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ORIGINAL ARTICLE

Incidence of traumatic spinal cord injury in Thessaloniki, Greece and Stockholm, Sweden: a prospective population-based study

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Study design: Prospective population-based open-ended study. This paper is part of the Stockholm–Thessaloniki Acute Traumatic Spinal Cord Injury Study.
Objectives: To calculate incidence and evaluate the epidemiological profile of the incident population with traumatic spinal cord injury (TSCI).
Settings: The greater Thessaloniki region in Greece and the greater Stockholm region in Sweden.
Methods: TSCI individuals, older than 15 years of age, who had survived the first 7 days post-trauma, were identified through an active surveillance system. The forms of the Nordic Spinal Cord Injury Registry were used.
Results: 87 individuals were injured in the greater Thessaloniki and 49 in the greater Stockholm region. Annual crude incidence was 33.6 per million for Thessaloniki and 19.5 per million for the Stockholm region. The leading causes of injury for the Thessaloniki region were transportation accidents (51%) and falls (37%), and those for the Stockholm region were falls (47%) and transportation accidents (23%). A significantly larger number of individuals of the Thessaloniki group were injured in transportation accidents. There was no significant difference between regions with regard to the type of resulting impairment.
Conclusions: Incidence of TSCI was considerably higher in the Thessaloniki region as compared with that in the Stockholm region, probably chiefly reflecting differences in preventative measures with regard to driving.
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Keywords: spinal cord injuries; incidence; cause of injury; spinal injury unit; demography; epidemiology

Introduction

Research and clinical experience provide strong evidence that centralisation of care for traumatic spinal cord injury (TSCI) in spinal injury units (SIUs), rather than in general wards, results in superior outcomes from health, functional, social and economical perspectives.[1–3] Although Sweden has established comprehensive SIUs at six university hospitals, TSCI individuals in Greece are still managed in a multitude of wards in many general hospitals.

Large quality-assured registries allow international comparisons, providing more in-depth knowledge and enabling identification of global trends. Moreover, the role of registries is vital in designing prevention strategies as well as therapeutic interventions, according to the needs of each individual setting.[4] Although Sweden maintains a thorough national registry on all incident and prevalent TSCI individuals, there is no form of regional or national registry on TSCI in Greece. So far, there has not been any well-designed study that has evaluated epidemiological and/or clinical characteristics of the incident TSCI cases in Greece and in Sweden.

This paper is part of a comparative study of TSCI in Greece and in Sweden, the Stockholm–Thessaloniki Acute Traumatic Spinal Cord Injury Study (STATSCIS). In summary, STATSCIS aims at evaluating the demographic and clinical characteristics, the clinical process and the outcomes at one year post-injury of the incident TSCI populations in a Northern and a Southern European Union (EU) region. The specific aim of this paper is to evaluate the epidemiological profile of the incident population with TSCI in the greater Thessaloniki and Stockholm regions.

Materials and methods

Design

Cohorts of all newly injured individuals with TSCI in the greater Thessaloniki and Stockholm regions were prospec-

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tively identified and evaluated in terms of demographic and injury characteristics in a population-based open-ended study design. Inclusion of acute cases commenced in September 2006 and was decided to run for at least a year, or until one of the regions reached approximately 100 cases.

Settings and identification of individuals

In accordance with the Nomenclature of Territorial Units for Statistics (NUTS) adopted by the European Commission, what in the present study is referred to as the 'greater Thessaloniki region', referred to as so in this study, consists of Central and Western Macedonia, Greece. The 'greater Stockholm region' consists of Stockholm County and Gotland County, Sweden. The two regions have similar population sizes of approximately 2 million inhabitants each, with the Thessaloniki region being three times larger in territorial size than the Stockholm region (Table 1).

Within the greater Thessaloniki region, of a total of 30 hospitals, five are at a tertiary level, and thus, in principle, able to handle acute TSCI. However, one out of these is a military hospital, unavailable to the public, and therefore not included in the surveillance system. All primary and secondary hospitals, except two (one public and one private), are either remotely situated and/or lacking ICU facilities and/or lacking neurosurgical or orthopaedic departments, thereby being unable to treat patients with acute TSCI; these were therefore not included in the surveillance system.

The 'active' surveillance system was designed and implemented with the aim of identifying all new TSCI cases during the study period. The main investigator (AD) maintained a weekly personal contact with the 25 hospital departments of the four tertiary hospitals, and regular telephone contact with the two included secondary-level hospitals.

A 6-week pre-study pilot registration was carried out to establish routines and identify possible flaws in the study design. Minor adjustments were then subsequently made in the study protocol.

With regard to the greater Stockholm region, there is a comprehensive system of care, consisting of one hospital-based SIU, two inpatient rehabilitation centres and one outpatient clinic for life-long follow-up. Thus, almost all cases could easily be identified through the existing 'passive' surveillance system, during the early post-acute phase at the SIU. In addition, we established an 'active' surveillance system by maintaining frequent personal communication with representatives from each part of the clinical pathway.

Inclusion criteria

All of the following criteria had to be satisfied for inclusion both in Stockholm and in Thessaloniki: (1) acute traumatic spinal cord or cauda equina lesion, (2) age 16 or older at the time of injury, (3) inpatient care in a hospital of the Thessaloniki or Stockholm regions during the study period, (4) survival for at least 7 days post-trauma, (5) being resident of the country of the respective region and (6) individual giving informed consent for STATSCIS.

The Nordic Spinal Cord Injury Registry (NSCIR)

To ensure comparability between regions, all data collection was carried out according to a subset of the NSCIR (www.nscic.se). The subset consisted of the socio-demographic and the acute forms. Pertinent operational definitions are given in Table 2.

Table 2 Operational definitions used in the study in cases where one single internationally accepted definition is lacking

Terms	*Definitions*
Trauma	Damage caused by an external physical force including iatrogenic causes (for example, surgical mishaps) and excluding malignancy (for example, spinal cord compression by metastasis)
Spinal cord injury	Acute traumatic injury of the spinal cord, including cauda equina and conus medullaris injuries, excluding lumbosacral plexus lesions or injury to peripheral nerves outside the neural canal, causing motor and/or sensory deficits, and/or neurogenic bladder and/or bowel dysfunction, persisting for at least 72 h post-trauma
Individuals of foreign background	Individuals who were either themselves, or any of their parents, born in a foreign country
Level of education	(i) Basic: 9 years or less (ii) Further: basic plus additional up to a total of 12 years (iii) Advanced: further plus University or College education
Area of living	(i) Urban area: city (>100 000 inhabitants) and town (<100 000 inhabitants), including sub-city districts (5000–40 000 inhabitants) (ii) Rural area: sparsely populated area, non-urban area

Table 1 Overview of Central and West Macedonian regions, Stockholm and Gotland counties

	Greater Thessaloniki region		*Greater Stockholm region*	
	Central Macedonia	*West Macedonia*	*Stockholm county*	*Gotlandcounty*
Population	1 927 823	293 864	1 918 104	57 122
Total population >15 years old	1 906 207		1 639 438	
GDP per capita	14 661	13 482	35 621	20 516
Population density (inhabitants km^2)	102	32	292	18
Disposable income (EUR per inhabitant)	11 469	10 004	18 148	17 340
Employment rate (%)	57.9	52.1	74.9	85.6
Unemployment rate (%)	11.1	18.0	6.7	4.5
Area of the regions (km^2)	19 147	9451	6789	3184

Source: General and Regional Statistics, Eurostat 2007, 2008; Swedish Official Statistics 2007.

Data collection and analysis

All TSCI individuals under initial hospitalisation during the 13-month study period were registered and followed up for one year post-injury. With regard to Thessaloniki, AD scrutinised all available medical records and communicated directly with all patients and medical teams.

The web-based software of the NSCIR was used in Stockholm and a Microsoft Office Access software adaption was used in Thessaloniki.

The aetiological category of 'falls' was primarily classified as 'intentional' or 'unintentional'. Such a differentiation was carried out because of the unique characteristics of intentional falls. The unintentional falls were then further classified according to the height of the fall: (a) fall on same level or from less than 1 m; (b) fall between 1 and 3 m; and (c) from more than 3 m.

Incidence was calculated by considering those cases that were injured from the first day of the study and during the next 12 months. Age- and gender-adjusted incidences were calculated by the method of direct standardisation, using the 2007 European population structure (Eurostat, Euro-27).

Descriptive data are presented as *n* (%), mean, standard deviation (s.d.) and median. Statistical significance was set at $P<0.05$. Differences in proportions between regions were examined by the Chi-square test and Fisher's exact test. Statistical mean differences between regions were determined by independent Student's *t*-test. In cases of ordinal or non-normal variables, the Mann–Whitney test was used. All statistical analyses were carried out with SPSS version 16.0 software.

Table 3 Epidemiological characteristics

	Thessaloniki	*Stockholm*
Consented cases	81	47
Gender (male:female)	7:1	3:1
Males	71 (88%)	36 (77%)
Females	10 (12%)	11 (23%)
Age (mean, median, s.d.)	43, 40, ±19	47, 46, ±18
16–30	33 (41%)	11 (23%)
31–45	9 (11%)	12 (26%)
46–60	22 (27%)	9 (19%)
61–75	13 (16%)	13 (28%)
>75	4 (5%)	2 (4%)
Foreign background	19 (24%)	7 (15%)
Level of education		
Basic	42 (53%)	14 (30%)
Further	28 (35%)	18 (38%)
Advanced	10 (13%)	15 (32%)
Aetiology		
Sports-related, including diving	3 (4%)	8 (17%)
Fall	30 (37%)	22 (47%)
Assault	2 (2%)	1 (2%)
Latrogenic	3 (4%)	2 (4%)
Transportation	41 (51%)	11 (23%)
Other	2 (2%)	3 (6%)
Work-relatedness	16 (20%)	5 (11%)
Level of impairment		
Tetraplegia	39 (48%)	21 (45%)
Paraplegia	42 (52%)	26 (55%)

Ethics

Ethical approvals for STATSCIS were obtained from the Human Ethics Committee at Karolinska Institutet and from the Hellenic Data Protection Authority. Additional approvals were obtained from the Nordic SCI Council, the Scientific Committee and the Board of all participating hospitals of Thessaloniki.

Results

Overall, 87 individuals in the Thessaloniki and 49 in the Stockholm region sustained a TSCI during the study period. The annual crude incidence for individuals older than 15 years of age was 33.6 per million for Thessaloniki and 19.5 per million for Stockholm. After standardisation, annual age-adjusted incidence was 33.6 per million (95% CI 25.4–41.9) and gender-adjusted incidence was 33.2 per million (95% CI 25.1–41.3) for Thessaloniki, whereas in Stockholm annual age-adjusted incidence was 19.6 per million (95% CI 12.8–26.4) and gender-adjusted incidence was 19.4 per million (95% CI 12.6–26.1).

The overall consent rate for participation in STATSCIS was 93% (81 individuals) for Thessaloniki and 95% (47 individuals) for Stockholm. There were no significant differences in basic demographic characteristics within study groups, between those who did and those who did not consent.

Thessaloniki region

Among the 81 individuals who consented to STATSCIS, 71 were males (88%) and 10 were females (12%), with a mean age of 43 years (s.d. = ± 19, Median = 40). Over 40% of TSCI individuals belonged to the 16–30 age group, 11% to the 31–45, 27% to the 46–60, 16% to the 61–75 and finally 5% to the oldest age group >75 years (Table 3).

One out of four individuals (24%) was of foreign background, one out of five (20%) acquired their injury during work and none acquired injury while being abroad. The peak months for occurrence of TSCI were August and September and the peak day was Saturday.

Transportation accidents were the leading cause of injury as they occurred in 41 individuals (51%), falls were reported in 30 (37%), iatrogenic in three (4%), assault in two (2%), sports-related injuries (including diving) in three (4%) and others in two (2%) (Table 3). With regard to individuals injured in transportation accidents, 22 were car occupants, 13 were motorcycle riders, one was a pedestrian, three were pedal cyclists and two were other/unknown. In falls, four were overall intentional and 26 were unintentional; five on the same level or from less than 1 m height, 12 from 1–3 m and nine from more than 3 m.

Transportation was the leading cause of injury for individuals up to 45 years of age, affecting three quarters of the youngest age group 16–30. In contrast, falls were the leading cause of injury in the three older groups with a peak at the age group of 46–60 (Figure 1).

The injury resulted in tetraplegia in 39 (48%) and paraplegia in 42 (52%) individuals. Falls resulted in twice the number of paraplegics than in tetraplegics, whereas

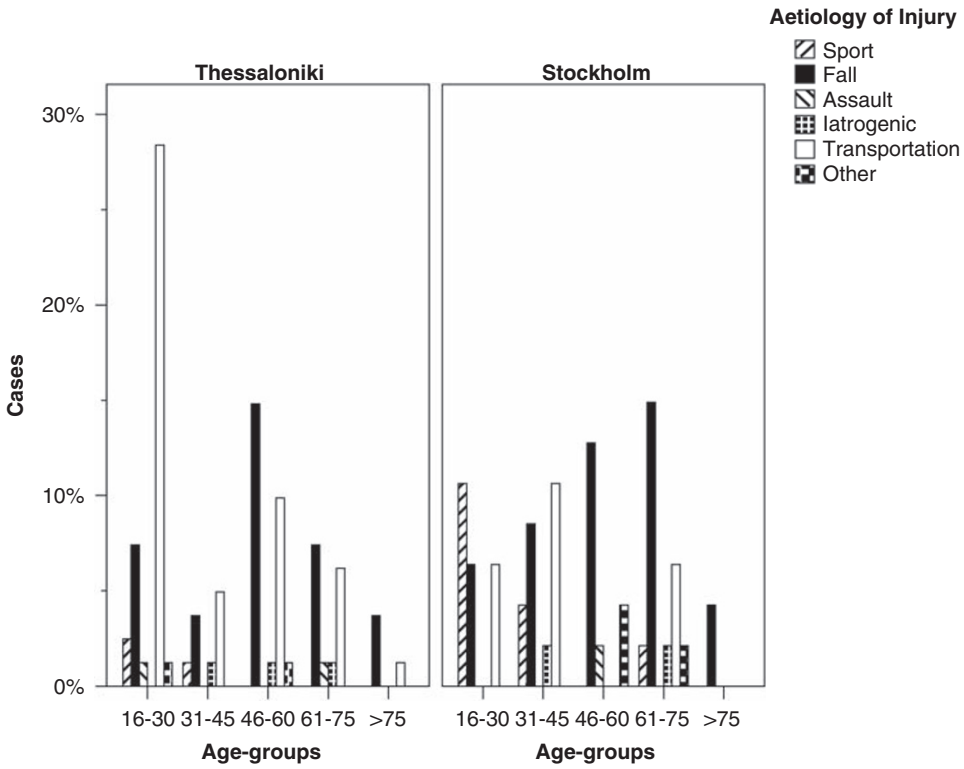

Figure 1 Aetiology of traumatic spinal cord injury in different age groups.

transportation accidents resulted in more tetraplegics than in paraplegics (Figure 2).

Stockholm region

Out of 47 individuals who consented to STATSCIS, 36 were males (77%) and 11 were females (23%), with a mean age of 47 years (s.d. = ± 18, median = 46). Just 23% of the individuals in the Stockholm group belonged to the 16–30 age group, nearly as many as to the 31–45 age group, 19% belonged to the 46–60 age group, 28% to the 61–75 age group and only 4% to the >75 years age group (Table 3).

One out of seven individuals (15%) was of foreign background, one out of ten (11%) acquired their injury during work and six (13%) while being abroad. The peak months for occurrence of TSCI were August and September and the peak day was Saturday.

Falls were the leading cause of injury as they occurred in 22 individuals (47%). Transportation accidents occurred in 11 (23%), sports-related injuries (including diving) in eight (17%), iatrogenic in two (4%), assault in one (2%) and other causes in three (6%) (Table 3). Within the category of falls, four were intentional and 18 unintentional; 10 occurred on the same level or from less than 1 m height, four from 1–3 m, three from more than 3 m and one unknown. Regarding individuals injured in transportation accidents, two were car occupants, five were motorcycle riders, one was a pedestrian and three were other/unknown.

Falls affected all age groups, whereas transportation accidents occurred in only three out of five age groups: 16–30, 31–45 and 61–75, with a peak in the middle one. Regarding the youngest age group, sports-related injuries (including diving) affected more individuals as compared with transportation accidents (Figure 1).

Injury resulted in tetraplegia in 21 (45%) and paraplegia in 26 (55%) individuals. In both major causes of injury, that is, falls and transportation, the number of paraplegics was slightly higher than that of tetraplegics (Figure 2).

Comparison between regions

There was no significant difference in the mean age of individuals between Thessaloniki and Stockholm. With regard to the aetiology of injury, the individuals from Thessaloniki were injured significantly more often ($P = 0.003$) in transportation accidents (Figure 3). When comparing age groups in relation to the aetiology of injury, transportation accidents in the 16–30 age group were significantly more common ($P = 0.017$) among Greeks than among Swedes (Figure 1). In both regions, falls were the leading cause of injury for all individuals older than 45 years of age.

Significantly lower levels of education ($P = 0.010$) were found in the Thessaloniki group, an aspect that was more prominent in the older age groups. There were no significant differences between study groups with regard to marital status, living conditions and vocational situation. By contrast, the Stockholm group was found to be significantly more urban ($P = 0.002$), in accordance with the different geography of the regions.

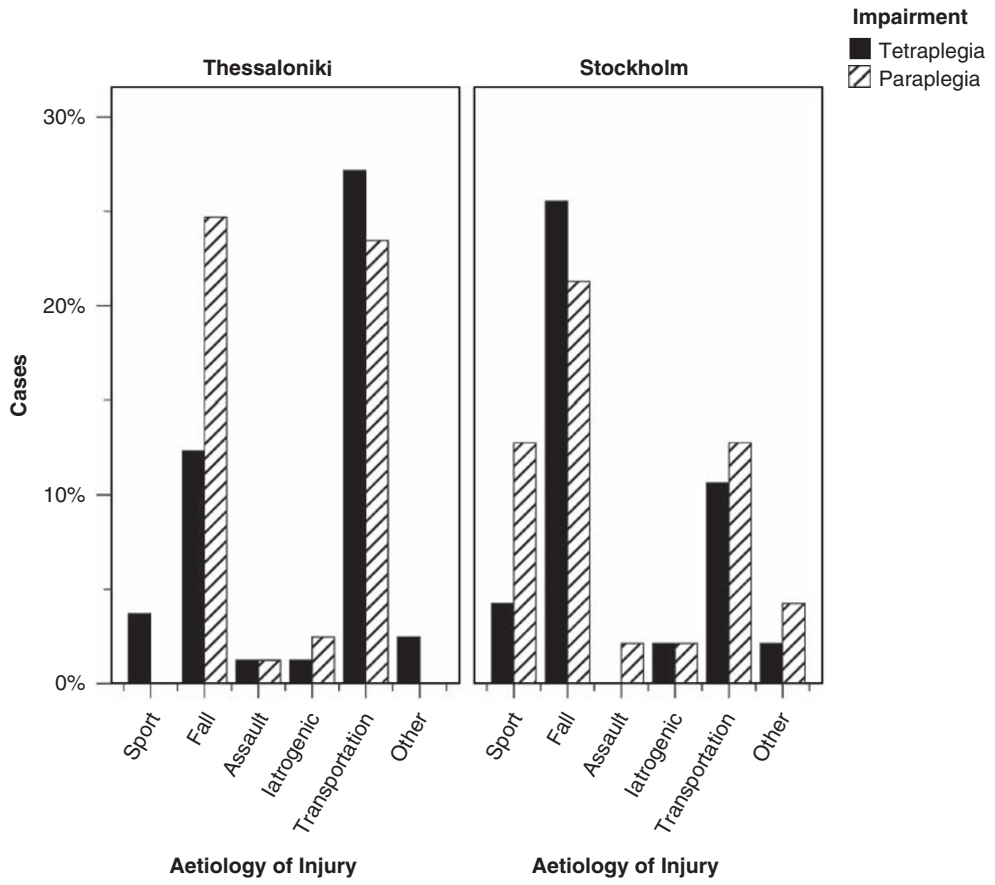

Figure 2 Aetiology of injury resulting in tetraplegia and paraplegia.

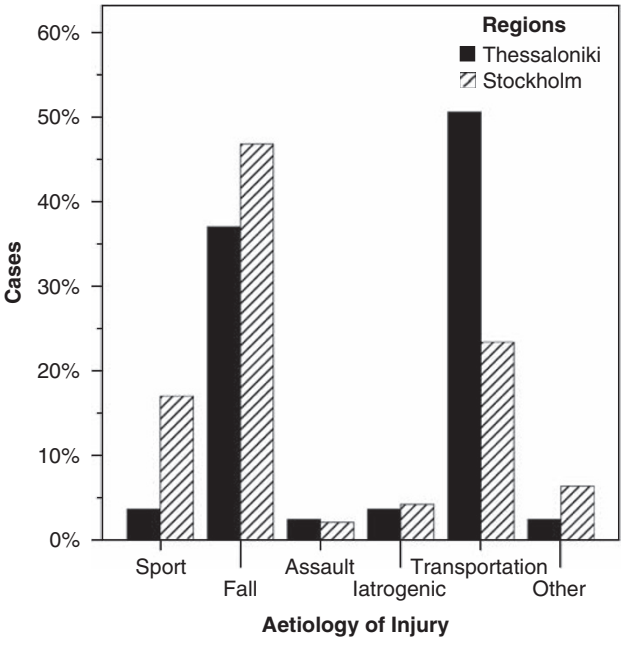

Figure 3 Aetiology of injury in the regions.

No significant differences between regions were found regarding the topography of column injury. Cervical spinal column injuries occurred in 39 (48%) individuals in Thessaloniki and 20 (43%) in Stockholm. Thoracic spinal column injuries occurred in 32 (40%) individuals in Thessaloniki and 21 (45%) in Stockholm. Lumbo-sacral spinal column injuries occurred in 10 (12%) individuals in Thessaloniki and 5 (11%) in Stockholm.

Discussion

To our knowledge, this is the first study on TSCI in Greece from an epidemiological perspective. The main strengths of this study, as we see it, are related to the prospective design, the active surveillance leading to a very low likelihood of missed cases, the personal examination of all cases, the highly structured protocols, the multiple data sources available for data cross-checking and the possibility for direct comparison between regions of a similar population size in two EU countries with very different systems of care for TSCI.

With regard to limitations, we need to point out the problem of assessing TSCI in early fatal cases. To avoid assessment problems relating to the contribution of TSCI to early deaths, we chose to exclude all fatalities occurring from the time of accident to the first week post-trauma. Presumably, there is a high incidence of TSCI in high-energy multitrauma, but early death in such cases is most likely to occur regardless of the presence or absence of TSCI; for

example, in cases with severe co-morbid brain injuries. Moreover, these cases are hard to identify as autopsies are not carried out systematically in all such instances in Greece, and documentation of pre-mortem clinical neurological examinations are often missing and/or not possible to be carried out in a reliable way. Our aim has been to isolate and include cases in which TSCI is the major or dominating medical problem. Still, the exclusion of very early fatalities inevitably leads to an underestimation of the true incidence of TSCI. In addition, pediatric SCI—a very rare event across the world—was not assessed by this study.

The annual age-adjusted incidence of TSCI (for individuals older than 15 years of age who survived for at least 7 days post-trauma) was 33.6 per million for Thessaloniki and 19.6 per million for Stockholm. Recent studies from other EU countries report annual survival incidences of TSCI of 10.4 per million inhabitants in the Netherlands[5] (survived first hospitalisation), 13.1 in Ireland[6] (survived acute care), 25.4 in Portugal[7] (survived 30 days after injury) and 19.4 in France[8] (older than 15 years who survived acute care).

The higher incidence in Thessaloniki likely reflects the differences in preventative measures, particularly with regard to transportation accidents, and underscores the need for improved road safety in Greece.

The male-to-female ratio was found to be 7:1 in Thessaloniki and 3:1 in Stockholm. Although the ratio in the Swedish group agrees with international data,[5,7] the ratio of Greek men who sustained a TSCI was remarkably high. A similar ratio of 7:1 was found in Ireland, where it was attributed to the small size of the sample.[6] Possibly, the male predominance reflects a cultural as well as a gender- and age-specific risk-taking behaviour in the use of motor vehicles.

Overall, more than half of the individuals in the Greek group were injured after a transportation accident, whereas nearly half of the individuals in the Swedish group were injured after a fall.

There were significantly more car occupants injured in the Greek group as compared with the Swedish group, and as compared with motorcycle injuries in either countries. The latter probably does not reflect that commuting by car is more dangerous than riding a motorcycle, but rather that motorcycle riding is more strongly associated with traumatic brain injuries than with TSCI.[9] Anyhow, our results strongly suggest the necessity for implementing more effective prevention programmes directed mainly towards young males in Greece, aiming to change their destructive driving culture.

Regarding Sweden, the leading cause of injury has shifted during the last decade from transportation to fall accidents. As in Australia, such a trend could probably be attributed to the success of public health measures directed at transport-related injury, as well as to the increasing need for prevention programmes directed at fall-related injuries.[10]

The results of this study will serve as a basis for further studies on TSCI in the two EU regions, focusing on early clinical characteristics, mortality, clinical process and outcomes at 1 year after injury.

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