Epidemiology of Traumatic Spinal Cord Injuries in Iran; a Systematic Review and Meta-Analysis

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Abstract: Introduction: Understanding the epidemiology of traumatic spinal cord injuries (TSCIs) can be helpful for policymakers and planners to consider appropriate strategies to control and prevent these injuries. This study aimed to determine the epidemiological characteristics of TSCI in Iran in order to increase knowledge and awareness of these injuries. Methods: A systematic literature search was conducted up to January 2022 in the electronic databases, including PubMed, Scopus, Web of Science, Google Scholar, SID, Iranmedex, and Magiran. The quality of included studies was evaluated using the STORBE checklist. Comprehensive meta-analysis was used to analyze the data. Results: Nineteen studies involving 9416 cases were included in the study. Participants' pooled mean age was 35.80 ± 1.07 years (95% CI: 33.69 to 37.91), of whom 69% (95% CI: 68% to 70%; P<0.05) were male. The most frequent TSCI occurred in the age group of less than 30 years. Motor vehicle collisions (MVCs) was the most common cause of TSCI (57%; 95% CI: 25% to 63%), followed by falls (32%; 95% CI: 26% to 38%). Most participants had thoracolumbar (27%; 95% CI: 10% to 55%) and cervical injuries (23%; 95% CI: 16% to 31%), respectively. The incidence of TSCI was estimated at 10.5 per million people. The prevalence of TSCI was 3 per 10000 people. The mortality rate due to TSCI was 3.9% (95% CI: 0.02 to 0.06; P<0.05). Conclusion: Based on the findings of this meta-analysis, the pooled incidence and prevalence of TSCI in the Iranian population were 10.5/1000000 people and 4.4/10000 people, respectively. TSCIs had occurred more frequently in males following MVCs, and in the age group under 30 years. The pooled mortality rate due to TSCI was 3.9% (95% CI: 0.02 to 0.06; P<0.05).

Keywords: Spinal Cord Injuries; Epidemiology; Prevalence; Incidence; Iran

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1. Introduction

Spinal cord injuries are classified into two types, traumatic and non-traumatic (1). Traumatic spinal cord injuries (TSCI) are one of the most severe conditions in terms of morbidity and disability (2, 3). The mortality rate in people with TSCI is higher than that of normal people (4). The in-hospital mortality rate of spinal cord injuries varies from region to region (4). The most common causes of TSCI are motor vehicle collisions (MVCs), falls, violence, and sports/leisure activities (5). TSCIs predominantly occur in males younger than 30 years old (6), and most frequently at the level of the cervical spine, followed by thoracic, and lumbosacral (7). In 2016, there were 0.93 million (0.78-1.16 million) new cases of SCI, with age-based standardized incidence rates of 13 (11-16) per 100 000 people for SCI (8).

The incidence rate is different from one country to another (9). TSCI is a costly injury for patients as the average cost for the initial injury and recovery phase of SCI can be $142,366 (10). The most common symptoms in patients with TSCI include pain, weakness, fatigue, and numbness (11). The most common outcomes after TSCI are paralysis (12), depression (13), anxiety (14), osteoporosis (15), adverse events, including urinary tract infections, pneumonia, neuropsychiatric pain, delirium, pressure ulcers (16), hydronephrosis, bladder stones, vesicoureteral reflux (17), Hypothermia (18), cardiovascular complications, and autonomic dysreflexia (19).

Given that TSCIs vary by country and region (20), and there is no meta-analysis regarding these injuries in Iran, there is an urgent need to determine the epidemiological characteristics of TSCI in the Iranian population.

2. Methods

The Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines (21) were used when writing the report, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was used when preparing the report (22).

2.1. Literature search strategy

Two authors, independently, carried out a systematic literature search in the most important electronic databases, including PubMed, Scopus, Web of Science, Google Scholar, SID, Iranmedex, and Magiran to identify the studies published in English or Persian languages up to January 2022 using keywords. Furthermore, the list of references of records included in the final analysis was scanned for more articles. The key search terms included traumatic spinal cord injuries, epidemiology, prevalence, incidence, risk factors, and Iran. The search strategy by database was:

**PubMed**
- #1. Spinal Cord Injur* [Title/Abstract] OR Spinal Cord Injuries [MeSH Terms]
- #2. Epidemiolog* [Title/Abstract] OR Epidemiology [MeSH Terms]
- #3. Incidence [Title/Abstract] OR Incidence [MeSH Terms]
- #4. Risk factor* [Title/Abstract] OR Risk factor [MeSH Terms]
- #5. Prevalence [Title/Abstract] OR Prevalence [MeSH Terms]
- #6. Iran [Title/Abstract]
- #7. 2 OR 3 OR 4 OR 5
- #8. 1 AND 7 AND 6

**Web of Science**
- #1. TI= (Spinal cord injur*)
- #2. TI= (Epidemiolog *)
- #3. TI= (Incidence)
- #4. TI= (Prevalence)
- #5. TI= (Risk factor*)
- #6. TI= (Iran)
- #7. 2 OR 3 OR 4 OR 5
- #8. 1 AND 7 AND 6

**Scopus**
- #1. TITLE-ABS-KEY (Spinal cord injur*)
- #2. TITLE-ABS-KEY = (Epidemiolog *)
- #3. TITLE-ABS-KEY = (Incidence)
- #4. TITLE-ABS-KEY = (Prevalence)
- #5. TITLE-ABS-KEY = (Risk factor*)
- #6. TITLE-ABS-KEY = (Iran)
- #7. 2 OR 3 OR 4 OR 5
- #8. 1 AND 7 AND 6

2.2. Study selection

Epidemiological studies conducted on the Iranian population with TSCI were included, and those conducted on individuals with non-traumatic spinal cord injuries, with irrelevant outcomes, case series, case reports, and the letters to the editor were excluded.

2.3. Data extraction and quality assessment

The methodological quality of included studies was assessed using ROBINS-I tool (23). Two authors extracted the epidemiological and demographic data, independently, using the same extraction form. The extracted information included 1) study characteristics (first author, year, place, period, and type), demographic characteristics (sample size, mean age, and sex), and epidemiological outcomes (preva-
### Table 1: Characteristics of included studies

| Study                  | Province          | Period           | N   | Ratio (M:F) | Mean age | Incidence /1000000 | Prevalence /1000   | Leading causes | Second causes |
|------------------------|-------------------|------------------|-----|-------------|----------|-------------------|------------------|----------------|---------------|
| Andalib, 2018 (24)     | Guilan            | 2015-2018        | 127 | 3.5:1       | 38.27    | NR                | NR               | MVCs           |              |
| Derakhshanrad, 2016 (25)| Tehran            | 2011-2013        | 137 | 3.8:1       | 29.1     | NR                | 2.36             | MVCs           | falling       |
| Fakharian, 2004 (27)   | Isfahan           | 1995-1999        | 225 | 3.6:1       | 39       | NR                | NR               | MVCs           |              |
| Fakharian, 2019 (26)   | Isfahan           | 2014-2017        | 986 | 3.3:1       | 39.5     | NR                | NR               | MVCs           | falling       |
| Ghaajirzadeh, 2019 (28)| Tehran            | 2013-2017        | 830 | 4.3:1       | 29       | NR                | NR               | MVCs           | falling       |
| Haddadi, 2015 (29)     | Mazandaran        | 2012-2014        | 908 | 1.3:1       | NR       | NR                | NR               | MVCs           | falling       |
| Jazayeri, 2015 (30)    | Tehran, Alborz    | 2015             | NR  | NR          | NR       | NR                | NR               | MVCs           | falling       |
| Kamravan, 2014 (31)    | Fars              | 2009-2012        | 261 | 3:1         | 37.2     | NR                | NR               | MVCs           |              |
| Khazaeipour, 2017 (32) | Tehran            | 2012-2013        | 140 | 2.5:1       | NR       | NR                | NR               | MVCs           | falling       |
| Rahimi-movaghar, 2009 (35)| Tehran          | 2007-2008        | 4   | 1:1         | 31.7     | NR                | 4.4              | MVCs           | falling       |
| Ramezani, 2019 (36)    | Guilan            | 2015-2017        | 170 | 2.3:1       | 40.2     | NR                | NR               | MVCs           | falling       |
| Rasouli, 2007 (33)     | Southeastern Iran | 1994-2005        | 64  | 18.1:1      | 27.42    | NR                | NR               | MVCs           |              |
| Saatian, 2020 (37)     | Hamadan           | 2007-2017        | 3219| 2:1         | 41.7     | NR                | NR               | MVCs           | falling       |
| Sharif-Alhoseini, 2014 (38)| Tehran          | 2010-2011        | 138 | 5.5:1       | 33.2     | 10.5             | NR               | MVCs           |              |
| Tabshe, 2018 (34)      | Isfahan           | 2012-2018        | 510 | 2.3:1       | 42.3     | NR                | NR               | MVCs           |              |
| Yousefzadeh-Chabok, 2010 (41)| Guilan      | 2005-2006        | 245 | 2.5:1       | 38.2     | NR                | NR               | MVCs           |              |
| Yousefzadeh-Chabok, 2015 (42)| Guilan      | 2015             | 76  | 8.5:1       | 35.2     | NR                | NR               | MVCs           |              |
| Yadollahi, 2018 (39)   | Fars              | 2017             | 171 | 4.9:1       | 38.2     | NR                | NR               | MVCs           |              |
| Yazdani, 2021 (40)     | Hormozgan         | 2017             | 207 | 2.5:1       | 40.2     | NR                | NR               | MVCs           | falling       |

N: number of participants, M: male, F: female, NR: not reported, MVCs: motor vehicle collisions.

### Table 2: Risk of bias (ROBINS-I)

| Study                  | Confounding | Selection | Intervention | Measurement | Missing Data | Outcome | Measurement | Reported Result | Overall |
|------------------------|-------------|-----------|--------------|--------------|--------------|---------|--------------|------------------|---------|
| Andalib, 2018          | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Derakhshanrad, 2016    | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Fakharian, 2004        | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Fakharian, 2019        | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Ghaajirzadeh, 2019     | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Haddadi, 2015          | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Jazayeri, 2015         | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Kamravan, 2014         | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Khazaeipour, 2017      | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Rahimi-movaghar, 2009  | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Ramezani, 2019         | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Rasouli, 2007          | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Saatian, 2020          | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Sharif-Alhoseini, 2014 | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Tabshe, 2018           | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Yousefzadeh-Chabok, 2010 | Moderate   | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Yousefzadeh-Chabok, 2015 | Moderate   | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Yadollahi, 2018        | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |
| Yazdani, 2021          | Moderate    | Low       | Low          | Low          | Low          | NR      | Low          | Moderate         | Moderate |

Note: Moderate=the study is sound for a non-randomized study with regard to this domain but cannot be considered comparable to a well-performed randomized trial; Low=the study is comparable to a well-performed randomized trial with regard to this domain.

2.4. Evidence synthesis

The epidemiological and demographic findings of included studies were summarized. The Comprehensive Meta-Analysis software was used to analyze the data. The mean difference (MD) and the risk ratio (RR) with a 95% confidence interval and incidence rate, risk factors, level of injuries, and mortality rate).
interval (CI) were used for continuous and dichotomous variables, respectively. The random-effect model was used for studies with I²>50% or P<0.1. Otherwise, the fixed-effect model was used.

3. Results

3.1. Search results

PRISMA flow diagram of the study selection process is shown in Figure 1. In total, 265 records were identified after duplicate removal by searching the databases and resources. After screening the records by their titles and abstracts, 36 studies were screened for eligibility. Finally, nineteen studies (24-42) involving 9416 cases were included in our analysis. The main characteristics of the included studies are presented in Table 1.

3.2. Assessment of risk of bias

The results of assessing risk of bias of included studies are presented in Table 2. The methodological quality of included studies was acceptable.

3.3. Demographic characteristics

The included studies reported the mean age of TSCI patients in the range of 27.42 to 42.31 years. The pooled mean age of the participants was 35.80 ± 1.07 (CI: 33.69 to 37.91) years. A small number of studies reported the frequency of TSCI by age groups. According to the findings of the studies, the largest age group was under 30 years. The majority of participants were male (69%; 95% CI: 68% to 70%) and the male-to-female ratio was 2.4:1. The lowest and highest male-to-female ratios were 1.3:1 and 18:1 in the North and South-East of Iran, respectively.

3.4. Etiology

MVCs were the leading cause of TSCI in Iran (57.9%; CI: 25% to 63%), followed by falls (32%; CI: 26% to 38%), assaults (7%; CI: 3% to 14%), and other causes (8%; CI: 6% to 11%), respectively (Figure 2). However, in two studies (27, 38), falls were presented as the main cause of TSCI.

3.5. Prevalence and incidence

Three studies (25, 30, 35) reported the prevalence of TSCI in the Iranian population. The meta-analysis result showed the prevalence of TSCI in the Iranian population was 4.4 per 10000 people (Figure 3). Only one study (38) examined the incidence of TSCI, according to which the incidence rate of TSCI among the Iranian population was estimated at around 10.5 per million people.

3.6. Mortality rate

Nine studies involving 6744 cases reported the mortality rate among people with TSCI. The findings of meta-analysis revealed that mortality rate due to TSCI was 3.9% (95% CI: 0.02 to 0.06; P<0.05) (Figure 4).

3.7. Injury level

Anatomical most common sites of TSCI were thoracolumbar (27%; CI: 10% to 55%), cervical (23%; CI: 16% to 31%), thoracic (20%; CI: 9% to 40%), lumbar (20%; CI: 12% to 31%), and other multiple traumas (16%; CI: 7% to 32%), respectively (Figure 5).

3.8. Sensitivity analysis

A sensitivity analysis was performed to compare the fixed- and random-effect estimates of the effect size. The result showed no change in the effect size.

4. Discussion

According to the present study’s findings, the overall mean age of TSCI in the Iranian population was 35.80 ± 1.07 years. The results of a systematic review conducted in the Middle East and North Africa showed that the mean age of the patients with TSCI was 31.32 years (43), which was similar to our finding. In addition, the most commonly affected people were in the 20-29 years age group (43). This result is also in line with our findings. A systematic review of the epidemiology of TSCI in Asian countries indicated that the mean age of injured people ranged from 26.8 to 56.6 years (44). Our study also revealed that most TSCIs (69%) occurred in males, and TSCI rate in men was almost 2.4 times greater than women. The pooled proportion of male gender in the Middle East and North Africa (43) was 77% of all cases, which was similar to our results. The evidence showed that in developing countries (45), males comprised most TSCI cases. Furthermore, a global study showed that the majority of TSCI occurred in males and mostly in individuals aged under 30 years (9). Our study demonstrated that MVCs were the leading cause of TSCI in Iran. A similar pattern was found in the Middle East and North Africa regions (43), in which MVCs were introduced as the main cause of injuries, followed by falls. Moreover, a systematic review (45) conducted in developing countries showed that MVCs and falls were the most common mechanisms of TSCI. Similar findings were observed in Asia (44) and around the world (9), which were in line with our results. However, in Europe, the most common causes of injuries were falls and MVCs, respectively (46).

The incidence and prevalence of TSCI varied between developing and developed countries (9). Based on the present study, the prevalence of TSCI in Iran was 4.4 per 10000 people, and the incidence rate of TSCI among the Iranian popu-
lation was estimated at 10.5 per million people. The pooled annual incidence of TSCI in the Middle East and North Africa (43) was 23.24 per million people, which was higher than that of Iran.

According to the meta-analysis, the mortality rate due to TSCI among the Iranian population was 3.9%. A meta-analysis (4) conducted by Chamberlain et al. showed that TSCI-related mortality rates ranged from 2.1%, 7.0%, 7.6%, to 24.1% in the WHO regions of Western Pacific, Europe, the Americas, and Africa, respectively. The result of research conducted in Europe (46) showed that most deaths occurred in the older age groups, especially in the female population. The most common causes of death were falls (53%) and MVCs (23%) with the same proportions in both sexes. Generally, older age, injuries related to TSCI, tetraplegia, and tracheostomy have been suggested as the risk factors associated with mortality due to TSCI (47, 48). Since environmental, behavioral, and health factors can play a key role in mortality after TSCI (49), intervention strategies focusing on these factors may lead to reduction in mortality due to TSCI (50).

Based on the findings of the current study regarding injury levels, most participants had thoracolumbar cord and cervical injuries. A literature review of worldwide epidemiology (51) showed that cervical level of the spine was the most common part to get injured. It seems that appropriate prevention and control strategies for TSCI in Iran should focus on males, MVCs, and the age group under 30 years. These findings can be helpful for health researchers and policymakers to plan strategies for controlling and preventing these injuries. However, further detailed studies with large sample sizes and subgroup data are required to investigate the factors affecting TSCI in Iran.

5. Limitations

This study had some limitations. First, not all studies in the meta-analysis reported the outcomes of interest, including standard deviation of mean age, male to female ratio, injury mechanisms, and injury levels. Second, most studies have been conducted in the central part of Iran, which can be considered as a problem for the generalizability of our findings. Finally, we could not perform a meta-analysis on TSCI-related mortality rates based on injury mechanisms, age groups, and sex due to lack of data.

6. Conclusion

Based on the findings of this meta-analysis, the pooled incidence and prevalence of TSCI in the Iranian population was 10.5/1000.000 people and 4.4/10.000 people, respectively. TSCIs had occurred more frequently in males following MVCs, and in the age group under 30 years. The pooled mortality rate due to TSCI was 3.9% (95% CI: 0.02 to 0.06; P<0.05).

7. Declarations

7.1. Acknowledgments

None.

7.2. Authors’ contributions

- Study design: Roya Amiri, Mohsen Saheban maleki
- Designing search strategy and performing the search: Seyyedeh Omolbanin Seyedrezaei, Mohsen Saheban Maleki, Farahnaz Khajehnasiri
- Data gathering: Maryam Ebrahimpour Roodposhti, Hesamedin Askari Majdabadi
- Analysis and interpreting the result: Behzad Khedri, Mohsen Poursadegiyan, Nasir Amanat
- Drafting the manuscript: Roya Amiri, Farahnaz Khajehnasiri
- Critical review of the paper: All authors
- All authors approved the final manuscript version and are accountable for all work aspects.

7.3. Funding Source

None.

7.4. Conflict of Interest

There is no conflict of interest.

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Figure 1: The PRISMA flow diagram of study selection process.
Figure 2: Forest plot of mechanism of injury: motor vehicle collisions (A), falls (B), assault (C), other causes (D).
**Figure 3:** Forest plot of prevalence rate of traumatic spinal cord injuries.

| Study name         | Event rate | Lower limit | Upper limit | Z-Value | p-Value |
|--------------------|------------|-------------|-------------|---------|---------|
| Derakhshenasrad, 2016 | 0.0002     | 0.0002      | 0.0003      | -123.2322 | 0.0000  |
| Jazayeri, 2015    | 0.0003     | 0.0003      | 0.0003      | -139.7546 | 0.0000  |
| Rahimi-movaghar, 2009 | 0.0004     | 0.0004      | 0.0005      | -162.0744 | 0.0000  |

**Figure 4:** Forest plot of rate of mortality due to traumatic spinal cord injuries.

| Study name             | Event rate | Lower limit | Upper limit | p-Value |
|------------------------|------------|-------------|-------------|---------|
| Andalib, 2018          | 0.016      | 0.004       | 0.061       | 0.000   |
| Saatian, 2020          | 0.049      | 0.042       | 0.057       | 0.000   |
| Chabok, 2010           | 0.092      | 0.045       | 0.181       | 0.000   |
| Fakharan, 2019         | 0.024      | 0.016       | 0.036       | 0.000   |
| Ghajarzadeh, 2019      | 0.027      | 0.018       | 0.040       | 0.000   |
| Kamravan, 2014         | 0.057      | 0.035       | 0.093       | 0.000   |
| Sharif-Alhoseini, 2014 | 0.007      | 0.003       | 0.015       | 0.000   |
| Yadollahi, 2018        | 0.135      | 0.091       | 0.194       | 0.000   |
| Yazdani, 2021          | 0.044      | 0.024       | 0.079       | 0.000   |
|                       | 0.039      | 0.025       | 0.062       | 0.000   |

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Figure 5: Forest plot of the level of the injury: cervical (A), thoracic (B), thoracolumbar (C), lumbar (D), multiple traumas (E).