

Epidemiological Review of Spinal Cord Injury due to Road Traffic Accidents in Latin America

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Highlights of the Study

- Road traffic accidents seem to be responsible for most cases of traumatic spinal cord injury in Latin America, while gunshot wounds and falls represent the most frequent cause in some countries.
- Studies specifically addressing this topic are scarce, heterogeneous, and include only a minority of Latin American countries.
- Registries for data collection on this condition are desirable.

Keywords

Spinal cord injury · Epidemiology · Traffic accidents · Latin America · South America

Abstract

Spinal cord injury (SCI) is a disease that affects the normal function of the spinal cord. Road traffic accidents (RTAs) represent the main cause of SCI worldwide. SCI may generate physical disability and economic dependency, which is especially significant in low- and middle-income countries such as most of the Latin American countries. The main objective of this study was to present an epidemiological re-

view of SCI secondary to RTAs. Stronger evidence on this condition in Latin America is important for future-specific data collection and prevention strategies. A literature review was carried out using specific search strategies in databases of indexed journals from the period 2000 to 2019. Data on SCI secondary to RTAs in the Latin American region were collected and analyzed. After initial screening and removal of duplicates, 16 articles met the inclusion criteria and were chosen for analysis. Data from 7 Latin American countries were retrievable. On average, RTAs were responsible for 40.81% of SCI. Data from different studies are heterogeneous. Car accidents and moto accidents were equally responsible for SCIs (50.61% vs. 49.06%). The thoracic

segments were the most commonly affected (57.87%). Males in their 30s were the most affected category (76.6%). SCI due to RTAs may represent a severe but preventable condition that affects mostly men in their productive age, generating important social and economic issues. Data about this condition in Latin America are scarce, and could limit prevention and treatment strategies. Prospective data collection about this condition is recommended.

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Introduction

Traumatic spinal cord injury (SCI) is a multifactorial condition derived from forceful mechanisms, penetrating injuries, or abrupt movements to the spinal structures. It can occur during road traffic accidents (RTAs), falls, sports, physical aggression, and work accidents, among others [1–7]. Trauma is responsible for approximately 15–41 cases of SCI per million inhabitants annually worldwide, and the population between 15 and 35 years of age is the most affected [1, 3, 8–10]. According to the literature, motor vehicle accidents are responsible for up to 50% of traumatic SCI cases [3, 11].

In low (LICs)- and middle (MICs)-income countries (LMICs), trauma patient costs are estimated to be about 100 billion dollars annually [12]. The World Health Organization has commented that “if the effectiveness of preventive actions is not increased, then road traffic injuries will continue to increase as well and will become a global public health crisis” [12–14]. Although multidisciplinary interventions have been implemented worldwide to reduce morbidity and mortality due to traumatic SCI, the prognosis can remain poor with tremendous social and economic costs [1, 7, 15–20].

Most data on the epidemiology of traumatic SCI derive from the USA and Canada, and information from other countries of the world is lacking, especially from LMICs [21]. It is estimated that 79,412 new persons are affected each year in Latin America [22].

Given that SCI due to RTAs is a potentially preventable condition, we feel the necessity to fill this lack of data in the Latin American region [8, 22–24]. This information could be helpful to define interventions and allocate resources to reduce the incidence, morbidity, and mortality of traumatic SCI in this region [25].

A literature review on traumatic SCI due to RTAs in Latin America was carried out using the following databases: Pubmed, LILACS, Scielo, Google Scholar, SCOPUS,

Table 1. Categorization of MeSH terms used for the database search

Region	Injury	Scenario	Statistics
Latin America	Spinal cord injury	Traffic accidents	Demography
Central America	Spinal cord trauma		Epidemiology
South America			
The Caribbean			

ClinicalKey, and ScienceDirect. All articles published between 2000 and 2019 were included for review. The MeSH terms used in the present study are categorized in the main groups listed in Tables 1 and 2.

Inclusion Criteria

Studies were included if they addressed epidemiological data of traumatic SCI in any Latin American country or countries, and contained data on spinal cord trauma secondary to RTAs in the Latin American region. Articles that were written in any language and published during 2000–2019 were included.

Exclusion Criteria

Studies were excluded if they (1) were published before the year 2000, (2) were not available in full-text format despite meeting the other inclusion criteria, (3) did not include data from Latin American countries, (4) reported on injuries other than traumatic SCI, and (5) published data on RTAs that did not include SCI.

Study/Source of Evidence Selection

This review was conducted following the SANRA scale for the quality assessment of narrative review articles. Following the search, all identified citations were uploaded into the Microsoft Excel for Office 365 format. Four researchers (L.F., D.E., L.A., and J.G.) independently assessed the relevance of each study by following the inclusion and exclusion criteria. The characteristics of the study (country, study period, and sample size) and the characteristics of the patients (age at presentation of SCI, mechanism of trauma, level of injury, and sex) were collected and tabulated. Full-text studies that did not meet the inclusion criteria were excluded. Any disagreements that arose between the researchers during either title and abstract screening or full-text screening were resolved through discussion [26].

Table 2. Specific MeSH terms used for the database search

MeSH terms	
Accidental falls/statistics and numerical data	Age factors
Accidents, traffic/statistics and numerical data	Cohort studies
Adolescent	Databases, factual/statistics and numerical data
Adult	Disabled persons
Middle aged	Incidence
Brazil/epidemiology	Life expectancy
Female	Prevalence
Male	Spinal cord injuries/diagnosis
Sex factors	Spinal cord injuries/therapy
Motorcycles	Global health
Patient admission/statistics and numerical data	Regression analysis
Spinal cord injuries/epidemiology	Spinal cord injuries/etiology
Spinal cord injuries/mortality	World Health Organization
Transportation of patients	
Prevenção	
Neurosurgery	
Spinal fractures	
Mortality	
Traumatology	

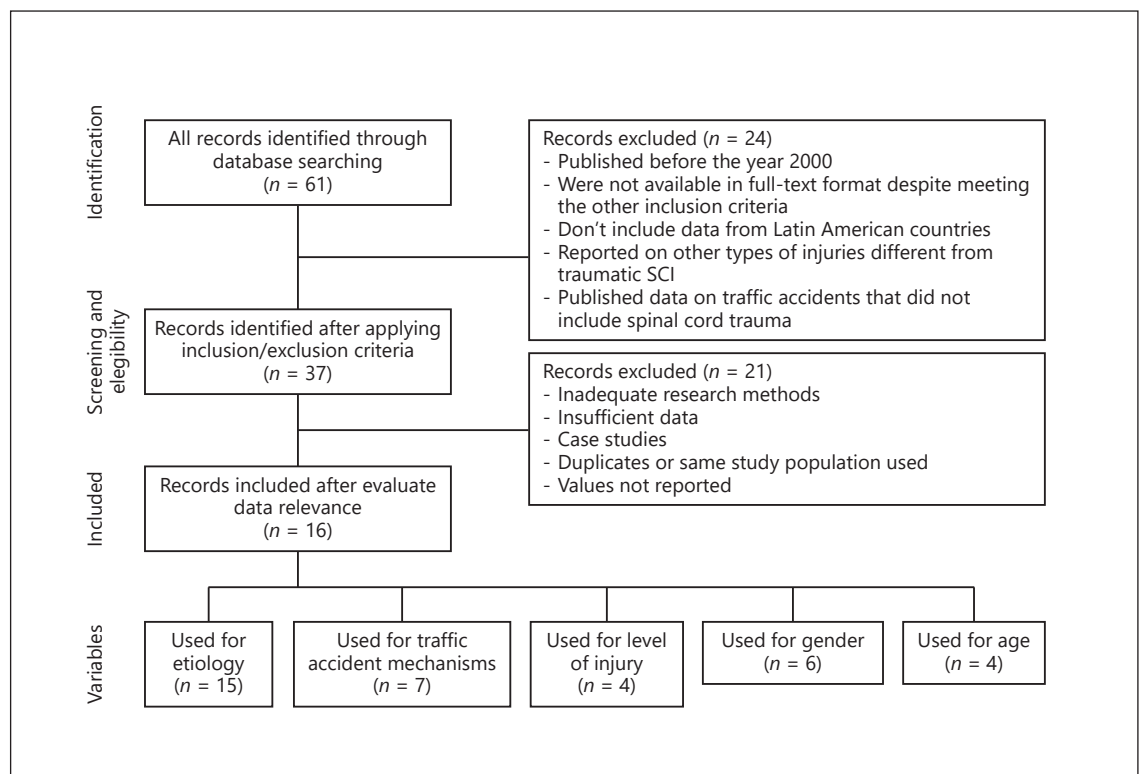


Fig. 1. Flowchart depicting the search strategy adopted to select the papers.



Fig. 2. Latin American countries included in studies from the literature review.

Data Extraction and Statistical Analysis

After retrieval of relevant studies, data were extracted according to the following variables: (1) etiology of SCI, (2) RTA mechanisms, (3) spinal level of injury, (4) gender, and (5) age. Statistical analysis (percentages, means, standard deviations, and ranges) was performed using Microsoft Excel for Office 365.

After the removal of duplicates, 61 articles were retrieved for screening. Ultimately, 16 articles met the inclusion criteria and were chosen for analysis (Fig. 1). These 16 articles provided data on 7 countries in Latin America (Fig. 2).

Etiology of SCI in Latin America

Fourteen studies reported on the etiology of SCI. These studies included a total of 3,690 patient records from health centers in Latin American countries. Six studies were from Brazil [27–32], 3 were from Colombia [11, 33, 34], 2 from Cuba [3, 35], 1 from Venezuela [36], 1 that registered patients from both Chile and Bolivia separately [37], and 1 from Mexico [38]. Altogether, 40.81% of all patients had a SCI secondary to RTAs. Other causes of SCI included gunshot wounds (21.72%), falls (21.39%), sports accident (1.03%), bladed weapon (0.29%), and other (13.43%).

Of the 6 studies from Brazil, 4 studies reported that the most common cause of SCI was RTAs. The remaining 2 found that falls were the most prevalent cause. In Colombia, of the 3 studies found, 2 reported that the most common cause was gunshot wounds, and 1 study cited falls as the most prevalent cause. In Venezuela, gunshot wounds were the most frequent cause of SCI in 1 study. Of the 2 studies in Cuba, one of them reported RTAs as the most

prevalent cause, while the other 1 found that RTAs and falls were equally responsible. The study that presented data from both Bolivia and Chile concluded that the most common causes were due to work accidents in Chile and falls in Bolivia. In Mexico, 1 study found that RTAs were the most common cause of SCI. A summary of this data is presented in Table 3.

Modality of Traffic Accidents in SCI

Seven studies reported data on the mechanism of RTAs related to SCI, which included automobile accidents, motorcycles, pedestrian injuries, and other means of transport (bus, truck, and bicycle) [1, 28–32, 39]. These data are summarized in Table 4. Six of these studies were from Brazil and 1 was from Cuba. These studies included a total of 1,225 SCI patients. According to these data, the vast majority of RTAs involved automobiles (50.6%) and motorcycles (49.1%). Pedestrian injuries (0.2%), and other vehicle modalities including buses, bicycles, etc. were less frequent (0.1%).

Level of Injury in SCI due to Traffic Accidents

Only 4 studies from Brazil reported on the level of SCI [28, 29, 39, 40]. These studies included 1,077 patients who suffered SCI due to RTAs in Brazil and classified these cases according to the anatomical level of trauma (Table 5). In the studies conducted by Bittencourt et al. [39] and Praga et al. [38], the cervical spine was most commonly injured (51.4% and 54.2%, respectively), while in the studies carried out by Oliveira et al. [27] and Barbeta et al. [28], thoracic injury predominated (52.8% and 61.3%, respectively). The least frequently injured was at the lumbosacral level in all studies.

Distribution of SCI Secondary to Traffic Accidents according to Gender and Age

Six articles (1 study from Mexico and 5 from Brazil) were found to report on the gender of patients with SCI RTAs [27–29, 38–40] (Table 6). In all these studies, men composed the majority of SCI cases, with a range of 69.4–87.7%.

Additionally, 4 studies from Brazil were also analyzed for data on the age of patients that was on average 30.2 years [27, 29, 39, 40] (Table 6).

Traumatic spinal injury comprises a variety of damages to the spinal cord and the other components of the spinal column. This can determine instability, pain, impaired mobility, and various grades of neurological impairment. SCI comprises a minority of spinal injuries that leads to neurological deficit. Among the patients re-

Table 3. Etiological distribution of traumatic SCI in Latin American Population

Etiological distribution of SCI in Latin American population										
country	author	year of publication	traffic accidents, n (%)	bladed weapon, n (%)	gunshot wound, n (%)	sports accident, n (%)	fall, n (%)	others, n (%)	not specified/ not founded/ missing patients	total of the records in the study
Brazil	Pereira et al. [27]	2010	49 (40.8)	5 (4.2)	33 (27.5)	nd	28 (23.3)	4 (3.3) deep sea diving and 1 (0.8) physical aggression	0	120
	Oliveira et al. [28]	2008–2009	36 (41.4)	nd	11 (12.6)	nd	37 (42.6)	3 (3.4) diving	0	87
	Barbetta et al. [29]	2014	907 (43.7)	nd	589.5 (28.4)	8.3 (0.4)	284.4 (13.7)	114.1 (5.5) diving, 6.2 (0.3) physical aggression, 37.3 (1.8) trampling, and 81 (3.9) impact of an object	47.7 (2.3%)*	2,076
	de Melo et al. [30]	2008–2012	174 (54.2)	nd	9 (2.8)	21 (6.54)	88 (27.41)	13 (4.04) shallow water immersion, 8 (2.49) trampling, and 8 (2.49) other	0	321
	Freire et al. [31]	2007–2008	10 (23.81)	nd	2 (4.76)	nd	26 (61.91)	4 (9.52) other	0	42
	Braga et al. [32]	2007–2012	27 (51.9)	nd	nd	nd	23 (44.23)	1 (1.92) accident with agricultural machinery and 1 (1.92) others	0	52
Colombia	Carvajal et al. [11]	2005–2010	22 (32)	1 (1.5)	39 (57)	1 (1.5)	5 (8)	Nd	0	68
	Teherán et al. [33]	2011–2014	49 (28.2)	nd	nd	nd	105 (60.3)	11 (6.3) blunt trauma and 9 (5.2) assault injury	0	174
	Henao et al. [34]	2009–2010	9 (20)	nd	20 (44)	nd	nd	16 (36) does not specify	0	45
Venezuela	Robles et al. [36]	2008–2010	17 (26.6)	1 (1.5)	32 (50)	nd	6 (9.4%)	8 (12.5%) shallow water	0	64
Cuba	García et al. [3]	2005–2010	16 (39.02)	4 (9.75)	1 (2.43)	nd	16 (39.02%)	3 (7.31) physical violence and 1 (2.43) indeterminate	0	41
	Bender et al. [34]	2000	47 (58.75)	nd	16 (20)	nd	8 (10)	5 (6.25) shallow water immersion, 2 (2.25) water accident, 1 (1.25%) fall from horse, and 1 (1.25) politrauma by earthquake	0	80
Chile	Vargas et al. [35]	2002–2010	29 (26.13)	nd	3 (2.70)	nd	33 (28.83%)	37 (32.43) work accident, 3 (2.70) home accident, and 8 (7.21) physical aggregation	0	113
Bolivia	Vargas et al. [37]	2002–2010	64 (25.48)	nd	15 (5.79)	nd	94 (37.07)	48 (18.92) work accident, 20 (8.11) home accident, and 18 (4.63) physical aggregation	0	259
Mexico	Pérez et al. [38]	2000–2004	50 (33.78)	nd	31 (20.94)	8 (5.40)	36 (24.32)	Medical causes: 23 (15.54)	0	148
Total	–	–	1,506.2 (40.81)	11 (0.29)	801.5 (21.72)	38.3 (1.03)	789.4 (21.39)	495.6 (13.43)	47.7 (1.33)	3,690 (100)

nd, no data. * Authors referred not missing data, but 2.3% of the remaining data were not found in the study.

Table 4. Mechanisms of traffic accidents in Latin American patients with SCI

Mechanisms of traffic accidents in Latin American patients with SCI							
country	author	year	car, <i>n</i> (%)	motorcycle, <i>n</i> (%)	pedestrian injuries, <i>n</i> (%)	bus, truck, bicycle, and others, <i>n</i> (%)	all types of traffic accident, <i>n</i> (100%)
Brasil	Praga et al. [39]	2007–2008	17 (70.83)	5 (20.83)	2 (8.33)	nd	24
	Oliveira et al. [28]	2008–2009	21 (58.33)	15 (41.66)	nd	nd	36
	Barbetta et al. [29]	2014	397 (43.77)	510 (56.22)	nd	nd	907
	Melo et al. [30]	2008–2012	125 (86.20)	49 (28.16)	nd	nd	174
	Freire et al. [31]	2007–2008	2 (20)	8 (80)	nd	nd	10
	Braga et al. [32]	2007–2012	12 (44.44)	14 (51.85)	nd	1 (3.70%)	27
Cuba	Bender et al. [35]	2000	46 (97.87)	nd	1 (2.12)	nd	47
Total	–	–	620 (50.61)	601 (49.06)	3 (0.24%)	1 (0.08%)	1,225

nd, no data.

Table 5. Level of spinal injury in SCI due to traffic accidents in Latin American patients

Level of spinal injury in SCI due to traffic accidents in Latin American patients							
country	author	total of the patients, <i>n</i> (%)	cervical, <i>n</i> (%)	thoracic, <i>n</i> (%)	lumbo-sacral, <i>n</i> (%)	not specified/not founded/not documented, <i>n</i> (%)	other considerations
Brazil	Bittencourt et al. [40]****	110*/105**	54 (51.4 of the 105 patients)	39 (37.2 of the 105 patients)	Lumbar 12 (11.4 of the 105 patients), Sacro – nd	4.95 (4.5 of the 110 patients)	1.8% of patients suffered injuries to more than one spinal segment
	Praga et al. [39]	24 (100)	13 (54.17)	7 (29.17)	Lumbar 4 (16.67), Sacro – nd	0	–
	Oliveira et al. [28]	36 (100)	10 (27.77)	19 (52.77)	Lumbar 7 (19.44), Sacro – nd	0	–
	Barbetta D et al. [29]	908 (100)	CA 169 (55.96)***, MA 133 (44.03)***, total: 302 (33.2)	CA 202 (36.33)***, MA 354 (63.66)***, (46)***, total: 556 (61.23)	CA27 (54)***, MA 23 (46)***, total: 50 (5.50)	0	–
	Total	–	1,073 (100)	379 (35.32)	621 (57.87)	73 (6.80)	–

CA, car accident; MA, motorcycle accident; nd, no data. * 110 patients in whom 4.5% the level of the lesion was not documented. ** 105 patients with information on the level of the lesion. *** (%) percentage of total cervical, thoracic, or lumbo-sacral injuries.

porting a traumatic spinal injury, a large difference exists between the proportion of patients with SCI in high-income countries (25.27%) compared to the MICs (36.6%) and LMICs (70.4%) [22].

A study by Lee et al. estimated the incidence of SCI in 131 of 178 countries using a population-based regression model, without differentiating the causes of it. Many of these countries included in their analysis lacked high-quality studies on this topic. In their study, 23 of 131 total

countries were part of the Americas, 3 of these were high-income countries, and 20 were MICs. For MICs, the estimated median incidence of SCI (per million persons) was 22 (range: 13–30). It is important to highlight that in 6 MICs located in the Americas, it was not even possible to estimate these data [41].

Ackery et al. [23] published a review on SCI epidemiology from 17 countries and 6 continents that included high-income countries, LMICs, and LICs. They found

Table 6. Distribution by gender and age of Latin American patients with SCI due secondary to traffic accidents

Distribution by gender and age of Latin American patients with SCI due secondary to traffic accidents							
country	author	period	total	M:F	female, n (%)	male, n (%)	age, years
Brazil	Bittencourt et al. [40]	2000–2010	110	1:0.14	14.3 (13)	95.7 (87)	30
	Praga et al. [39]	2007–2008	24	1:0.20	4 (16.66)	20 (83.33)	27.1
	Pereira et al. [27]	2010	49	1:0.13	6 (12.24)	43 (87.75)	32.9
	Oliveira et al. [28]	2008–2009	36	1:0.44	11 (30.6)	25 (69.4)	n.a.
	Barbetta et al. [29]	2014	907	1:0.33	225.09 (24.81)	681.9 (75.16)	31
Mexico	Pérez et al. [38]	2002–2004	50	1:2.57	14 (28)	36 (72)	n.a.
Total	–	–	1.176	1:0.30	274.39 (23.33)	901.6 (76.66)	n.a.
Mean age	–	–	–	–	–	–	30.2

n.a., not available.

that in high-income countries, patients suffering from traumatic SCIs have a longer life expectancy than those in LMICs or LICs. They conclude that injury prevention programs are needed in those areas [23]. This is particularly true in SCI due to RTAs as it most often occurs in the economically productive age-groups (adolescence and young adults), causing serious social and economic issues [25, 42–44]. According to the last Organization for Economic Co-operation and Development list, among the Latin American countries, only Chile, Uruguay, and some Caribbean Islands are classified as high-income countries and not as LMICs [45].

Even before analyzing the results of our study, the lack of homogeneous information about SCI due to RTAs in Latin America is evident. Among the 21 Latin American countries, it was possible to retrieve information from only 7 of them (33.3%). Notably, even if only one-third of the Latin American countries are represented in this review, around 80% of the population of Latin America live in these regions.

According to the available literature, RTAs are the most common cause of traumatic SCI worldwide, and one could expect that these results could fit also for the Latin America region [3, 11]. Surprisingly, according to our review, this assumption is not homogeneous in the area. Even in Brazil (where anyway lives around 38% of the population of Latin America), 2 out of 6 articles reported falls as the most common cause of traumatic SCI [28, 31]. Nevertheless, these studies comprise a few numbers of patients, and a total of 1,203 out of 2,698 Brazilian patients suffered SCI due to RTAs (44.6%). Violence seems to be the most relevant cause of traumatic SCI in

Colombia (2 out of 3 studies; in none of the studies, RTA was the most common cause) and in Venezuela, and in both countries, the percentage of SCI due to RTAs seems to be up to 32% of cases. This well correlates with the high rate of homicides, where 27 and 57 homicides per 100,000 inhabitants yearly are reported for Colombia and Venezuela, respectively. We could not compare countries with higher homicide rates (e.g., El Salvador, Honduras) as we did not find studies exploring this topic in these countries [46]. In Chile (4 homicides per 100,000 inhabitants yearly), violence seems to be responsible for a negligible proportion of cases, and RTAs follow falls as the second most common cause. In high-income countries, the rate of homicides (and similarly the rate of SCI due to violence) is significantly lower [47].

RTAs remain responsible for most cases in Brazil, Cuba (with percentages reaching almost 59% of cases), and Mexico. The large number of cases in the Brazilian region of SCI due to RTAs contributes to make this the most relevant cause of traumatic SCI in Latin America; excluding the patients of the Brazilian studies, the number of patients suffering from SCI due to RTAs is 303 out of 992 (30.5%). We assume that the heterogeneity of the causes of SCI in Latin America is multifactorial and includes demographic, social, and cultural differences among the countries.

Regarding the mechanism of RTAs responsible for SCI, the information was available for only 2 countries (Brazil and Cuba). In Cuba, the vast majority of cases was due to car accidents (almost 98%), but the number of patients included in the study is small. The results from the Brazilian studies are heterogeneous, as car accidents are

reported as the most common cause in 3 studies (from 58.33% to 86.2%) and motorcycle in 3 other (from 51.85% to 80%). Altogether, in Brazil, 48.7% of SCI due to RTAs seems to be caused by car collisions and 51% by motorcycle accidents.

Regarding the level of the lesion, information was available only from Brazilian studies. Two studies found the cervical spine as the most affected, while other studies found it was the thoracic one. In all studies, the lumbosacral region was the least commonly affected. These data are consistent with other studies that confirm the cervical and thoracic regions as the most vulnerable to road traffic collision [4, 8, 48]. Notably, only one of these studies (i.e., the study with the larger number of patients) correlates the exact mechanism of road accident and the level of injury, finding a higher proportion of cervical injuries in car accidents and of thoracic injuries in moto vehicle collisions [29].

The available literature reports that males are more affected than females by SCI due to RTAs and our results confirm these data, even if this information was available only from Brazil and Mexico (76.7%). Notably, in none of the study, females were more affected than male, and only in 1 study, the proportion of affected females reached 30% [28].

Regarding age, it has been described that SCI due to RTAs most commonly affects the economically active young population between the ages of 15–35 years. The data in our review also confirm these results in Brazilian studies.

The results of our study demonstrate the lack of information about traumatic SCI due to RTAs in the Latin American region, even if this is considered the most common cause of traumatic SCI worldwide. Only a few studies from a small number of countries focus on this topic, they are often small series of cases, and they generally provide insufficient demographic and clinical data.

This paucity of information precludes a real understanding of the phenomena and the consequent development of prevention and action strategies. These may include legislative interventions (i.e., to stimulate the use of helmets and seat belts or to contrast the use of cell phone or alcohol intake when driving), enforcement (i.e., increase of policy enforcement), public awareness/educational policies, speed control, and road condition improvement [49]. The development of high-quality prospective clinical registries about this condition is desirable.

Our review was limited by the lack of sufficient studies for a more complete and complex analysis on several Latin American countries. Most of the collected data were from Brazilian studies, so it should be noted that the rest

of Latin American countries have insufficient or no data on SCI associated with the analyzed variables. For most of the analyzed countries, only 1 study was available. This generates selection bias, and these data therefore may not be extrapolated to other countries of Latin America.

Conclusions

RTAs are one of the leading causes of SCI in the Latin American population. SCI due to this specific cause is a condition that mostly affects men in their early adult age. The cervical and thoracic spine are the most commonly affected regions. However, data available on SCI in Latin America and specifically those secondary to RTAs are scarce. The development of clinical registries for prospective data collection about this condition in the region would contribute to a better understanding of the phenomena. These data could be helpful for the development of clinical practice guidelines adjusted to the Latin American context for both prevention measures as for the management and comprehensive monitoring of this condition.

Statement of Ethics

All authors have adhered to institutional and generally accepted ethical standards. The research was conducted ethically according to the World Medical Association Declaration of Helsinki.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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Author Contributions

Laura Lucía Fernández Londoño conceived and designed the analysis, collected the data, performed the analysis, wrote the paper, and critically revised the paper; Nicolò Marchesini performed the analysis, wrote the paper, and critically revised the paper; Deyer Espejo Ballesteros, Laura Álzate García, Johanna Alejandra Gómez Jiménez, and Elizabeth Ginalis conceived and designed the analysis, collected the data, performed the analysis, and wrote the paper; Andrés M. Rubiano conceived and designed the analysis, and critically revised the paper. Dylan Griswold conceived and designed the analysis, collected the data, and critically revised the paper; Andrés Mariano Rubiano conceived and designed the analysis, and critically revised the paper.

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