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Epidemiology of traumatic brain injury in Austria

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Summary

Background Traumatic brain injury (TBI) is an important cause of preventable deaths. The goal of this study was to provide data on epidemiology of TBI in Austria.

Methods Data on all hospital discharges, outpatients, and extra- as well as in-hospital deaths due to TBI were collected from various sources for the years 2009–2011. Population data (number of male/female people per age-group, population of Austrian cities, towns, and villages) for 2009–2011 were collected from the national statistical office. Incidence, case fatality rate(s) (CFR), and mortality rate(s) (MR) were calculated for the whole population and for age groups.

Results Incidence (303/100,000/year), CFR (3.6 %), and MR (11/100,000/year) of TBI in Austria are comparable with those from other European countries. We found a high rate of geriatric TBI. The ratio between male and female cases was 1.4:1 for all cases, and was 2.2:1 for fatal cases. The most common mechanism was falls; traffic accidents accounted for only 7 % of the cases. Males died more frequently from traffic accidents and suicides, and females died more frequently from falls. CFRs and MRs increased with increasing age. CFRs were higher in patients from less populated areas, and MRs were lower in cases who lived closer to hospitals that admitted TBI.

Conclusions The high rate of geriatric TBI warrants better prevention of falls in this age group.

Keywords Traumatic brain injury · Epidemiology · Outcome · Severity · Age · Sex · Geographical factors

Epidemiologie des Schädel-Hirn-Traumas in Österreich

Zusammenfassung

Ziel der Studie Schädelhirntraumen (SHT) sind eine relevante Ursache von potentiell verhinderbaren Todesfällen. Das Ziel der Studie war, Daten zur Epidemiologie des SHT in Österreich zu erheben.

Methodik Angaben zu SHT-bedingten Spitalaufnahmen und Ambulanzbesuchen sowie zu präklinischen und innerklinischen Todesfällen für die Jahre 2009–2011 wurden von verschiedenen Institutionen zur Verfügung gestellt. Angaben zur Bevölkerung (Geschlechtsverteilung, Altersgruppen, Einwohnerzahlen der österreichischen Gemeinden) der Jahre 2009–2011wurden von der Webseite der „Statistik Austria" heruntergeladen. Inzidenz, Letalität, und Mortalität wurden für die gesamte Population sowie für Altersgruppen errechnet.

Ergebnisse Inzidenz (303/100.000/Jahr), Letalität (3,6 %), und Mortalität (11/100.000/Jahr) des SHT in Österreich entsprechen den Werten, die für andere europäische Länder erhoben wurden. Auffällig war die hohe Anzahl von geriatrischen SHT-Fällen. Das Verhältnis zwischen männlichen und weiblichen Fällen betrug 1,4:1 insgesamt, und betrug 2,2:1 in Fällen mit letalem Ausgang. Der häufigste Unfallmechanismus war Fall/Sturz; Verkehrsunfälle machten nur 7 % der Fälle aus.

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Männer verstarben häufiger durch Verkehrsunfälle und Selbstmorde, Frauen verstarben häufiger durch Fall/Sturz. Letalität und Mortalität nahmen mit zunehmendem Alter zu. Die Letalität war höher bei Patienten aus Regionen mit geringer Bevölkerungsdichte. In Regionen mit einem Krankenhaus, das SHT-Fälle versorgt, war die Mortalität niedriger als in Regionen ohne solches.

Schlussfolgerungen Die hohe Rate an SHT-Fällen durch Fall/Sturz bei geriatrischen Patienten legt nahe, dass hier Präventionsmaßnahmen dringend erforderlich sind.

Schlüsselwörter Trauma · Schädelhirntrauma · Epidemiologie · Altersgruppen · Geschlecht · Unfallmechanismus · Geografische Faktoren

Introduction

Traumatic brain injury (TBI) is a major cause of morbidity and mortality, and is the leading cause of death in people aged 15–45 years [1]. Tagliaferri et al. [2] reported that TBI accounted for the majority of trauma deaths in Europe. TBI has been called "the silent epidemic" [3] because the actual number of cases is rarely known, and because people as well as policy makers are frequently unaware of the serious consequences of TBI. Due to a number of factors (e.g., prevention policies, safer cars), the incidence of TBI is decreasing in developed countries [4]. However, the decline in TBI cases aged <40 years is accompanied by an increase in geriatric TBI cases.

Epidemiology data on TBI in Austria are not available. There are some estimates regarding cases of moderate and severe TBI [5], which have been based on rates of hospital admissions. The goal of this article is to describe the epidemiology of TBI in Austria.

Methods

Only Austrian residents were included in this analysis. In the Austrian system, almost all patients with head trauma (even those with small cuts or bruises) are seen at hospital emergency rooms; therefore, there was no need to obtain statistics on visits to physician's offices.

Statistik Austria (national statistics office) provided data on all deaths (years 2009–2011) due to International Classification of Diseases [10th revision (ICD-10)] codes S01.0–S01.9, S02.0, S02.1, S02.7, S06.0–S06.9, T01.0, T02.0, T04.0, T06.0, T90.1, T90.2, or T90.4–T90.9, and provided data on all hospital discharges (years 2009–2011) with ICD-10 codes S06.0–S06.9, T68, or T07. Patients who were transferred to another hospital as well as re-admissions are included twice. Data on TBI severity were not available. Data on hospital discharges as well as fatalities included year and month of TBI, age, sex, and residency (postcode) of the cases, and cause of accident. Data on fatalities had additional information on mechanism of accident (ICD-10 codes V01.1–Y89.9) and location of death. Data on hospital discharges had additional information on duration of hospital stay and outcome (discharge or death). Data on the population of the area where the patients lived and on the availability of a hospital admitting TBI within the area of residency were added to the database. Statistik Austria provided data regarding the size of the age-groups (years 2009–2011; 5-year intervals) of the Austrian population.

Data on hospital discharges (years 2009–2011; ICD-10 codes S06.0–S06.9) to seven trauma centers funded by the Austrian Worker's Compensation Board (Allgemeine Unfallversicherungsanstalt, AUVA) were provided by the office of the Medical Director. These data were available with hospital ID numbers; thus, we were able to estimate the number of re-admissions (86/7,734 cases; 1.11 %) because these cases had identical hospital ID numbers. Data on outpatient treatment for TBI (years 2008–2010) were provided by AUVA; age, sex, number of outpatients, ICD-10 code (S06.0–S06.9), and name of hospital were available. During these 3 years, the trauma hospitals treated close to a million outpatients, and 1,483 of these were TBI cases. The total number of outpatients treated for TBI was estimated using data on annual trauma department visits from Statistik Austria, which, unfortunately, did not provide a diagnosis other than "injury." Data from the prospective data collection of the Trauma hospital "Lorenz Boehler" in Vienna were used to estimate the number of multiple trauma cases with TBI. TBI (= any Abbreviated Injury Score (AIS) for the region "head" >0) was present in 138/246 cases (43.9 %, years 2008–2011) that had been coded as "multiple trauma." The total number of multiple trauma cases with TBI was estimated using this factor.

Data on TBI discharges of Austrian residents to Austrian hospitals were provided by the office of the Main Association of the Austrian Social Security Institutions. This database had information on the number of interhospital transfers ($n=3,880$ in 2009–2011) of TBI patients. These cases were identified in the database provided by Statistik Austria by searching for cases with identical age, sex, residency, trauma mechanism, and ICD-10 diagnosis, and double entries were marked as "transfers." A total of 3,150 cases were found.

All databases had complete sets of data for 3 years. Data for the 3 years from 2009 to 2011 were averaged for calculation of incidence (cases/100,000/year), case fatality rates (CFRs; deaths/number of cases), and mortality rates (MRs; deaths/100,000/year) by age-groups and sex. Data were not averaged for all other analyses. We investigated hospital discharges and causes of death (males vs. females), CFR and MR vs. cause and diagnosis of TBI, and CFR and MR vs. availability of a hospital admitting TBI in the residential area, and vs. population of residential area.

Means with respective standard deviations were used as central measures of continuous variables, and counts with percentages were used as frequency measures of categorical variables. For the statistical analysis for continuous variables, Student's T-test, and for the analysis of categorical variables, the χ^2 test, was used. A p-value of <0.05 was considered statistically significant.

Results

There were no differences in case numbers between the years 2009, 2010, and 2011; they contributed to 33.4, 33.3, and 33.3 % of all TBI cases, respectively. Overall incidence was 303/100,000/year (Table 1); this number included all hospital survivors, all patients who died, and all patients treated as outpatients (estimated). Correction for re-admissions (estimated) and patients with multiple trauma plus TBI (estimated) gave an incidence of 305/100,000/year. Overall CFR was 3.6 %, and overall MR was 11/100,000/year.

TBI was seen more frequently in males (Fig. 1). The highest numbers of cases were found in male teens and in female octogenarians. The high number of cases in the female geriatric population, however, did not translate into a higher incidence, as the female population aged >65 years is larger than the male population aged >65 years (see also Table 1). The high incidence in pediatric patients was not associated with a high number of fatal cases (Fig. 2)—CFRs were lower than those in all other age-groups (Table 1). The lowest incidences were seen in adults of both sexes, with lower rates for females. Incidence increased in geriatric patients to reach a maximum of 2,422/100,000/year in female, and of 2,991/100,000/year in male patients aged >94 years. These cases also had the highest CFR as well as MR. In cases <15 years of age, females had higher CFRs and MRs; in older cases,

Table 1 Age, sex, incidences, case fatality rates, and mortality rates

	A	A	A	A	A	A	F	F	F	F	F	F	M	M	M	M	M	M
	total cases/year	total deaths/year	incidence/100 000/yr	case fatality rate (%)	deaths/100 000/year (total)	deaths/100 000/year (hosp)	total cases/year	total deaths/year	incidence/100 000/yr	case fatality rate (%)	deaths/100 000/year (total)	deaths/100 000/year (hosp)	total cases/year	total deaths/year	incidence/100 000/yr	case fatality rate (%)	deaths/100 000/year (total)	deaths/100 000/year (hosp)
age																		
0-4	1849	3	470	0.14	0.68	0.34	**896**	**2**	467	0.26	1.22	0.52	**954**	**0**	473	0.03	0.17	0.17
5-9	1362	3	335	0.24	0.82	0.33	**546**	**6**	276	1.04	2.87	0.51	**819**	**1**	393	0.12	0.48	0.16
10-14	1534	11	348	0.72	2.50	0.23	**534**	**1**	248	0.25	0.62	0.31	**992**	**1**	439	0.13	0.59	0.15
15-19	2335	26	469	1.10	5.16	1.47	**903**	**3**	373	0.30	1.10	0.69	**1423**	**14**	558	1.01	5.62	2.22
20-24	1854	27	355	1.46	5.16	2.36	**580**	**4**	225	0.63	1.42	0.90	**1277**	**27**	483	2.14	10.33	3.78
25-29	1224	17	220	1.42	3.12	1.26	**374**	**2**	135	0.62	0.84	0.48	**853**	**18**	306	2.15	6.58	2.03
30-34	905	22	170	2.43	4.13	1.06	**270**	**2**	102	0.86	0.88	0.13	**630**	**14**	235	2.28	5.35	1.99
35-39	893	26	150	2.87	4.32	1.23	**275**	**2**	92	0.85	0.78	0.33	**615**	**20**	208	3.31	6.88	2.14
40-44	1044	41	149	3.93	5.87	1.00	**324**	**4**	93	1.34	1.25	0.58	**703**	**19**	200	2.75	5.49	1.42
45-49	1186	41	169	3.43	5.79	1.71	**392**	**6**	113	1.61	1.82	0.96	**795**	**36**	224	4.53	10.15	2.44
50-54	1195	41	198	3.46	6.85	2.60	**412**	**11**	136	2.67	3.63	1.76	**789**	**37**	262	4.65	12.19	3.43
55-59	1010	18	202	1.75	3.53	3.26	**363**	**6**	142	1.65	2.35	1.57	**666**	**31**	272	4.70	12.78	5.03
60-64	994	58	214	5.87	12.57	5.89	**315**	**9**	131	2.75	3.61	2.08	**677**	**48**	302	7.04	21.27	9.96
65-69	1135	68	256	5.96	15.28	7.08	**393**	**12**	168	3.05	5.11	3.12	**738**	**52**	355	7.09	25.16	11.54
70-74	1311	87	362	6.64	24.06	13.00	**517**	**25**	263	4.84	12.71	8.47	**790**	**58**	479	7.38	35.38	18.40
75-79	1267	97	473	7.63	36.10	19.67	**602**	**30**	387	5.04	19.52	12.02	**661**	**62**	588	9.38	55.14	30.24
80-84	1571	127	721	8.06	58.15	39.64	**881**	**56**	638	6.32	40.33	28.98	**685**	**65**	859	9.54	81.90	58.08
85-89	1679	131	1213	7.82	94.87	71.76	**1150**	**68**	1143	5.94	67.92	54.00	**525**	**59**	1389	11.23	156.00	118.99
90-94	822	62	2210	7.58	167.49	140.62	**597**	**39**	2096	6.48	135.82	119.43	**225**	**23**	2576	10.36	266.78	209.61
95+	286	21	2538	7.45	189.11	135.92	**220**	**14**	2422	6.20	150.24	98.94	65	7	2991	10.71	320.42	289.90
total	25456	927	303	3.64	11.04	6.03	**10544**	**303**	245	2.87	7.04	4.86	**14884**	**596**	364	4.00	14.57	7.26

A = all patients; F = female patients; M = male patients; hosp = hospital; bold print: p < 0.001 for differences between male and female cases

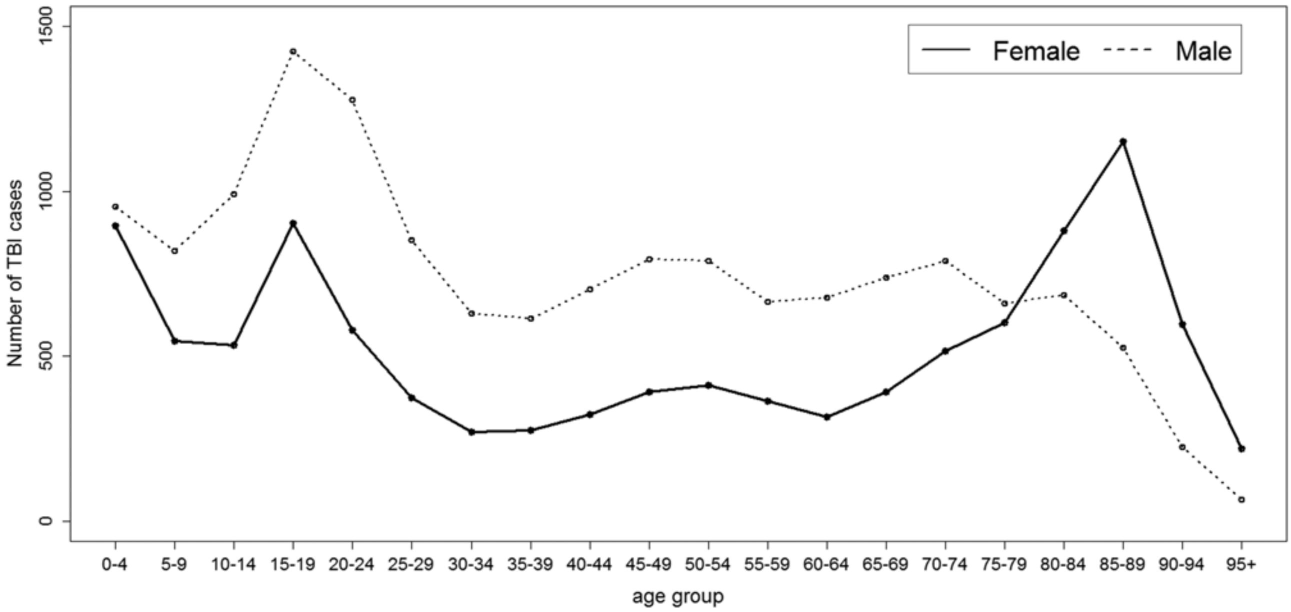

Fig. 1 Total cases of traumatic brain injury vs. age-groups and sex (1-year average)

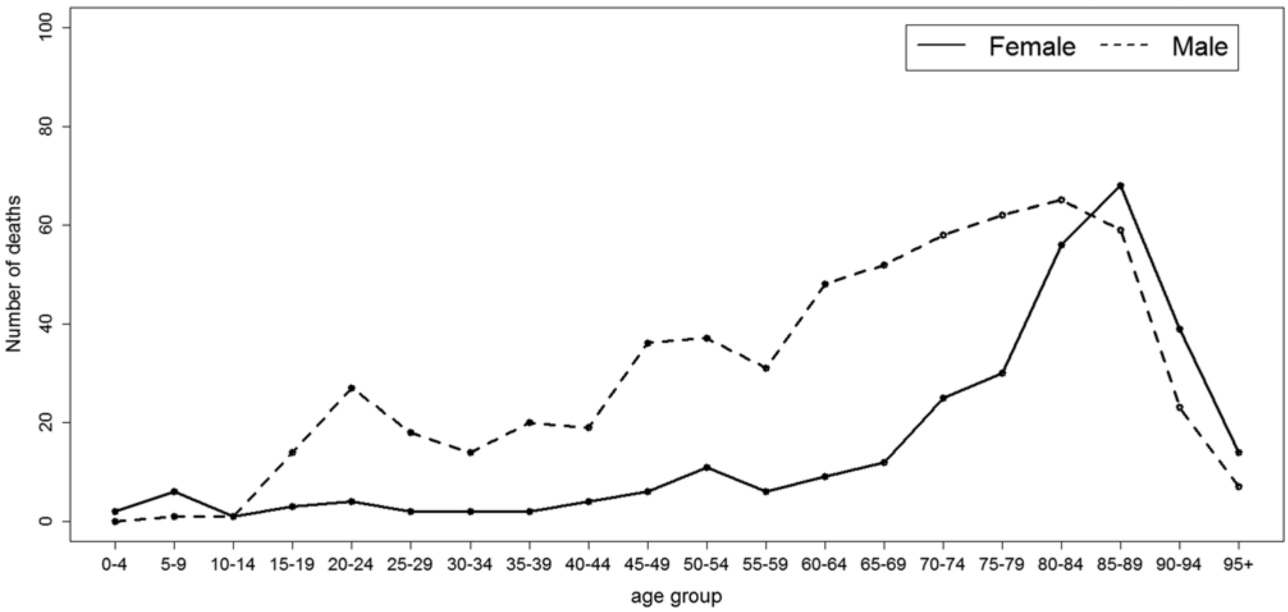

Fig. 2 Fatal cases of traumatic brain injury vs. age-groups and sex (1-year average)

males had significantly higher CFRs and MRs. The rates of extra-hospital deaths were >50 % for the pediatric and adult cases of both sexes, and decreased to approximately 30 % in geriatric cases.

The proportion of different ICD-10 codes showed significant variations between the age-groups. The proportion of the most common diagnosis "concussion" decreased from approximately 90 % to approximately 60 % with increasing age. The proportions of "focal brain injury" (0.1–3.4 %), "subdural hematoma" (0.5–18.5 %), "subarachnoid hemorrhage" (0.2–7.2 %), and "other brain injury" (0.1–2.2 %) increased with increasing age. The highest proportions of "brain edema" (0.7 %) and "epidural hematoma" (2.9 %) were found in cases aged 30–60 years, and were lower in younger as well as older patients. The proportions of "TBI with prolonged coma" (approximately 0.2 %) and "unspecified brain injury" (approximately 5 %) remained more or less constant over all age-groups.

With regard to hospital discharges (Table 2), approximately 58 % of the cases were male. The mean age of females was 9 years higher than that of males. The cases were distributed evenly over the year. Injuries during private activities (mostly falls) were the most frequently

Table 2 Hospital discharges (January 2009 to December 2011)

	Female		Male		Total		*p*-value
Cases	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	
	30,790	41.8	42,832	58.2	73,622	100	
Age	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	< 0.001
	49.5	31.7	40.9	26.7	44.5	29.2	
Season	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	< 0.01
Spring	7,824	25.4	10,899	25.4	18,723	25.4	
Summer	7,408	24.1	10,718	25.0	18,126	24.6	
Fall	7,396	24.0	10,341	24.1	17,737	24.1	
Winter	8,162	26.5	10,874	25.4	19,036	25.9	
Total	30,790	100	42,832	100	73,622	100	
Cause	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	< 0.001
Other private	16,570	53.8	20,741	48.4	37,311	50.7	
Other/unknown	9,715	31.6	13,053	30.5	22,768	30.9	
Traffic-related	1,954	6.3	3,084	7.2	5,038	6.8	
Sports-related	1,345	4.4	2,625	6.1	3,970	5.4	
Work-related	481	1.6	1,508	3.5	1,989	2.7	
Violence-related	272	0.9	1,066	2.5	1,338	1.8	
School-related	343	1.1	533	1.2	876	1.2	
Home/garden work	100	0.3	181	0.4	281	0.4	
Suicide attempt	10	0.0	41	0.1	51	0.1	
Total	30,790	100	42,832	100	73,622	100	
Diagnosis	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	< 0.001
Concussion	24,022	78.0	32,641	76.2	56,663	77.0	
Subdural hematoma	2,138	6.9	2,995	7.0	5,133	7.0	
Unspecified brain injury	1,383	4.5	2,067	4.8	3,450	4.7	
Diffuse brain injury	956	3.1	1,630	3.8	2,586	3.5	
Subarachnoid hemorrhage	998	3.2	1,294	3.0	2,292	3.1	
Focal brain injury	513	1.7	834	1.9	1,347	1.8	
Epidural hematoma	374	1.2	693	1.6	1,067	1.4	
Other brain injury	311	1.0	519	1.2	830	1.1	
Brain edema	73	0.2	124	0.3	197	0.3	
Injury with prolonged coma	22	0.1	35	0.1	57	0.1	
Total	30,790	100	42,832	100	73,622	100	
Hospital days	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	< 0.001
< 1	1,926	6.3	4,253	9.9	6,179	8.4	
1–3	21,522	69.9	28,606	66.8	50,128	68.1	
4–7	3,218	10.5	3,627	8.5	6,845	9.3	
8–14	2,044	6.6	2,751	6.4	4,795	6.5	
15–21	844	2.7	1,239	2.9	2,083	2.8	
22–28	569	1.8	927	2.2	1,496	2.0	
29–35	219	0.7	389	0.9	608	0.8	
35+	448	1.5	1,040	2.4	1,488	2.0	
Total	30,790	100	42,832	100	73,622	100	
Outcome	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	0.699
Died	627	2.0	891	2.1	1,518	2.1	
Discharged	30,163	98.0	41,941	97.9	72,104	97.9	
Total	30,790	100	42,832	100	73,622	100	

Table 2 (continued)

	Female		Male		Total		*p*-value
Age	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	
Died	78.4	17.3	69.2	20.0	73.0	19.5	<0.001
Discharged	48.9	31.6	40.3	26.5	43.9	29.0	<0.001
Total	49.5	31.7	40.9	26.7	44.5	29.2	<0.001

The *p*-value relates to the differences between females and males
SD standard deviation

observed cause, followed by traffic accidents that contributed to 7% of the cases. Three-quarter of the cases were diagnosed as "concussion," 7% had "subdural hematoma," and 3% each had "subarachnoid hemorrhage" or "diffuse brain injury." "Epidural hematoma" as well as "focal brain lesions" were diagnosed in <2% of the cases.

Two-third (62.3%) of the 719 cases/year treated as outpatients were male. The mean age of male (35.8 ± 19.8 years) as well as female cases (38.6 ± 23.2 years) was significantly lower than that of admitted cases. Most cases (91.3%) were diagnosed as "concussion"; intracranial hematomas were diagnosed in only 4.8%. Few cases (0.9%) were observed for some hours in the emergency room, 3.1% received medications, and all others just received medical advice. The number of patients who left against medical advice has not been recorded.

Between 2009 and 2011, 8,435 trauma-related deaths had been registered; of these, 2,665 (31.6%) were due to TBI. More than two-third of the patients were male, and their mean age was almost 10 years lower than that of females (Table 3). The cases were distributed evenly over the seasons. Three-quarter of the deaths were due to accidents, and these were significantly more frequent in females. The most important mechanisms of accidents were "falls" followed by "other factors" (e.g., banging the head against an object, etc.) and "traffic-related" injuries. Suicides were the second most important cause; these were seen significantly more frequently in males (25 vs. 5% of all deaths). The most important mechanisms of suicides were gunshots to the head. With regard to the location of TBI, most cases happened at "other locations" (e.g., outdoors, at homes of friends or relatives, etc) followed by "home" and "street." The cases where location was "unknown" are those who died from sequelae of TBI. Most patients died at hospitals; approximately a quarter of them died at home; some died at "other locations" (e.g., the scene of TBI); and a few died at other medical institutions. Significant differences between patients who died from accidents and those who died from suicides were found: most accidental cases were admitted to hospitals, and fewer died on the scene of TBI, whereas suicide cases mostly died at the scene of TBI, and only few of these survived until hospital admission.

An analysis of CFRs (based on hospital discharges) for different causes of TBI and for different diagnoses is given in Table 4. Cases of TBI due to "school" accidents, to "sports," or to "inter-personal violence" had CFRs <1%. Most other causes had CFRs between 1 and 5%. Attempted suicide was found to have the highest CFR; half of the patients who reached the hospital alive died there. Cases of "concussion" had the lowest CFR; "epidural hematoma" had a CFR of 3.7%; "diffuse brain injury" and "subarachnoid hemorrhage" had a CFR of approximately 7%, "subdural hematoma" had a CFR of 11.6%; and "brain edema" had the highest CFR of 33.5%.

The size of the village/town/city where the TBI cases lived had significant influence on CFRs and MRs—both decreased significantly with increasing population (Table 5). Incidence decreased as well (statistically insignificant). The availability of a hospital that admitted TBI cases in the area of residency had a small (statistically insignificant) effect on CFRs. However, if only TBI cases that happened at home are considered, MR was significantly lower in cases that happened closer to hospitals (2.29 vs. 3.34 deaths/100,000/year, $p < 0.001$). It seems that most cases were treated at hospitals in their country of residence; the proportion of TBI cases in each province closely matched the proportion of TBI hospital discharges in that province.

Discussion

Austria is a small Central European country (83,855 km^2, 32,377 square miles) with nine provinces. It is populated by approximately 8.4 million residents. Only one-third of the country lies <500 m (1,640 ft); three-quarters are covered by the Eastern Alps and their foothills. Approximately a quarter of the population lives in the capital area (Vienna and suburbs), another quarter lives in 120 cities with >7,500 inhabitants (mostly in flat and/or low-lying areas), and the other 50% live in 2,236 towns and villages with <7,500 inhabitants (approximately half of these in the Alpine area). Approximately half of the population lives close to one of the 84 hospitals that admit TBI cases. Despite excellent cover by air medical services (38 helicopters) and ambulance cars, prehospital time (including treatment by emergency physicians) can exceed 90 min in some difficult-to-reach areas. These conditions are the reason why the CFR was higher in less populated areas, and why hospital mortality was lower in cases who lived closer to a hospital admitting TBI cases. A comparable finding was published in a study from the United States [6]: the CFR tended to decrease with an increase in population density (with the notable exception of the District of Columbia).

Table 3 Fatal traumatic brain injury cases in Austrian residents (January 2009 to December 2011)

	Female		Male		Total		*p*-value
Cases	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	
	825	30.9	1,840	69.0	2,665	100	
Age	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	
	73.5	19.8	62.5	20.2	65.9	20.7	<0.001
Season	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	0.571
Fall	205	24.9	462	25.1	667	25.0	
Spring	188	22.8	456	24.8	644	24.2	
Summer	212	25.7	471	25.6	683	25.6	
Winter	220	26.7	451	24.5	671	25.2	
Total	825	100	1,840	100	2,665	100	
Cause	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	<0.001
Accident	731	88.6	1.266	68.8	1.997	74.9	
Suicide	41	4.9	467	25.4	508	19.1	
Sequelae of TBI	20	2.4	66	3.6	86	3.2	
Not defined (accident or suicide)	9	1.1	28	1.5	37	1.4	
Aggression	23	2.8	12	0.7	35	1.3	
Iatrogen	1	0.1	1	0.1	2	0.1	
Total	825	100	1,840	100	2,665	100	
Mechanism of accidents	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	<0.001
Fall	473	64.7	620	48.9	1,093	54.7	
Other factor	158	21.6	361	28.5	519	26.0	
Traffic-related	90	12.3	232	18.3	322	16.1	
Accidental hit	4	0.6	23	1.8	27	1.4	
Work-related	1	0.1	15	1.2	16	0.8	
Sports-related	1	0.1	10	0.8	11	0.6	
Trapped by object(s)	0	0.0	5	0.4	5	0.3	
Total	731	100	1,266	100	1,997	100	
Mechanism of suicides	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	<0.001
Fall	20	48.8	26	5.6	46	9.1	
Gun	19	46.3	422	90.4	441	86.8	
Vehicle/train	2	4.9	15	3.2	17	3.3	
Other mechanism	0	0.0	4	0.9	4	0.8	
Total	41	100	467	100	508	100	
Location of TBI	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	<0.001
Other	448	54.3	929	50.5	1,377	51.7	
Home	223	27.0	495	26.9	718	26.9	
Street	94	11.4	248	13.5	342	12.8	
Unknown	18	2.2	63	3.4	81	3.0	
Care center	30	3.6	29	1.6	59	2.2	
Workplace	5	0.6	25	1.4	30	1.1	
Mountain	2	0.2	23	1.3	25	0.9	
Railway	2	0.2	17	0.9	19	0.7	
Sports facility	2	0.2	10	0.5	12	0.5	
Hospital	1	0.1	1	0.1	2	0.1	
Total	825	100	1,840	100	2,665	100	

Table 3 (continued)

	Female		Male		Total		*p*-value
Location of death (all causes)	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	< 0.001
Hospital	544	65.9	859	46.7	1,403	52.6	
Home	155	18.8	498	27.1	653	24.5	
Other	69	8.4	395	21.5	464	17.4	
Other medical institution	55	6.7	85	4.6	140	5.3	
Transport	2	0.2	3	0.2	5	0.2	
Total	825	100	1,840	100	2,665	100	
Location of death (accidents)	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	< 0.001
Hospital	524	71.7	758	59.9	1,282	64.2	
Home	110	15.0	197	15.6	307	15.4	
Other	48	6.6	249	19.7	297	14.9	
Care center	47	6.4	60	4.7	107	5.4	
Transport	2	0.3	2	0.2	4	0.2	
Total	731	100	1,266	100	1,997	100	
Location of death (suicides)	*n*	*Percentage*	*n*	*Percentage*	*n*	*Percentage*	0.043
Home	21	51.2	273	58.5	294	57.9	
Other	11	26.8	127	27.2	138	27.2	
Hospital	6	14.6	61	13.1	67	13.2	
Care center	3	7.3	5	1.1	8	1.6	
Transport	0	0.0	1	0.2	1	0.2	
Total	41	100	467	100	508	100	

The *p*-value relates to the differences between males and females
SD standard deviation, *TBI* traumatic brain injury

Table 4 Case fatality rates of hospital discharges for different causes and diagnoses

	Died (*n*)	Discharged (*n*)	Total (*n*)	CFR (%)
Cause				
School	1	875	876	0.1
Sports-related	9	3,961	3,970	0.2
Violence	4	1,334	1,338	0.3
Work-related	24	1,965	1,989	1.2
Other/unknown	487	22,281	22,768	2.1
Other private	826	36,485	37,311	2.2
Traffic-related	127	4,911	5,038	2.5
Home/garden work	14	267	281	5.0
Suicide attempt	26	25	51	51.0
Total	1,518	72,104	73,622	2.1
Diagnosis				
Concussion	100	56,563	56,663	0.2
Epidural hematoma	39	1,028	1,067	3.7
Unspecified brain injury	149	3,301	3,450	4.3
Diffuse brain injury	173	2,413	2,586	6.7
Subarachnoid hemorrhage	155	2,137	2,292	6.8
Focal brain injury	124	1,223	1,347	9.2
Subdural hematoma	596	4,537	5,133	11.6
Other brain injury	107	723	830	12.9
Brain injury with prolonged coma	9	48	57	15.8
Brain edema	66	131	197	33.5
Total	1,518	72,104	73,622	2.1

The CFR values are significantly different ($p < 0.001$)
CFR case fatality rate

Table 5 Incidences, case fatality rates, and mortality rates by population of residency and by availability of traumatic brain injury hospital in area of residency

Population in village/town/city of residence	population in this segment (n)	total cases (n)	total deaths (n)	case fatality rate (%)	cases/100 000/year	deaths/100 000/year
<1000	388 585	3772	162	4.3	323.6	13.9
1000-1999	1 227 949	9686	411	4.2	262.9	11.2
2000-2999	967 373	8482	307	3.6	292.3	10.6
3000-3999	616 483	5398	191	3.5	291.9	10.3
4000-5999	723 531	6357	240	3.8	292.9	11.1
.000-9999	720 225	6912	250	3.6	319.9	11.6
10 000-29 999	919 427	7914	276	3.5	286.9	10.0
30 000-99 999	421 934	3808	115	3.0	300.8	9.1
100 000-299 999	726 275	6295	192	3.1	288.9	8.8
>300 000 (Vienna)	1 731 236	16 120	496	3.1	310.4	9.6
total	8 443 018	74 744	2640	3.5	295.1	10.4
p-value				**0.017**	**0.342**	**0.022**
TBI hospital in area						
no	4 805 593	40 518	1577	3.9	281.0	10.9
yes	3 637 425	34 226	1063	3.1	313.6	9.7
total	8 443 018	74 744	2640	3.5	295.1	10.4
p-value				**0.07**	**0.182**	**0.406**

TBI = traumatic brain injury

The overall incidence of 303/100,000/year found in our study is lower than the incidences of 337 [7] and of 332/100,000/year [8] calculated for German regions, and of354/100,000/year given for Northern Sweden [9]. A lower incidence of 235/100,000/year was reported by Tagliaferri et al. [2]; however, the incidences given in the reviewed studies were 100–546/100,000/year. Higher rates were reported for the British region of Exeter (453/100,000/year [10]), for the United States (538/100,000/year [11]), and for New Zealand (790/100,000/year [12]). This latter study also included self-referred cases who were considered to have had TBI if they "had seen stars" or "were dazed" or "confused" after a head injury. The incidence was calculated from 1,369 cases, and only 71 cases (5.2%) had moderate-to-severe TBI. In most other studies, moderate and severe cases contributed to approximately 15%; thus, the New Zealand study may have overestimated the number of cases with mild TBI. Alternatively, all other studies done so far may have underestimated the number of cases with mild TBI. The overall MR (11/100,000/year) and CFR (3.6%) are lower than those reported by Tagliaferri et al. (15/100,000/year and 11%, respectively [2]). Again, the rates given in the reviewed studies were 5.2–24.4/100,000/year and 1–25%, respectively. An MR of 17.5/100,00/year was calculated for the United States [11].

The ratio between male and female cases was 1.4:1 for all, and was 2.2:1 for fatal cases. Comparable male-to-female ratios (all cases) were reported for Sweden (1.2:1 [11]) and for the United States (1.5:1 [11]). For severe and fatal cases, male:female rates of 3:1 (France [13]) and 3.6:1 (United States [6]) have been published. The difference in the male-to-female ratios between all cases and severe cases is due to the higher CFRs in males, which was also observed in our study.

Regarding age, our data are in accordance with some previous studies [11, 14]: we found a peak in teens and young adults, and a second peak in geriatric patients. Studies from New Zealand, however, reported a first peak in children <5 years of age, and a second peak in teens and young adults [12, 15]; almost 70% were observed in cases aged <35 years. In our study, due to the high number of geriatric TBI, cases aged <35 years contributed only to 43% of all cases. A significant increase in the rates of geriatric TBI was documented in studies from the United States [16] and Italy [17].

Austrian hospitals record the activity during which an accident occurred as "cause of injury," and the record-able activities have been selected to define which social security institution has to pay for treatment. The activities "school," "work," and "traffic to/from work" are covered by AUVA (see above); all other activities are covered by health insurance. Thus, many possible mechanisms are summarized under "other private" activities. With regard to TBI, most of these cases are falls; however, cases of unintentional hits, of objects falling on patients, and of TBI due to other external forces (explosion, firearm injury) could be summarized under "other private" activities, too. For fatal cases, more detailed descriptions of cause and mechanism of injury are recorded on the death certificates. Even with these limitations in mind, the extremely high rate of falls found in our study (up to 80 % of all hospitals discharges, 43 % of all fatal cases) as well as the extremely low rate of traffic-related TBI (7 % of all hospital discharges, 17 % of all fatal cases) is remarkable. In most previous studies, TBI was caused by traffic-related events more frequently than by falls [2]. Studies from Norway [18], with 62 % falls and 21 % traffic; Sweden [14], with 58 % falls and 16 % traffic; and Finland [19], with 61 % falls and 26 % traffic-related injuries, reported rates somehow comparable with those found in Austria. The higher number of falls in our study is most probably due to the large proportions of geriatric (25 % of all cases aged > 64 years) and pediatric cases (19 % of all cases aged < 15 years) in our study.

Another remarkable aspect of our study is the high CFR of suicides. Suicides were the cause of TBI in 0.7 % of all cases (178/25,456 cases/year), and in 19 % of all fatal cases. Firearms were the most frequently observed mechanism of suicide-related TBI (87 %). Only few of the patients made it to a hospital alive; most died at the scene. Half of the patients who were admitted to hospitals died there, including patients who died on the scene (508/533 cases died; CFR: 95 %). A much lower rate of suicides (0.1 %) was found in a German study [8]. A high proportion of suicides by firearms (29 % of all fatal TBI cases!) was found in a study from the United States [6].

The rate of TBI due to inter-personal violence was rather low (1.7 %). Higher rates were published in studies from Scotland (28 % [20]), Sweden (15 % [21]), Germany (14.2 % [8]), and the United States (11 % [22]). This difference might partly be due to under-reporting, as it is not uncommon that beaten women report "fall" rather than "having been hit" as cause of accident to avoid further problems with their violent partners. The difference might also partly be due to the fact that the age-group most at risk (i.e., young males aged 15–24 years) represents < 6 % of the Austrian population.

Limitations of this study include the following: the data regarding outpatients and re-admissions have been estimated from the documented numbers of cases available from AUVA hospitals. This sample ($n = 7,645$ cases) represents 10.4 % of all hospital discharges ($n = 73,622$ cases). Discharge and re-admission strategies might be different at other trauma departments, and the actual rates of outpatients and re-admissions may be incorrect. The same is true for the estimated number of patients with TBI who have been coded as "multiple trauma." However, given the low numbers of re-admissions, outpatients, and patients with multiple trauma plus TBI, any errors are unlikely to significantly change calculated incidence, CFR, and MR. We are confident that this study included all patients with relevant TBI over a period of 3 years. Cases with mild TBI who did not need medical attention are not included in this study, but these cases are unlikely to be of any relevance.

Conclusions

Our study showed that incidence, CFR, and MR of TBI in Austria are comparable with those from other European countries. We found a high rate of geriatric TBI. The most common mechanism was falls; traffic accidents accounted for only 7 % of the cases. CFRs were higher in patients from less populated areas, and MRs were lower in cases who lived closer to hospitals that admitted TBI. The Austrian system of reporting cause of accident for hospital admissions should be changed to describe the actual mechanism instead of the activity during which the accident occurred, and should include severity of TBI. The high rate of geriatric TBI warrants better prevention of falls in this age-group.

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Conflicts of interest
There are no conflicts of interest

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