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Incidence trends of traumatic spinal cord injury and traumatic brain injury in Spain, 2000–2009

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ABSTRACT

Aims: The aim of the present study was to estimate the incidence of hospital discharges for traumatic spinal cord injury (TSCI) and traumatic brain injury (TBI) in Spain by injury circumstances (traffic crashes and others), injury severity, gender and age group and to describe its trends over the period 2000–2009.
Methods: It is a study of trends that includes hospital discharges with a primary diagnosis of TSCI or TBI. Crude and age-standardised rates were calculated per million inhabitants. Changes in rates between 2000 and 2009 were assessed through calculation of the relative risk adjusted for age, using Poisson regression.
Results: Between 2000 and 2009 in Spain, 10,274 patients were admitted for traumatic TSCI, and 206,503 for TBI. The annual incidence rate for TSCI was 23.5 per million, that for TBI was 472.6 per million. The overall incidence rate for TSCI fell significantly between 2000 and 2009 by 24.2% (traffic-related 40.9%, other 12.9%), as did that for TBI (23.8% overall, 60.2% traffic-related, with no change for other circumstances). Among people aged 65 years and over, no change was observed for TSCI, incidence of TBI fell significantly when due to traffic crashes, but there was a dramatic increase of 87% in men and 89.3% in women when due to other circumstances.
Conclusions: Over the last decade the incidence of these types of injury has fallen significantly when the injury resulted from traffic crashes, and to a lesser extent when from other circumstances. However TBI incidence among people aged 65 and over injured in non-traffic-related circumstances has risen dramatically.

1. Background

Traumatic injuries have a considerable impact on the population's health in terms of mortality, morbidity and disability. Worldwide they represent a leading cause of death and disability for all age groups except that of people aged 60 years and over (Peden et al., 2002). Traffic injuries and self-inflicted injuries are the leading causes of injury-related deaths worldwide (Peden et al.,

Abbreviations: TSCI, traumatic spinal cord injury; TBI, traumatic brain injury.

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2002). Traumatic spinal cord injuries and traumatic brain injuries deserve special attention due to the individual, family and social consequences.

Incidence of traumatic spinal cord injury (TSCI) reported in the literature varies between 12.1 and 57.8 cases per million inhabitants in developed countries, and between 12.7 and 29.7 in developing countries (Chiu et al., 2010; van den Berg et al., 2010). A recent study of TSCI incidence in Spain, limited to one region (Aragon), estimated the rate as 15.5 cases per million (van den Berg et al., 2011). On the other hand, in general there is considerable variability in estimates for traumatic brain injury (TBI) due to the different definitions and information sources used. In Europe the estimated annual incidence of TBI is 2350 cases per million inhabitants (this figure includes hospitalisations, emergency department and pre-hospital mortality) (Tagliaferri et al., 2006). Rates have been reported which vary between 5460 per million inhabitants in Sweden in 1992–1993, to 950 cases per million inhabitants in Finland over the period 1991–1995 (Tagliaferri et al., 2006). In the USA annual incidence rates have been estimated at 4030 cases per million emergency room visits, 850 hospitalisations and 180 deaths per million inhabitants (Corrigan et al., 2010; Faul et al., 2010). The most common causes of TSCI and TBI are traffic crashes and falls (Chiu et al., 2010; Faul et al., 2010; van den Berg et al., 2010).

Over the last decade in Spain, there has been a rise in the intensity of road safety interventions, in an attempt to reduce the number of cases of injury and death due to traffic crashes. The Road Safety Special Measures Action Plan 2004–2005 was launched in 2004, and followed by the Strategic Road Safety Plan 2005–2008. The authorities involved have placed special emphasis on measures to ensure compliance with regulations, particularly in regard to speed, drinking and driving, helmet and safety belt use, and child restraint systems. In 2006 the Penalty Points system was introduced, and in 2007 the Penal Code was amended to facilitate applying criminal law to some risky behaviours so that dangerous driving can be penalised with prison sentences. These measures have been shown to be effective in reducing the number of deaths and people injured in traffic crashes (Castillo-Manzano et al., 2010, 2011; Novoa et al., 2011a,b, 2010; Pérez et al., 2006). There has been a reduction from 143 deaths per million inhabitants in 2000, to 59 in 2009 (Dirección General de Tráfico, 2010).

Given the impact of injuries due to external causes, and the lack of related scientific literature in Spain, it is of interest to study the consequences of non-fatal injuries, particularly serious injuries such as TSCI and TBI. The aim of the present study was to estimate the incidence of hospital discharges for TSCI and TBI in Spain by injury circumstances (traffic crashes and others), injury severity, gender and age group and to describe its trends over the period 2000–2009.

2. Methods

2.1. Design, population and information sources

Study of trends: The study population corresponds to the population resident in Spain during the period 2000–2009. Information was obtained from the National Hospital Discharge Register (Conjunto Minimo Básico de Datos, CMBDAH) for the years 2000–2009, of the Spanish Health Information Institute (Ministry of Health, Social Policy and Equality). The register includes information from the network of public and private hospitals. It also includes hospitals specialising in neurological injuries. The number of hospitals reporting to the CMBDAH increased over the decade of study. Overall, the coverage of notification is estimated to be over 95%.

Incidence rates have been calculated using the population resident in Spain during the study period, 2000–2009, as the denominator, provided by the National Institute of Statistics (INE).

2.2. Study variables

The dependent variables considered were the number of patients discharged from hospital whose primary diagnosis code, according to the ninth revision of the International Classification of Diseases-Clinical Modification (ICD9-CM), implied one of the following:

(i) Traumatic spinal cord injury (TSCI) ICD9-CM codes: 806 and 952;
(ii) Traumatic brain injury (TBI), ICD9-CM codes: 800, 801, 803, 804, 850, 851, 852, 853 and 854.

As a way of approximating the selection of new disease cases (incidence) only emergency admissions have been considered, programmed admissions and re-admissions being excluded. The Hospital Discharge Register considers as re-admission any new application for admission to the same hospital within 30 days of the patient's prior discharge.

As explanatory variables, we considered sex, age, severity, year of discharge, and injury circumstances in two categories: traffic crashes and other circumstances. Hospital discharge resulting from a traffic crash was defined as any discharge for which payment for the hospital stay was attributed to a traffic crash insurance company or the presence of an external cause-of-injury corresponding to traffic crashes (codes E810-819 or E826) or both. Out of 216,777 discharges for TSCI or TBI during the study period, 62,871 discharges were of patients considered injured in a traffic crash. Of them 24.8% only had a financial code of a traffic crash insurance company, 28% only had an E code of traffic crash, and 47.2% had both codes.

Cases that were not considered as injured in traffic crashes were considered as injured in "other circumstances". These included falls, cuts, firearm, drowning or submersion, fire, machinery, poisoning, struck by or against, but because the ICD9-CM codes for external cause-of-injuries (E codes) were often missing, it was not possible to determine the mechanism or injury circumstances in more detail.

It has been reported that incidence of injuries based on hospital discharges might be affected, among other reasons, by the probability of admission, that can vary depending on changes of criteria for admission or advances in technology (Stephenson et al., 2005). To address this issue we also analysed the data according to injury severity. We used the Injury Severity Scale (ISS) which considers all injuries reported, not only the principal diagnosis (Baker et al., 1974). It has been derived from the trauma option for Stata (Clark et al., 2011). Injury severity was classified as slight-moderate (ISS < 9), serious (ISS 9–15) and severe (ISS 16–75). For TBI we also used another measure of severity: TBI type 1 according to the Barell matrix which describes evidence of an intracranial injury or moderate to prolonged loss of consciousness, defined with a principal diagnosis code of 800, 801, 803, 804 (0.1–0.4, 0.6–0.9, 0.03–0.05 and 0.53–0.55), 850 (0.2–0.4), or 851–854 (Barell et al., 2002; Stephenson et al., 2005).

2.3. Statistical analysis

Annual hospital incidence rates, both crude and age-standardised, have been calculated per million inhabitants. The annual rate was calculated using Local Census population figures for each corresponding year as denominators (provided by INE). Standardisation was performed by the direct method

Table 1
Number of people discharged, hospital age-standardised incidence rates of traumatic spinal cord injury or traumatic brain injury per 1,000,000 inhabitants and relative risk with respect to the year 2000, by year, circumstances of injury and gender. Spain 2000–2009.

	Traffic crashes						Other circumstances					
	Male			Female			Male			Female		
	n	IRa	RR	*n*	IRa	RR	*n*	IRa	RR	*n*	IRa	RR
Spinal cord injury												
2000	329	16.2	1	112	5.2	1	463	23.6	1	164	7.8	1
2001	283	13.7	0.850*	97	4.6	0.858	480	23.7	1.013	177	8.4	1.058
2002	302	14.4	0.892	105	4.8	0.920	439	21.2	0.907	165	7.7	0.971
2003	283	13.3	0.822*	103	4.7	0.890	480	22.8	0.969	201	9.2	1.155
2004	275	12.8	0.794**	83	3.7	0.714*	431	20.2	0.859*	177	8.0	1.010
2005	303	13.9	0.860	100	4.4	0.850**	492	22.5	0.958	183	8.1	1.025
2006	274	12.4	0.769**	73	3.2	0.617***	529	23.8	1.014	177	7.7	0.977
2007	292	13.3	0.820*	58	2.5	0.487	495	22.0	0.937	208	8.9	1.123
2008	279	12.3	0.764**	66	2.8	0.547***	466	20.2	0.864*	202	8.6	1.081
2009	235	10.3	0.646***	50	2.2	0.411***	442	18.9	0.808***	195	8.2	1.027
Total	2855	13.3	0.997***,a	847	3.8	0.991***,a	4717	21.9	0.998**,a	1849	8.3	1.000a
Traumatic brain injury												
2000	6770	327.8	1	2427	114.1	1	8910	448.1	1	5060	246.4	1
2001	4969	240.0	0.729***	1816	85.3	0.745***	10,055	497.3	1.110***	5573	267.4	1.081***
2002	5369	256.5	0.780***	1986	92.3	0.808***	8736	425.8	0.946***	4917	232.2	0.936**
2003	4697	221.4	0.673***	1749	80.2	0.702***	8880	422.9	0.941***	4984	230.8	0.931***
2004	4239	199.3	0.606***	1579	72.1	0.630***	9071	426.7	0.948***	5283	240.9	0.971
2005	4162	192.9	0.585***	1538	69.3	0.606***	9103	418.2	0.929***	5386	240.2	0.968
2006	3646	167.6	0.509***	1358	60.7	0.531***	9235	416.1	0.926***	5486	239.3	0.965
2007	3449	157.9	0.480***	1188	52.6	0.460***	9385	416.8	0.928***	5645	242.5	0.978
2008	3124	139.8	0.427***	1093	47.5	0.417***	9122	395.0	0.879***	6032	252.3	1.019
2009	2895	127.9	0.393***	1072	45.9	0.405***	9820	417.4	0.930***	6596	270.1	1.088***
Total	43,320	201.3	0.991***,a	15,806	74.4	0.990***,a	92,317	428.8	0.999***,a	54,962	247.7	1.001**,a

n: number of people with traumatic spinal cord injury or traumatic brain injury. Sex is unknown for 6 persons with traumatic spinal cord injury and 98 with traumatic brain injury. IRa: age-standardised incidence rate per 1,000,000 men or women. RR: relative risk, reference year 2000

[a] Relative risk of the trend for the whole period. Indicates the annual change.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

taking the sum of the populations over all years as the reference population.

The evolution of rates between 2000 and 2009 were analysed by fitting Poisson regression models where the dependent variable was the number of people discharged. Cumulative percentage increases or decreases in rates over the period 2000–2009 were derived from the relative risk (RR) and its 95% confidence interval (95% CI). The year was included as a categorical variable in the model and 2009 was compared to 2000. In addition the trend was included to estimate the annual percentage change. The percentage difference was derived from the RR (RR-1 × 100). Absolute differences between the incidence rates of 2000 and 2009 have also been calculated.

The analysis was stratified by type of injury (TSCI or TBI), injury circumstances (traffic crashes or other circumstances), age group and sex. All analyses were conducted with the STATA statistical package, version 11.

3. Results

From 2000 to 2009, 10,274 people with a primary diagnosis of TSCI and 206,503 people with a primary diagnosis of TBI were discharged (3459 more people had a secondary diagnosis of TSCI and 70,756 more had a secondary diagnosis of TBI).

TSCI accounted for 0.5% of the total number of emergency admissions for traumatic injuries (0.7% in men, 0.3% in women), while TBI accounted for 10.0% (12.3% in men, 7.4% in women). Among TSCI patients, 35.5% were traffic-related injuries (men 37.1%, women 30.8%), while among TBI patients, the corresponding figure was 28.1% (men 31.4%, women 29.9%).

The E code was missing for 43.0% of TSCI patient discharges (27.2% in traffic crashes cases, 57.9% in those of other circumstances), and among TBI patients it was missing in 45.4% of discharges (traffic crashes: 26.7%, other circumstances: 53.0%). Among patients with TSCI from traffic crashes for which the E code was not missing, 41.5% were motorcyclists, 11.9% pedestrians, 37.0% were car occupant and 9.6% cyclists. Among patients with TBI from traffic crashes for which the E code was not missing, 30.9% were motorcyclists, 31.0% pedestrians, 17.2% were car occupant and 20.9% cyclists. Among injuries resulting from other circumstances and for which the E code was not missing, in 72.2% of discharges of TSCI patients and 73.9% of TBI patients, the mechanism involving the injury was a fall.

3.1. Hospital discharge incidence rate

3.1.1. Hospital discharge incidence rate among TSCI patients in Spain, 2000–2009

The average annual incidence rate of hospital discharges with primary diagnosis of TSCI in Spain during the period 2000–2009 was estimated to be 23.5 cases per million inhabitants (age-standardised rates being 35.2 per million in men, 12.2 per million in women). The incidence rate, standardised by age, for discharges of TSCI patients injured in a traffic crashes was 8.5 cases per million in habitants (13.3 per million in men, 3.8 per million in women), while for TSCI patients injured in other circumstances the corresponding figure was 15.0 cases per million inhabitants (21.9 per million in men, 8.3 per million in women) (Table 1).

The male/female ratio was 3.4 for injuries due to traffic collisions, and 2.6 for injuries resulting from other circumstances. By

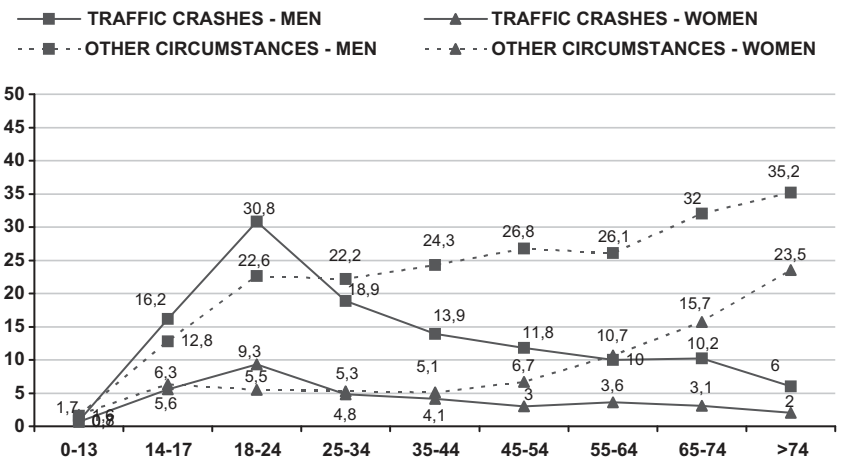

Fig. 1. Annual incidence rate of traumatic spinal cord injury hospital discharges per 1,000,000 inhabitants, by gender, age group and circumstances of injury. Spain 2000–2009.

age group, for both men and women alike, the highest incidence rates of hospital discharges of TSCI patients injured in traffic collisions corresponded to the group aged 18–24 years. In contrast discharges of TSCI patients injured in other circumstances tend to rise with age, the highest rates being among people aged over 64 years (Fig. 1).

3.1.2. Hospital discharge incidence rate among TBI patients in Spain, 2000–2009

The average annual incidence of hospital discharges with primary diagnosis of TBI in Spain during the period 2000–2009 was estimated to be 472.6 cases per million inhabitants (age-standardised rates: 630.1 per million in men, 319.2 per million in women). The age-standardised incidence of hospital discharges of TBI patients injured in traffic crashes was 135.5 cases per million inhabitants (201.3 per million in men, 71.4 per million in women). The age-standardised incidence for TBI resulting from injuries in other circumstances was 337.1 cases per million inhabitants (428.8 per million among men, 247.7 per million among women) (Table 1).

The male/female ratio was 2.7 in discharges related with traffic-crashes injuries, and 1.7 for those related with other circumstances. By age groups, for both men and women, the highest incidence of hospital discharges of TBI patients injured in traffic crashes is observed in young people, particularly the group aged 14–17 years. In contrast, in discharges of patients injured in other circumstances the highest incidence rates are observed in children aged 0–13 years, and among people aged 74 years and over (Fig. 2).

3.2. Trends in hospital discharge incidence rate

3.2.1. Trends in hospital discharge incidence rate for TSCI patients in Spain, 2000–2009

The incidence rate corresponding to TSCI fell over the period from 2000 to 2009, with a reduction of 6.7 cases per million inhabitants (4.8 for TSCI resulting from traffic crashes and 1.9 for those resulting from other circumstances) (Table 2). Overall, the incidence rate for TSCI patients declined significantly, by 24.2%. The rate corresponding to TSCI resulting from traffic crashes injuries fell significantly between 2000 and 2009, with an overall reduction of 40.9% (men: 35.4%, women: 58.9%), while the rate corresponding to injuries sustained in other circumstances fell by 19.2% in men, with no significant change among women (Table 2).

3.2.2. Trends in hospital discharge incidence rate for TBI patients in Spain, 2000–2009

Over the period from 2000 to 2009, the incidence rate for TBI fell by 287.3 cases per million inhabitants. In the case of TBI resulting from traffic crashes, the reduction was of 142.3 cases per million, whereas a rise of 6.2 per million was observed in those resulting from other circumstances (Table 2). Overall, the TBI incidence rate presents a significant reduction of 23.8% (29.7% in men, 12.7% in women). The incidence rate for TBI resulting from traffic crashes presented a significant reduction of 60.2% while the rate for TBI resulting from other circumstances fell significantly in men, 7.0%, but rose 8.8% among women (Table 2).

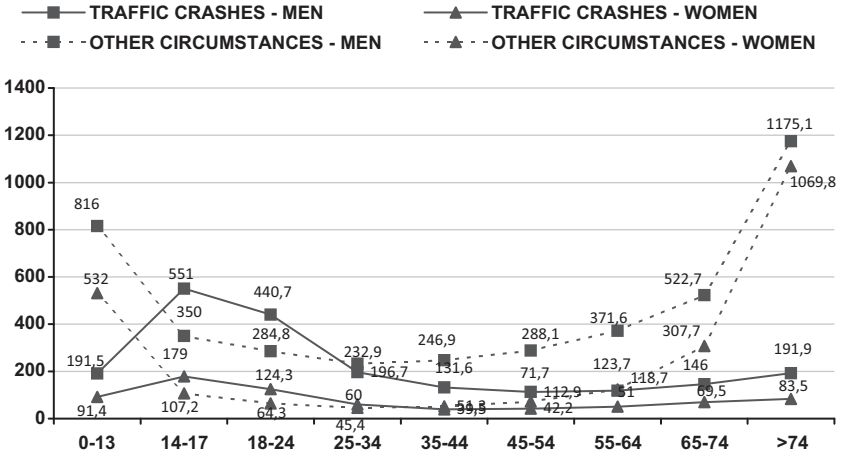

Fig. 2. Annual incidence rate of traumatic brain injury hospital discharges per 1,000,000 inhabitants, by gender, age group and injury circumstances. Spain 2000–2009.

Table 2
Age-standardised annual hospital incidence rate, absolute incidence differences and relative differences between 2009 and 2000 for traumatic spinal cord injury and traumatic brain injury per 1,000,000 inhabitants by circumstances of injury and gender. Spain 2000–2009.

	IRa[a]	95% CI		AD 2009–2000	% difference[b]	95% CI		*p*
Spinal cord injury	23.5	23.1	24.0	−6.6	−24.2	−30.6	−17.2	≤0.001
Traffic crashes	8.5	8.2	8.8	−4.8	−40.9	−49.1	−31.4	≤0.001
Male	13.3	12.8	13.7	−6.4	−35.4	−45.4	−23.6	≤0.001
Female	3.8	3.6	4.1	−3.3	−58.9	−70.5	−42.6	≤0.001
Other circumstances	15.0	14.7	15.4	−1.9	−12.9	−22.0	−2.7	0.014
Male	21.9	21.3	22.6	−4.2	−19.2	−29.0	−7.9	0.001
Female	8.3	8.0	8.7	0.3	2.7	−16.6	26.4	0.805
Traumatic brain injury	472.6	470.6	474.7	−287.3	−23.8	−25.3	−22.4	≤0.001
Traffic crashes	135.5	134.4	136.6	−142.3	−60.2	−61.6	−58.7	≤0.001
Male	201.3	199.4	203.2	−216.3	−60.7	−62.4	−58.9	≤0.001
Female	71.4	70.3	72.5	−72.0	−59.5	−62.3	−56.5	≤0.001
Other circumstances	337.1	335.4	338.8	+6.2	−0.9	−3.1	1.4	0.437
Male	428.8	426.0	431.6	−24.7	−7.0	−9.6	−4.3	≤0.001
Female	247.7	245.6	249.8	+34.5	8.8	4.9	12.9	≤0.001

[a] Age-standardised annual hospital incidence rate and 95% confidence interval. AD: absolute difference between crude rates 2009–2000.
[b] The percentage difference was derived from the relative risk RR (RR-1 × 100).

3.2.3. Trends in hospital discharges incidence rate for TSCI and TBI by age group

The evolution f incidence varied depending on the age group (Table 3). The incidence rate for TSCI resulting from traffic collisions fell significantly only in young males, whereas in women it fell in all groups aged under 64 years. In contrast, TSCI resulting from other circumstances only presented significant changes among young and adult males.

The incidence rate for TBI from traffic crashes showed significant reductions in both sexes and all age groups. These reductions were of over 65% among people under 35 years, of over 50% in adults, and somewhat less for older people (33.5% in women, 40.2% in men). The incidence rates of TBI resulting from other circumstances presented significant reductions in males aged under 65 years, and in women under 35 years. In contrast, among people aged 65 and over the trend was reversed, with a dramatic increase of 87.0% in men and 89.3% in women.

3.2.4. Trends in hospital discharges incidence rate for TSCI and TBI by injury severity

Injury severity of patients with TSCI was serious (ISS 9–15) for 43.4% and severe (ISS 16–75) for 56.4%. Severity was higher for patients injured in traffic crashes (64.6% ISS 16–75) than those injured in other circumstances (51.8% ISS 16–75). The trends for age-standardised incidence rates of the more severe TSCI also showed significant reductions in 2009 compared to 2000 (23.6%, 39.4% for traffic and 10.2% for other).

Among patients with TBI, 41.1% had slight-moderate injuries, 26.8% serious and 32.2% severe. Severity for patients injured in traffic crashes was also higher (35.3% ISS 16–75) than those injured in other circumstances (30.9% ISS 16–75). Trends for age-standardised incidence rates of more severe TBI (ISS 16–75) showed a significant overall increase (11.4%). Stratifying by circumstances, trends for age-standardised incidence of patients injured in traffic collisions showed a significant reduction (42.5%), but trends for other circumstances showed a significant increase (53.4%). On the other hand 59.7% of patients with TBI had a TBI type I (62.4% traffic collisions, 54.7% other). Trends of age-standardised incidence of TBI type I showed a significant overall reduction (4.3%), a significant reduction for traffic crashes (52.6%), but a significant increase for other circumstances (29.5%).

4. Discussion

The present study provides information at national level of hospital incidence rates of TSCI and TBI, and of their evolution in the last decade in Spain, among people injured in traffic crashes and in other circumstances, by age groups, sex and injury severity. In Spain there are around 1000 new cases of TSCI every year, and around 20,000 people suffer TBI requiring hospitalisation. Overall the incidence of these types of injuries declines significantly, the magnitude of the decrease being greater for injuries produced in traffic crashes than for those produced in other circumstances. Among people aged 65 years and over no changes are observed in the trends for spinal cord injury, a significant reduction is observed in the incidence of TBI resulting from traffic crashes, and a notable increase in cases produced in other circumstances. These are two serious types of injury which generate a considerable burden of disability and functional limitations.

4.1. Incidence

Any comparison with other studies is difficult due to the different methodologies used, in terms of the design, inclusion of participants, injury mechanisms and study period covered. Even so, our findings fall within the ranges reported by other studies in developed countries, which have published incidence rates for TSCI of between 12.1 and 57.8 cases per million inhabitants (Chiu et al., 2010; van den Berg et al., 2010). The estimates obtained in the present study are higher than those of the study by van den Berg et al. (2011) dealing with only one region of Spain for the period 2001–2008, and which reports incidence rates for TSCI of 13.4 per million (20.4 in men, 4.7 in women), whereas our figures were 23.5 (men 35.2, women 12.2). These differences may be explained by the fact that the Van den Berg study used data from only one hospital in a particular region, and despite being the reference hospital for these types of injuries, cases could have been admitted to other hospitals.

The rates estimated for TBI incidence in this study are in general lower than those reported (Barker-Collo et al., 2009; Tagliaferri et al., 2006; Vazquez-Barquero et al., 1992). Several reasons could contribute to explain these differences. Other studies may include hospital emergencies, patients in observation, non urgent hospitalisations, re-hospitalisations or patients with TBI as a secondary diagnosis, while we exclude all of them. Including cases with a secondary diagnosis of TBI in our study would increase the rate by one third. Moreover there could be differences between countries in criteria to hospitalise patients, utilisation of different ICD versions (ICD-9CM, or ICD10) and differences in recording the diagnoses. In Spain TBI could be underreported if the patient has other diagnoses of higher severity.

Table 3
Number of people discharged, annual hospital incidence rate, and relative incidence rate differences between 2009 and 2000 of traumatic spinal cord injury and traumatic brain injury per 1,000,000 inhabitants, by circumstances of injury, gender and age group. Spain 2000–2009.

Age	Traffic crashes							Other circumstances						
	n	IR	95% CI		% difference[a] 2009–2000	95% CI		*n*	IR	95% CI		% difference[a] 2009–2000	95% CI	
Spinal cord injury														
Male														
0–17	179	4.6	3.9	5.3	−44.0	−72.0	11.8	171	4.4	3.7	5.1	−21.7	−62.7	64.6
18–34	1368	23.1	21.9	24.3	−54.6***	−65.0	−41.2	1324	22.3	21.2	23.6	−43.3***	−56.2	−26.6
35–64	1043	12.2	11.5	13	−22.8	−40.7	0.6	2186	25.6	24.5	26.7	−20.5*	−34.4	−3.7
65+	261	8.4	7.4	9.5	21.8	−31.4	116.1	1034	33.4	31.4	35.5	23.5	−6.0	62.3
Female														
0–17	72	1.9	1.5	2.4	−93.0**	−99.1	−46.6	104	2.8	2.3	3.4	−44.1	−76.8	34.9
18–34	358	6.4	5.7	7.1	−65.4***	−79.8	−40.8	300	5.4	4.8	6.0	17.6	−27.6	90.9
35–64	309	3.6	3.2	4.0	−56.5**	−73.8	−27.6	611	7.1	6.6	7.7	6.5	−27.0	55.4
65+	108	2.6	2.1	3.1	18.1	−59.0	240.5	831	19.6	18.3	21.0	5.4	−22.6	43.5
Traumatic brain injury														
Male														
0–17	10,962	278.8	273.6	284.1	−67.8***	−70.5	−64.8	27,637	702.9	694.6	711.2	−42.5***	−45.5	−39.4
18–34	16,758	282.9	278.6	287.2	−68.5***	−70.7	−66.1	14,884	251.2	247.2	255.3	−17.9***	−23.7	−11.6
35–64	10,444	122.2	119.8	124.5	−53.4***	−57.2	−49.3	25,001	292.4	288.8	296.1	−5.6*	−10.8	−0.1
65+	5123	165.3	160.8	169.9	−40.2***	−47.0	−32.4	24,691	796.7	786.7	806.7	87.0***	76.5	98.2
Female														
0–17	4189	112.6	109.3	116.1	−69.9***	−74.0	−65.2	15,949	428.9	422.2	435.6	−42.7***	−46.5	−38.6
18–34	4644	82.8	80.5	85.2	−67.1***	−71.3	−62.2	2920	52.1	50.2	54.0	−33.0***	−43.5	−20.5
35–64	3723	43.5	42.1	44.9	−58.1***	−63.8	−51.5	6638	77.6	75.7	79.5	−1.8	−11.6	9.2
65+	3245	76.5	73.9	79.2	−33.5***	−42.9	−22.6	29,300	691.1	683.2	699.0	89.3***	79.5	99.7

IR: incidence rate.
[a] The percentage difference was derived from the relative risk RR (RR-1 × 100).
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

As other studies have also reported, we found that men presented higher rates than women in all years for both types of injury, and for both injury-producing circumstances studied, traffic collisions and other (van den Berg et al., 2010). This is probably also reflecting the differing levels of exposure to risk between men and women, not only in terms of type of vehicle, position in the vehicle and frequency of trips, but also in the case of injuries produced in other circumstances, since men engage more often in occupational and sporting activities which imply greater exposure.

As previously reported, we also found a bimodal distribution by age group in the incidence rates for TSCI, with more young people injured in traffic crashes, and more old people injured in other circumstances (van den Berg et al., 2011; O'Connor, 2006; van den Berg et al., 2010). Particularly notable are the high rates among the elderly of injuries in other circumstances, probably falls. On the other hand, the highest incidence rates of TBI among the age group 14–17 years could probably be explained by the fact that in Spain, until September 2009 anyone aged 14 years or over could ride a moped.

4.2. Evolution of incidence

Studies in the USA, Finland and Australia have found a decreasing trend in the incidence of TSCI resulting from traffic crashes, particularly among young men, and an increasing trend in the incidence of TSCI related with falls, particularly among the elderly (Kannus et al., 2007; Nobunaga et al., 1999; O'Connor, 2006). In our study, the absolute numbers and proportions of people aged 65 years and over with TSCI rise over time (from $n = 188$, 17.6% in 2000 to $n = 249$, 27.0% in 2009), but the incidence rates do not present a statistically significant change in either of the circumstances we have studied.

Regarding injuries resulting from traffic crashes, the TSCI incidence rates fall over the period from 2000 to 2009: 35.4% in men, and 58.9% in women, while the reductions corresponding to TBI were 60.7% in men and 59.5% in women. Other studies have also found a declining trend for the incidence of these types of injuries resulting from motor-vehicle crashes (Nobunaga et al., 1999; O'Connor, 2006). Stephenson et al. have reported that the relative decline in incidence trends of hospitalised TBI might be related to a change in the probability of admission that can vary depending practice guidelines or advances in technology rather than a real change, particularly among less severe TBI (Stephenson et al., 2005). In our study, the incidence trend of severe injuries follow a similar pattern as the overall incidence.

In Spain, as mentioned in Section 1, several road safety interventions have been implemented during the last decade, many of which focused on increasing the levels of enforcement of road traffic regulations. For instance, the number of speed cameras installed increased from 4 to 295 between the years 2004 and 2009, the ratio of alcohol checkpoints performed to the number of registered drivers increased from 11.1% in 2003 to 22.1% in 2008 (Dirección General de Tráfico, 2006, 2007). Also, the penalty points system was introduced on the 1st of July 2006, and the reform of the Penal Code became effective on the 1st of December 2007. Other measures apart from enforcement were also implemented, such as passing further traffic regulations: in 2004 standardised child safety seats and bicycle helmets on non-urban roads were made compulsory, and in 2006 the useful life for school buses was set at a maximum of ten years (Rodriguez, 2009). Also, a significant part of the budget was allocated to educating road users and increasing awareness in society.

The set of measures implemented following road safety prioritisation considerably reduced the burden of road traffic injuries in Spain. In 2009, 2714 people were killed in road traffic crashes, which implies that road fatalities have been reduced by 53% compared to the figures in 2001, meaning Spain achieved its target of halving the number of deaths 2010, compared to 2001, as established in the White Paper of the European Commission. Also, road fatalities have been reduced by 50% compared to 2003, therefore

achieving the targeted 40% reduction set out in the Road Safety Strategic Programme 2005–2008 (Dirección General de Tráfico, 2006). Several evaluations have shown that road safety measures implemented in Spain during recent years have been effective in reducing the number of traffic crashes injury cases (Castillo-Manzano et al., 2010, 2011; Novoa et al., 2011a,b, 2010; Pérez et al., 2006) and thus may explain the observed decline in incidence rates. The greater decline in incidence for TBI may reflect the increased use of helmets by users of two-wheeled vehicles. The percentage of motorcycle users, not wearing helmets, who died in traffic crashes in Spain fell from 56.6% in 2003 to 34.4% in 2007 (Dirección General de Tráfico, 2009).

The incidence of injuries produced in other circumstances evolves rather differently to that of traffic crashes. Although smaller in magnitude, the declines for both TSCI and TBI in men are significant (19.2% and 7%, respectively). In contrast, among women no significant changes were observed in the incidence of spinal cord injuries, but a significant rise was observed for TBI (8.8%). It is possible that the significant reduction of injuries of this type among men can be explained by the development of occupational safety initiatives (Benavides et al., 2011) in jobs traditionally occupied by men. For Spain as a whole, the incidence of cases of injury requiring time off work fell by 50% between 2000 and 2009: from 84.3 to 45.3 per 1000 wage-earners (Benavides et al., 2011).

Some studies have also drawn attention to the important increase in injuries produced in circumstances other than traffic, mainly in falls among elderly people (Jamieson and Roberts-Thomson, 2007; Kannus et al., 2007; Nobunaga et al., 1999; O'Connor, 2006). In our study we observed a notable rise in the incidence of TBI in both men and women aged 65 years and over. Apart from the fact that there may have been changes in the notification of injuries of this type, aging of the population means that the number of elderly, in delicate health, is continually on the increase (Hu and Baker, 2010; Kannus et al., 2007). In fact the number for people older than 74 increased by 35% over the last decade (INE, 2011). Moreover, advances in technology, science and medicine contribute to increase the life expectancy and life conditions among injury cases in situations in which, a few years ago, survival rates were much lower (Hu and Baker, 2010). Given the burden of disease that these injuries involve, as well as the aging of the population, there would appear to be an urgent need to develop interventions of recognised effectiveness in order to prevent falls among the elderly (Frick et al., 2010; Gillespie et al., 2009). Exercise programmes that target strength, balance, flexibility, or endurance, gradual withdrawal from some types of drugs for improving sleep, reducing anxiety, treating depression, and cataract surgery has been shown to reduce falls (Gillespie et al., 2009). Moreover, health planning ought to take account of the rise in health care demands associated to elderly people hospitalised with these types of injuries.

4.3. Limitations and strengths of the study

It must be pointed out that these data do not include people who die after suffering a TSCI or TBI before they reach a hospital or they only visit the emergency department but are not hospitalised. They also do not include people with multiple injuries in whom TSCI or TBI is reported as a secondary diagnosis. The incidence estimates thus obtained are therefore conservative. Some studies have reported that pre-hospital mortality due to TSCI accounts for 16% of all cases in Portugal (Martins et al., 1998) and Canada (Dryden et al., 2003) or 43% in France (Lieutaud et al., 2010). In Spain it is not possible to study the population of deaths prior to hospital admission since the death certificate only codes the underlying cause of death. Only one cause of death is coded, which in the case of external causes usually corresponds to the circumstances in which the death occurred, but the injuries involved are not coded. If this information becomes available in the future, it would be interesting to investigate it in order to complement findings based solely on hospitalisations.

Another limitation refers to the quality of diagnoses included in the Hospital Discharge Register. However, bearing in mind the severity of the injuries under study, we believe that the impact of any misclassification bias must be small. In contrast, lower levels of completeness and precision in the coding of external cause-of-injury may affect identification of the mechanism of injury. Despite this, in the case of traffic injuries we believe that they are identified correctly based on other variables, such as the hospitalisation payment code.

The lack of completeness in E-code data for external cause-of-injury prevents ascertaining in detail the circumstances which gave rise to the injury. The E-code was missing in more than 40% of the cases and when present was often non-specific. Therefore it was not possible to determine injury mechanism, and in the case of traffic injuries it was not possible to distinguish between different types of collisions, vehicles, nor type of road user (whether driver, pedestrian, etc.) for a large number of cases.

As strengths of the present work we note that it is a population-based study of the incidence and trends of two types of severe injury, providing information separately for injuries sustained in traffic crashes compared to other circumstances, by age groups sex and injury severity, that has been derived from a national-level database and that covers a relatively long period, i.e. 10 years.

4.4. Conclusions and recommendations

In summary, the incidence of TSCI and TBI in Spain is high, although within the range reported in other countries. Over the last decade incidence of these types of injury, when resulting from traffic crashes, have fallen significantly, and to a lesser extent those produced in other circumstances. Despite the overall reduction, among people aged 65 years and over we have observed no changes in trends for spinal cord injury, a significant reduction in the incidence of TBI due to traffic crashes, and a very important increase in those due to other circumstances.

Any progresses in prevention of TSCI or TBI will require determining the mechanisms involved in detail, which means it is necessary to improve both qualitatively and quantitatively the recording of E codes in hospital discharges. Given that availability of the external cause-of-injury code in a data source such as the Hospital Discharge Register would be of considerable value for the study of injuries, for monitoring them, and evaluating the impact of interventions, we would recommend taking the steps necessary to ensure that E-codes be notified. Similarly, in regard to mortality registers, it would be convenient to code both the injury causing death, as well as the external cause which produced it.

Given the magnitude of the burden of disease which these injuries represent, there is an urgent need to implement interventions of recognised effectiveness in order to prevent severe forms such as TSCI and TBI resulting from falls (Frick et al., 2010). Moreover, despite the good results obtained in recent years, road safety policies must be intensified with the aim of reducing the, still high, incidence rate of severe injuries among motor-vehicle users, cyclists and pedestrians, in line with the UN General Assembly resolution proclaiming a Decade of Action for Road Safety 2011–2020 (United Nations, 2011).

Conflict of interest

None.

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