwe		56	11	4	11	-	MVC: 50 Bicycle: 4 Scotch carts: 2 Others: 18	-	-	-	-	-	-	-	-

Results

Our search found 64 studies (fig. 1) [8, 11-73] related to the 28 developing countries all around the world. Tables 1 and 2 show the study period, number of patients, age, sex, level of injury, completeness of SCI and etiology. A paper about SCI epidemiological characteristics had been written in the two cities of Kabul and Herat, Afghanistan, independently [11]. Therefore, we included the paper as two independent studies. One unpublished study from Saudi Arabia was extracted from the ISCoS. Our personal contact with the ISCoS office showed that they published data without estimation.

The proportion of male patients was higher than 66% in all studies. The random pooled estimate for male proportion among all countries was 82.8 (95% confidence interval, CI: 80.3-85.2). The data were heterogeneous (Q: 1,097, d.f.: 51, $p < 0.001$, moment-based estimate of between-studies variance = 0.007). Zimbabwe had the highest male-to-female ratio (12.4:1) [73] and Nigeria had the lowest (2:1) [40].

The random pooled estimate for mean age was 32.4 years (95% CI: 29.7-35.2, test for heterogeneity Q: 1,928, d.f.: 25, $p < 0.001$, moment-based estimate of between-studies variance = 50.4). The mean age of SCI patients ranged from 20.6 in Kuwait [36] to 46 years in China [23]. The most commonly affected age group was patients aged 20-30 years (Bangladesh, India and Pakistan; table 1).

In developing countries, the SCI incidence (25.5/million/year, 95% CI: 21.7-29.4/million/year) ranges from 2.1 in Saudi Arabia [8] to 130.7 in Bulgaria per million [21] (fig. 2; Q: 6,869, d.f.: 26, $p < 0.001$, moment-based estimate of between-studies variance = 99.9). In figures 2-8, the size of each square is correlated with the weight and inverse of variance of study in the meta-analysis.

The relative frequency of complete SCI was 56.5% (95% CI: 47.6-65.3; test for heterogeneity Q: 1,665, d.f.: 24, $p < 0.001$, moment-based estimate of between-studies variance = 0.048; fig. 3). The relative frequency of incomplete SCI was 43.0% (95% CI: 34.1-52.0; test for heterogeneity Q: 1,727, d.f.: 24, $p < 0.001$, moment-based estimate of between-studies variance = 0.050; fig. 4).

The relative frequency of paraplegia was 58.6% (95% CI: 51.3-66.0; test for heterogeneity Q: 6,295, d.f.: 47, $p < 0.001$, moment-based estimate of between-studies variance = 0.065; fig. 5). The relative frequency of tetraplegia was found to be 40.7% (95% CI: 33.3-48.1; test for heterogeneity Q: 6,816, d.f.: 47, $p < 0.001$, moment-based estimate of between-studies variance = 0.067; fig. 6).

Fig. 3. Meta-analysis of SCI by completeness in developing countries.

Cervical SCI causes tetraplegia and T₁–L₁ SCI causes paraplegia. The comparison of reported data for level of injury (thoracolumbar vs. cervical) was almost the same as that for paraplegia versus tetraplegia. However, we did not perform meta-analysis for level of injuries, because there was no clear identification of conus medullaris ($\geq L_1$) versus cauda equina ($< L_1$) in many papers.

Motor vehicle collisions were found to be the causative mechanism in 41.4% of patients (95% CI: 35.4–47.4; test for heterogeneity Q: 5,309, d.f.: 50, $p < 0.001$, moment-based estimate of between-studies variance = 0.046; fig. 7).

A fall was identified as the mechanism of injury in 34.9% of patients (95% CI: 26.7–43.1; test for heterogeneity Q: 8,392, d.f.: 44, $p < 0.001$, moment-based estimate of between-studies variance = 0.077; fig. 8).

MVCs and falls were the leading causes of SCI except 2 reports from South Africa, which showed violence was the cause of SCI in more than half of the patients [61, 63], and 1 report from Brazil, which showed violence was more

common than MVCs and falls [17]. In the Plateau State of Nigeria, collapsing tunnels in illegal mining are the most prevalent cause [44]. In 31 reported data, MVC was more common than falls and in 23 reported data, a fall was more common than MVC and in 1 report, both had similar percentages of SCI causes. In 2 reports from Nigeria [40, 42] and 1 report from Saudi Arabia [8], MVCs accounted for more than 80% of SCI patients. Also, Iran has one of the highest mortality rates due to MVCs [74]. However, in 2 reports from Nepal [39] and Pakistan [50], falls accounted for more than 80% of SCI patients. Bangladesh has one of the highest SCI rates due to falls [12].

There was lack of information on the training and qualifications of the individuals identifying SCI patients in developing countries except in Iran, in which a registered nurse with specific training rechecked the patients in their home. In the Iran study, patients and their files were re-evaluated by a neurosurgeon in the neurotrauma clinic.

Based on meta-regression analysis, the relative frequency of complete or incomplete SCI does not increase

Fig. 4. Meta-analysis of SCI by incompleteness in developing countries.

significantly during the years of studies from 1975 to 2009. Addition of male gender and mean age to the model does not change the significance either.

The relative frequency of MVC-related SCI did not change significantly during the study period from 1975 to 2009. However, the relative frequency of fall-related SCI has increased in these years significantly. Share of fall has increased by 0.9% (95% CI: 0.2–1.5%) annually. Male gender, age and type of SCI (incomplete vs. complete) and neurological injury (tetraplegia vs. paraplegia) were found to have no association with the mechanism of injury.

There is a significant association between tetraplegia and male gender; each 1% increase in proportion of males:females is associated with a 1.8% (95% CI: 0.4–3.3%) increased risk of tetraplegia. Each 10-year increase in mean age is associated with a 0.15% (0.02–0.28%) increase in tetraplegia.

There are also specific common etiologies for SCI in specific seasons or groups. For example, in India there

was seasonal variation in incidence of traumatic SCI, with a marked increase during summer [29, 30], which is compatible with increased movement of people during this season. In Fiji [27], most injuries occurred in native-born individuals rather than in tourists or visitors. In South Africa, the etiology of SCI showed a shift from stab wounds (38% in 1988 to 17.5% in 1992) to gunshot injuries (28.5% in 1988 to 47% in 1992).

China [23] and Pakistan [50] reported the highest rate of cervical injury (71.5 and 68%, respectively). With respect to the classification of SCI (complete vs. incomplete), 19 countries reported complete and incomplete SCIs (table 1). Only 4 of these studies found that complete injuries were more common [23, 30, 33, 49]. Similarly some studies from developed countries mention a trend toward complete over incomplete SCIs over the last decade [5, 75]. In the study from South Africa [61], it has been mentioned that there is 74% involvement of the thoracic and lumbar area but 90.3% of patients are paraple-

Fig. 5. Meta-analysis of SCI by paraplegia in developing countries.

gic. Also there are 26% cervical injuries, but only 9.7% have tetraplegia.

Most studies gave retrospective hospital-based data. However, 4 studies were prospective [14, 42, 48, 66]. A paper from Romania showed mixed data in which the first 17 years of the study were retrospective and the last year was prospective [55]. Only 1 study was a population-based study in SCI [31].

Regarding secondary complications, pressure ulcers were relatively common after SCI [76, 77]. Among studies reporting secondary complications of SCI, all except 3 from Bangladesh [12], Kuwait [36] and Zimbabwe [73] suggested pressure ulcer as the most common complication following SCI. In Iran, the prevalence of pressure ulcer was 71.8% among traumatic SCI cases [77]. The complications that are seen with SCI are related to almost all human body systems. However, in this review,

we did not focus on the complications, which need a separate extensive review and just mentioned the 2 most common complications of pressure sore and urinary tract infection. Body systems and their SCI complications include: urinary tract with infection, renal stone, hydronephrosis, urinary incontinence, vesicouretral reflux; gastrointestinal tract with constipation, hemorrhoids, stool incontinence, cholecystitis, appendicitis, upper gastrointestinal bleeding, superior mesenteric artery syndrome, pancreatitis; skin with pressure sore; cardiovascular system with autonomic dysreflexia, thromboembolism; pulmonary tract with infection, ventilatory failure, sleep apnea; musculoskeletal system with osteoporosis, muscular weakness, paralysis, atrophy, spasticity, pain; endocrine system with hypercalcemia; sexual organs with erectile dysfunction, male infertility; psychiatry with depression.

Fig. 6. Meta-analysis of SCI by tetraplegia in developing countries.

Discussion

We identified 64 papers from 28 countries. The incidence of SCI in developing countries was 25.5/million/year. Males (82.8%) were more likely to sustain SCI than females. The mean age of SCI occurrence was 32.4 years. The relative frequency for following subgroups of SCI was: MVC 41.4% and falls 34.9%; complete and incomplete SCI were 56.5 and 43.0%, respectively; paraplegia and tetraplegia were 58.6 and 40.7%, respectively. However, there was no significant difference between MVC and falls, complete and incomplete SCI, paraplegia and tetraplegia. The most commonly reported complication was the development of pressure ulcers.

Incidence of SCI

The annual incidence of SCI ranged from 2.1 (Saudi Arabia) [8] to 130.7 (Bulgaria) [21] per million in devel-

oping countries compared to the reported incidence of SCI from developed countries of 12.1–57.8 cases per million [1]. In most developing countries, especially Arabic countries, the incidence of SCI was less than that in developed countries. The lack of organized national registries and death at the scene of an injury or in the prehospital phase in developing countries might explain the higher mortality of SCI in those developed countries who have registered prehospital death [78]. In many developing countries, there are limited numbers of hospitals capable of managing SCI patients. Therefore, examination of admission data from these centers retrospectively allows incidence to be estimated.

Twenty-nine papers from the following 19 countries reported the annual incidence of SCI: Brazil [16, 17, 19], Bulgaria [21], Chile [22], China [23, 25, 26], Fiji Island [27], Greenland [28], Iran [31, 32, 34], Jordan [35], Kuwait [36], Qatar [55], Romania [56], Russia [57, 58], Sau-

Fig. 7. Meta-analysis of SCI by etiology of MVCs in developing countries.

di Arabia [8], Sierra Leone [60], South Africa [61], Thailand [64, 65], Turkey [67, 69–71], Vietnam [72], Zimbabwe [73] (table 1). As mentioned before, the low incidence of SCI from some countries may not be accurate since data may be aggregated from hospitals or rehabilitation centers and not directly collected.

Etiology of SCI

There was no single classification used to organize SCI etiology, so it was somewhat difficult to compare different countries. Although fall and MVC were reported in the majority of the studies, there was discrepancy in reporting other causes of SCI. To address this problem, it is recommended that authors in future studies use the classification reported by De Vivo et al. [79], to standardize the reporting of the cause of injury. A recent study noted a trend toward an increased prevalence of falls and MVC in developing countries likely related to urbaniza-

tion and increased use of motor vehicles [30]. Likewise, the World Health Organization predicts that there will be a major increase in MVCs in coming decades if preventative measures are not taken [80]. Many developing countries do not have defined programs to prevent MVCs. Therefore, the incidence of MVC is high [81–83]. In some developing countries in which urbanization and motorization processes have not developed, there is a lower incidence of MVC. In these countries such as Bangladesh, the large number of falls is a result of fruit harvesting, which is an important part of their largely agricultural economy [12]. Falls while carrying a heavy load is another common cause of SCIs in Bangladesh. The mean age is lower in developing countries than developed ones. Therefore, falls and SCIs related to osteoporosis are not as common as in developed countries. Sports-related SCIs have been mentioned for diving in Brazil [20]. It is notable that in India a large number of

Fig. 8. Meta-analysis of SCI by etiology of falls in developing countries.

patients were illiterate, poor villagers. In future studies, assessments should be done to determine whether low socioeconomic situation and low educational level are associated with a higher SCI incidence. Since MVCs and falls are the two major etiologies of SCI, preventive measures should be employed to reduce the frequency of SCI in the majority of developing countries. However, in South Africa, preventive measures should be focused on curbing gun violence.

Age Distributions and Male-to-Female Ratios

Age groups were variably defined in the reviewed manuscripts. It is recommended that in future studies, age at the time of SCI should be reported as has been previously recommended by De Vivo et al. [79] with the aim of reaching a standard structure for reporting data on SCI. In most of the developing countries, the majority of patients were young adults (age group 20–40 years). The

mean age of incident cases of SCI patients seems to be higher in developed countries [78] possibly due to longer life expectancies, a higher mean age of population and better medical care systems [78]. The younger mean age of patients with SCI in developing countries will inflict a high burden on these countries [78]. Regarding the gender of SCI victims, traumatic SCI is more prevalent in males than females [5]. The male-to-female ratio in developing countries (82.8% males; M/F: 4.8/1) is higher compared to developed ones as most studies in developed countries have a male-to-female ratio of approximately 3–4 [78]. This may reflect a higher level of social and sport activities of females in developed countries compared to developing ones. Additionally, women in developing countries often have more traditional home-based activities, which likely diminishes their risk of developing an SCI [12, 35]. Authors from India suggested that gender distribution of SCI today compared to a few decades ago

reflects the changing cultural and societal trends of the females' role in the home and workplace [29].

Level and Severity of SCI

Only 21 papers from 15 countries of Brazil, China, Fiji, India, Iran, Jordan, Kuwait, Nepal, Nigeria, Pakistan, Qatar, Romania, Russia, Thailand and Zimbabwe used a classification system for the assessment of level and severity of SCI (table 1). In contrast, the American Spinal Injury Association Impairment Scale classification has been used more frequently in reports from developed countries [78].

The summation of complete and incomplete SCI is not 100% (complete SCI: 56.5%; incomplete SCI: 43.0%) because of difficulties in defining complete/incomplete injuries in some studies. For example, an L₁ conus medullaris injury with urinary and bowel incontinence but without lower extremity neurological deficit is difficult to classify as complete or incomplete SCI. Similarly, the above-mentioned SCI patient is neither paraplegic nor tetraplegic. Therefore, we reported complete/incomplete SCI and paraplegia/tetraplegia with summations of 99.5 and 99.3%, respectively (not 100%). However, in males and females, the summation was accurately 100% and in all studies, and the proportion of males was higher than that of females.

We performed random model pooling to have an estimate for our multiple variables. This extent of dissimilarity in 95% CI is expected.

The proportions of cervical, thoracic and lumbar injuries are not the same as the percentages of paraplegia/paresis and tetraplegia/paresis. This is because some authors included cauda equine injuries (which we subsequently excluded), and some T₁ fractures may cause some upper extremity weakness and be classified as quadripareisis.

Secondary Complications following SCI

Comparing results of developing and developed countries showed that pressure ulcers and urinary tract infections are major secondary complications in all regions [78].

Limitations of the Study

There was lack of information on the training and qualifications of the individuals collecting the SCI data except in Iran, where a registered nurse with specific training rechecked the patients in their home. Patients

and their files were also re-evaluated by a neurosurgeon in the neurotrauma clinic.

One important limitation of this review is that we relied on only a few published articles from each country that were available in the literature. There is no data about the prehospital admission, and it is not clear if the study settings are representative of the epidemiological pattern of SCI in that country. Moreover, it is not clear whether hospitals participating in the published studies treat all traumatic SCIs within that country or if there were any other hospitals in the region that also treat traumatic SCIs. The results drawn from the meta-analysis of etiology and level of SCI should be interpreted carefully due to a discrepancy in the collection period and variation in the collection and reporting methods of the different countries. However, it does provide important preliminary data in this poorly studied field.

Future Study

Due to the lack of SCI registries in developing countries, an accurate estimation of the incidence and epidemiological patterns of SCI in the majority of developing countries is not feasible. There is a need for large national epidemiological surveys in developing countries assessing the incidence, prevalence and etiology of SCI. Moreover, there is diversity in the standards of reporting epidemiology of SCI in developing countries. Future studies should follow the standard for reporting their results that have been published by the ISCoS.

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