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A B S T R A C T

Introduction: In industrialised countries, trauma is a public health challenge. Despite disposing of a highly evolved and complex health care system, France does not dispose of a national trauma registry or trauma system. Little is known about the epidemiology of trauma in France. This study aims at describing, using the national billing database, the epidemiology of French trauma.
Methods: A retrospective population-based cohort study has been conducted on trauma patients in France using the National Hospital Discharge Data Set Database for 2016. Patients were selected using the Trauma Audit and Research Network (TARN) criteria, inspired by the UK trauma system. Sociodemographic, clinical information and hospital characteristics were collected. The main outcome was 30-day mortality.
Results: Among 1,144,596 patients hospitalised in French hospitals for trauma in 2016, 144,058 patients were included based on the TARN criteria. The mean age of the patients was 64 years (± 24). Women (50.8%) were over-represented among patients older than 75 years. The 30-day mortality was 5.9%, and regional variations were identified. In multivariate analysis, age, gender, area-level deprivation, injury localisation, co-morbidities, injury severity, transfusion, surgery, and ICU admission were independent factors of risk for 30-day mortality. Age and injury severity were the stronger predictors for mortality and area-level deprivation was associated with higher mortality.
Conclusion: The national burden of trauma care was assessed with medico-administrative data in a country without a trauma system. The 30-day mortality associated with trauma in France was around 6%, with regional variations.

Introduction

Trauma represents a leading cause of mortality and morbidity worldwide. According to the Global Burden of Diseases study in 2015, injuries account for 8.5% of deaths, representing 4.7 million people [1]. The trauma-related mortality rate was stable from 2005 to 2015, but age-standardised rates declined by 15.8% [2]. Trauma covers a large range of injuries including transport injuries, unintentional injuries such as falls, self-harm, and interpersonal violence. The rates of each type of injury and their associated mortality differ in each country [3]. International comparisons between countries are rare, due to large differences in trauma organisation and data collection methods [4].

In industrialised countries, trauma remains a challenge for the organisation of pre-hospital systems including the triage of patients between different hospitals. In France, a group of experts [5] recently suggested a strategic proposal for a national trauma system. At variance with other countries [6], no registry being available, the epidemiology of trauma patients was never described at a large scale [7,8]. The FIRST (French Intensive Care Recorded in Severe Trauma) study has been performed in 2004–2007 to provide information on severe trauma patients in France but was limited to 14 university hospitals [7]. Nevertheless, an

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estimation of the burden represented by this patient population is required to improve the organisations. To this purpose, an approach based on national administrative data may provide the best approximation to describe a large population.

Administrative health databases are reliable sources for epidemiological studies and surveillance. In France, the French National Uniform Hospital Discharge Data Set Database (PMSI) is an inclusive database that describes all inpatient hospital stays in a standardised data set, no matter the type of hospital, across the country [9]. This database identifies each hospital and summarises information about the patient's stay: most notably the diagnosis, procedures, specific aspects of the stay (e.g., intensive care unit (ICU) admission), and the patient outcome. Based on this exhaustive system, we used the Trauma Audit and Research Network (TARN) criteria from the UK trauma system to identify a population of patients with trauma requiring hospitalisation [10,11].

Our aim was to describe the epidemiology of trauma in France during 2016. Our first goal was to assess the French global and regional variations in-hospital mortality rates of those patients. Our secondary goal was to determine the risk factors associated with 30-day mortality.

Methods

Study design and data source

This is a population-based, retrospective cohort study of trauma patients hospitalised in a French hospital from January 1, 2016 to December 31, 2016. This study is based on data from the French Hospital database (*PMSI – Programme de Médicalisation des Systèmes d'Information*), which systematically collects administrative and medical information for acute care (PMSI-MCO) [9]. The diagnoses are coded according to the International Classification of Diseases, Tenth Revision (ICD-10). Because the study of Peroziello et al. [12] reported the inadequacy of the Major Diagnosis Category 26 for identifying trauma, we followed the TARN methodology based on length of stay (LOS) criteria, ICD codes, admission to ICU and death [11]. Trauma patients were firstly identified using a code of trauma (beginning with S or T related to the chapter concerning injury, poisoning, and certain other consequences of external causes, according to the ICD-10 classification) as the principal diagnosis of admission into an acute care unit. Secondly, we selected patients using the TARN criteria [11]. Trauma patients were chosen irrespective of age who fulfilled one of the following

Table 1
Population charactenics and mortality rates.

	Whole population *n* = 144 058	In-hospital 30-day mortality rates *n* = 8 475 (5.9%)
Socio-demographic characteristics		
Age, *n* (%)		
< 15y	4 505 (3.1)	1.91%
15–50	31 218 (21.7)	2.46%
50–75	43 812 (30.4)	4.01%
> 75	64 523 (44.8)	9.09%
Gender, *n* (%)		
Female	73 222 (50.8)	5.06%
Male	70 836 (49.2)	6.73%
Geographical deprivation index, *n* (%)		
1st quartile: most advantaged	34 493 (25.0)	5.58%
2nd quartile: quite advantaged	34 493 (25.0)	6.11%
3rd quartile: quite disadvantaged	34 460 (25.0)	6.09%
4th quartile: most disadvantaged	34 498 (25.0)	6.06%
Clinical characteristics		
Major injury regions, n (%)		
Head	48 464 (33.6)	11.52%
Thoracic	53 104(36.9)	5.33%
Abdominal	43 642(30.3)	3.51%
Extremities	69 364 (48.2)	3.80%
Chronic co-morbid conditions (Charlson score)		
0	93 288 (64.8)	3.94%
1–2	32 227 (22.4)	7.50%
> 2	18 543 (12.9)	12.86%
Injury severity (ICISS), *n* (%)		
Minor (0.941–1)	78 450 (54.5)	2.44%
Moderate (0.665–0.940)	56 177 (39.0)	8.38%
Severe (0–0.664)	9 431 (6.6)	19.62%
Tranfusion, *n* (%)		
Yes	14 763 (10.3)	11.42%
No	129 295 (89.8)	5.25%
Surgery during hospitalisation, *n* (%)		
Yes	75 105 (52.1)	4.26%
No	68 953 (47.9)	7.65%
Hospital stay characteristics		
Transfer during the first 48 hours after admission, *n* (%)		
Yes	15 557 (10.8)	6.03%
No	128 501 (89.2)	5.87%
ICU admission during hospitalisation, *n* (%)		
Yes	40 294 (28.0)	10.43%
No	103 764 (72.0)	4.12%
Type of hospital admission, *n* (%)		
University hospital	44 552 (30.9%)	6.72%
General hospital	81 171 (56.4%)	5.80%
Private hospital	18 335 (12.7%)	4.22%

ICISS: international classification of diseases ICD10-based injury severity score; ICU: intensive care unit.

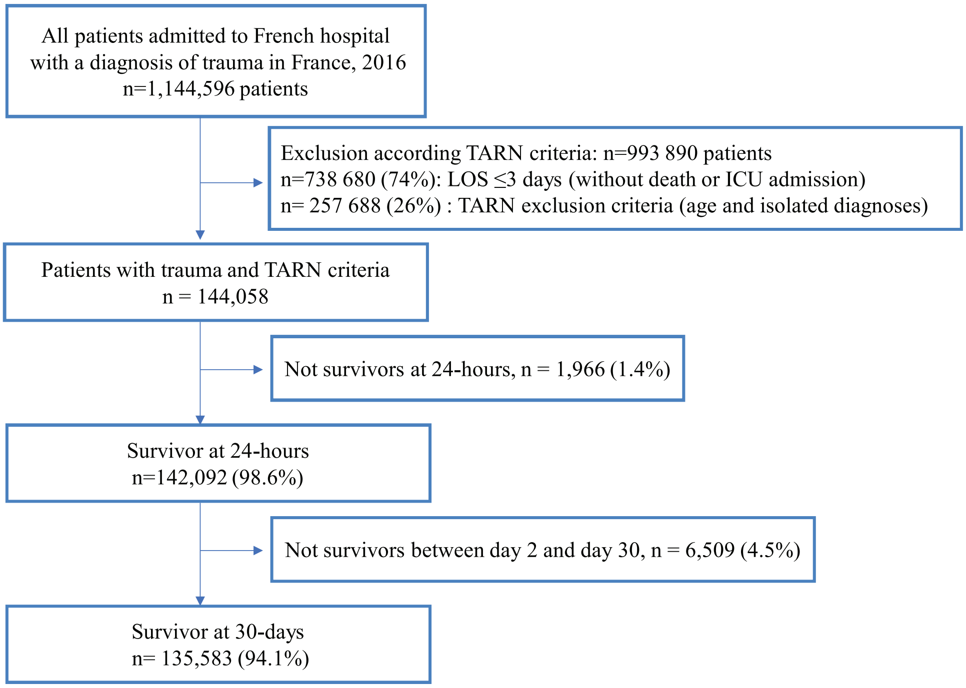

Fig. 1. Flowchart of the study population. TARN: trauma audit and research network; LOS: length of stay.

LOS criteria: in hospital for ≥ 3 days; admitted to ICU (regardless of LOS); transferred out for specialist care or repatriation (total LOS > 3 days); deaths (including deaths in the emergency department) and whose isolated injuries corresponded to a specific ICD code (depending on the ICD code, inclusion was systematic or depended on patient age, association with another ICD code, or operative intervention). The PMSI-specific codes are listed in Supplementary Table 1. All consecutive hospitalisations were linked into one sequence to reconstitute a suite of successive hospitalisations until either the death or the discharge from the hospital to prevent loss of information due to transfer of the patient between distinct hospitals. Only the first hospitalisation sequence (initial hospitalisation and possible transfer) was retained for patients who had several hospitalisation sequences in the year.

Outcome measure

The main outcome measure was 30-day intra-hospital mortality.

Collected data

The following data were collected:

- sociodemographic information: age, gender, and area-level deprivation index (FDep99 index) based on the patient's address

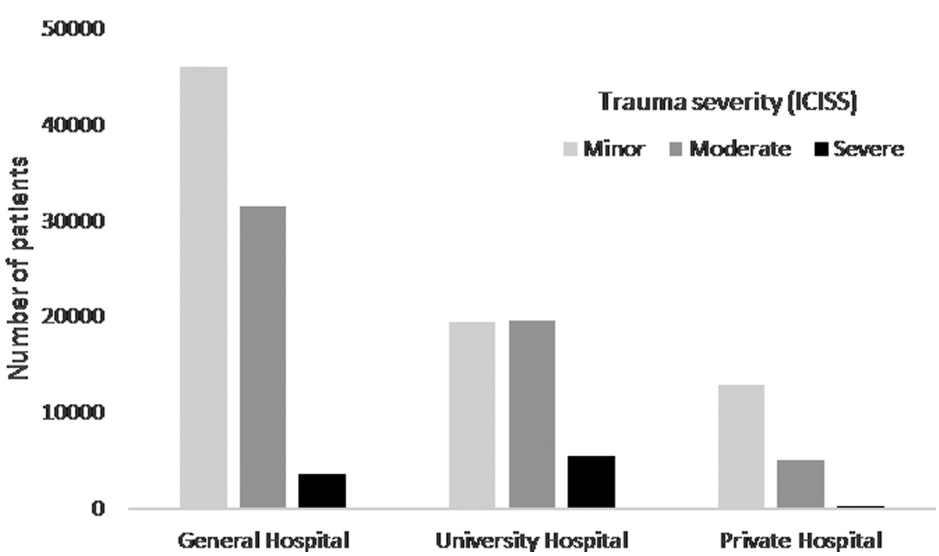

Fig. 2. Injury severity (according to ICISS) and type of hospital (General, University, Private). ICISS: ICD10-based Injury Severity Score [minor (0.941–1.0); moderate (0.665–0.940); severe (0-0.664)].

Table 2
French geographical administrative regions and mortality rates.

	Number of hospitals	Whole population n = 144,058	In-hospital 30-day mortality rates n = 8475 (5.9%)	In-hospital 30-day Standardised mortality rates n = 8475 (5.9%)
Metropolitain areas				
Ile-de-France	161	19 293	1 075 (5.6%)	1 101 (5.7%)
Auvergne-Rhône-Alpes	150	20 014	1 066(5.3%)	1 166 (5.8%)
Nouvelle-Aquitaine	120	14 581	942 (6.5%)	905 (6.2%)
Occitanie	119	14 204	829 (5.8%)	865 (6.1%)
Provence-Alpes-Côte d'Azur	109	14 190	837 (5.9%)	840 (5.9%)
Hauts-de-France	104	11 860	720 (6.1%)	668 (5.6%)
Grand Est	109	116 44	710 (6.1%)	695 (6.0%)
Pays de la Loire	60	7 519	438 (5.8%)	450 (6.0%)
Bretagne	63	8 302	513 (6.2%)	510 (6.1%)
Normandie	64	6 720	413 (6.2%)	396 (5.9%)
Bourgogne-Franche-Comté	63	6 381	393 (6.2%)	388 (6.1%)
Centre-Val de Loire	47	4 766	326 (6.8%)	289 (6.1%)
Corse	12	956	39 (4.1%)	52 (5.5%)
Overseas regions	26	3 628	174 (4.8%)	151 (4.2%)

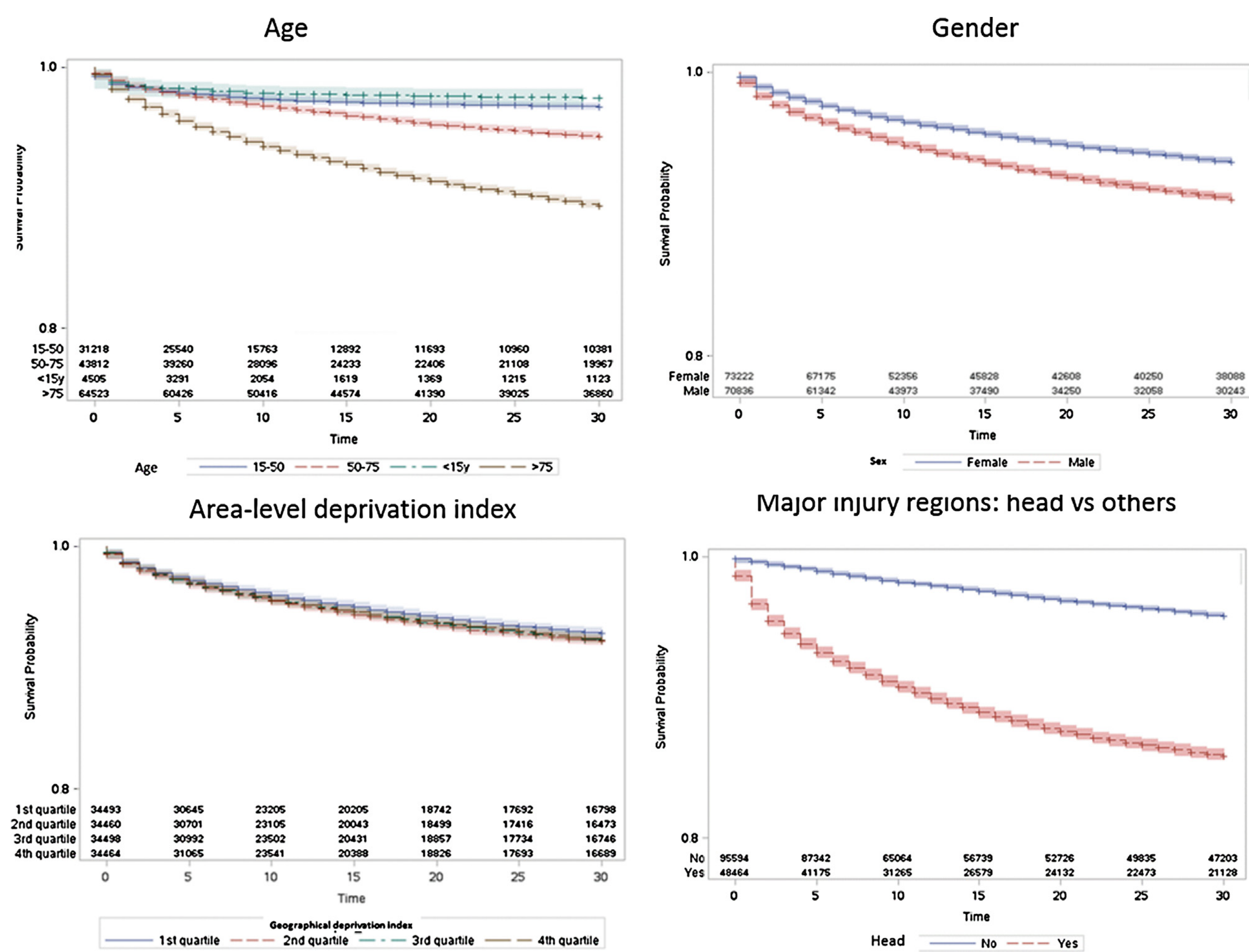

Fig. 3. Kaplan–Meier cumulative survival curves of patients with trauma according age, gender, area-level deprivation index and major injury region.

and validated by French data [13]. This index was used as a proxy of the social environment and is the first component of a principal component analysis involving four socio-economic ecological variables: percentage of high-school graduates, median household income, percentage of blue-collar workers, and the unemployment rate. We categorised this index according to quartiles;

- clinical information: injury region (head, thorax, abdomen, and extremities), comorbidities based on the Charlson comorbidity index using the algorithm developed by Quan et al. [14], injury severity based on the 10th Revision (ICD-10)-based Injury Severity Score (ICISS) with stratification derived from a Geteborg et al. study [15] (minor (0,941–1,0); moderate (0,665–0,940); severe (0-0,664)), transfusion and surgery (corresponding to a surgical code from the "Classification Commune des Actes Médicaux" list on the patient's discharge summary);
- hospital characteristics: geographical administrative region, transfer during the first 48 hours after admission, ICU admis-

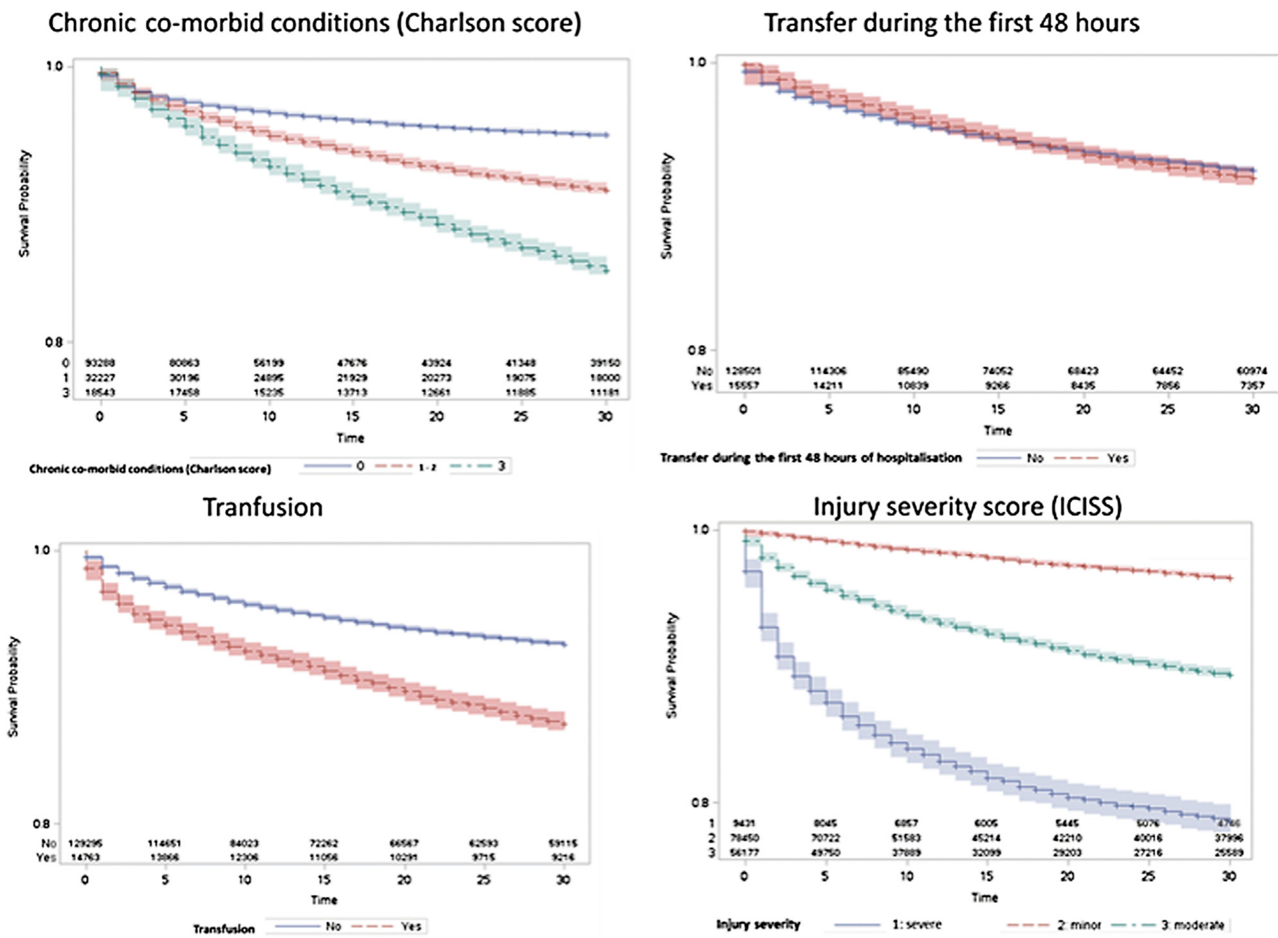

Fig. 4. Kaplan–Meier cumulative survival curves of patients with trauma according Charlson score, patient transfer, and injury severity score.

sion, type of hospital (i.e. university, public, and private hospital).

Statistical analysis

Descriptive analyses for socio-demographic, clinical, and hospital data were presented as frequencies and percentages. In-hospital 30-day mortality rates were calculated for the whole population and each geographical administrative region. Age- and sex-specific mortality rates were calculated for each region using indirect standardisation based on age-sex specific rates of the French trauma population issued from our exhaustive study. Associations between socio-demographic, clinical, and hospital data and mortality within 30 days were performed using Kaplan–Meier cumulative survival curves and univariate Cox proportional-hazards (with a Sandwich Estimator to take into account correlation within a hospital). Variables relevant to the model were selected based on a threshold *P*-value (≤ 0.2) in the univariate analysis and included in multivariate Cox proportional-hazards: age, gender, geographical deprivation index, head trauma, chronic comorbid conditions, ICISS score, transfusion, surgery, and transfer during the 48 first hours after admission, ICU admission, and type of structure. We tested the interaction between the outcomes and time to determine if the proportionality of hazard across time. Adjusted hazard-ratios (HR) with 95% confidence intervals (95% CI) were calculated. Finally, we compared socio-demographic, clinical, and hospital stays characterised by gender using chi-square tests. Statistical significance was defined as $P < 0.05$. The statistical analysis was performed with SAS 9.4 (SAS Institute).

Results

Among 1,144,596 patients admitted to French hospitals for trauma in 2016 (with diagnosis codes S or T), we excluded 993,890 (87%) patients based on TARN criteria, resulting in the inclusion of 144,058 patients. The flowchart is presented in Fig. 1. Among those patients, 8,475 (5.9%) did not survive 30 days.

The features of patients and 30-day mortality rates are shown in Table 1. The mean age was 64 years (± 24) and 73,222 (50.8%) were females. Comorbidity was found in 35.3% of the cohort. The regions of injury were distributed between the head (33.6%), thorax (33.9%), abdomen (30.3%), and extremities (48.2%). The severity of injury was minor for 54.5%, and severe for 6.6% of our cohort. ICU admission was reported for 40 294 (28%) patients. Surgery during hospitalisation was required for 52.1% of our patients.

The patients were admitted to 1,208 different facilities: general hospitals (56.4%), university hospital (30.9%), and private hospitals (12.7%). The mean number of patients admitted by facilities was 152 (± 444). The severity of trauma differed according to the type of hospital. Minor or moderate trauma cases were admitted to general or private hospitals (70.9% of cases were minor and moderate), while severe trauma cases were more often admitted to university hospitals (58.3% of cases were severe) (Fig. 2). The mean hospitalisation duration was 12.8 ± 14.8 days (median = 9, interquartile range = [6;15]). Transfers during the first 48 hours were required for 10.8% of the cohort.

Table 3
Comparison of socio-demographic. Clinical and hospital stay characteristics by gender.

	Men n = 70 836 (49.2%)	Women n = 73 222 (50.8%)	P-value
Socio-demographic characteristics			
Age, n (%)			$P < 0.0001$
< 15y	2 841 (4.0)	1 664 (2.3)	
15-50	23 345 (33.0)	7 873 (10.8)	
50–75	24 830 (35.1)	18 982 (25.9)	
>75	19 820 (27.9)	44 703 (61.1)	
Geographical deprivation index, n (%)			$P < 0.0001$
1st quartile: most advantaged	16 346 (23.1)	18 147 (24.8)	
2nd quartile: quite advantaged	16 590 (23.4)	17 870 (24.5)	
3rd quartile: quite disadvantaged	16 909 (23.9)	17 589 (24.0)	
4th quartile: most disadvantaged	16 958 (23.9)	17 506 (23.9)	
Clinical characteristics			
Major injury regions, n (%)			
Head	28 621 (40.4)	19 843 (27.1)	$P < 0.0001$
Thoracic	30 455 (43.0)	22 649 (30.9)	$P < 0.0001$
Abdominal	21 097 (29.8)	22 545 (30.8)	$P < 0.0001$
Member	31 274 (44.2)	3 090 (52.0)	$P < 0.0001$
Chronic co-morbid conditions (Charlson score), n (%)			$P < 0.0001$
0	47 801 (67.5)	45 487 (62.1)	
1–2	13 796 (19.5)	18 431 (25.2)	
>2	9 239 (13.0)	9 304 (12.7)	
Injury severity (ICISS), n (%)			$P < 0.0001$
Minor (0.941–1)	33 327 (47.1)	45 123 (61.6)	
Moderate (0.665–0.940)	30 838 (43.5)	25 339 (34.6)	
Severe (0–0.664)	6 671 (9.4)	2 760 (3.8)	
Tranfusion n (%)			$P < 0.0001$
Yes	6 900 (9.7)	7 863 (10.7)	
No	63 936 (90.3)	65 359 (89.3)	
Surgery n (%)			$P < 0.0001$
Yes	37 330 (52.7)	37 775 (50.3)	
No	33 506 (47.3)	35 447 (51.4)	
Hospital stay characteristics			
Transfer during the 48 first hours after admission n (%)			$P < 0.0001$
Yes	8 028 (11.3)	7 529 (10.3)	
No	62 808 (88.7)	65 693 (89.7)	
ICU admission n (%)			$P < 0.0001$
Yes	26 968 (38.1)	13 326 (18.2)	
No	43 868 (61.9)	59 896 (81.8)	

The 30-day mortality rates according each French geographical administrative region are presented in Table 2. In-hospital 30-day standardised mortality rates varied from 4.2 to 6.2%. The risk factors of 30-day mortality are shown in Supplementary Table 2. In non-survivors, the delay between admission and death was 12.2 days ± 23.3 days (median = 6, Interquartile range = [2; 15]). The effects of age, gender, area-level deprivation index, injury regions, co-morbidities, inter-hospital transfer within 48 hours, transfusion, injury severity on survival are presented in Fig. 3 and 4.

The analysis according to gender is shown in Table 3. In brief, patients older than 75 years were over-represented among women (61.1% versus 27.9%), those with extremity injuries (52.0% versus 44.2%), and those with minor trauma (61.6% versus 47.1%). In contrast, those over 75 had less head injuries (27.1% versus 40.4%) and required less ICU admission (18.2% versus 38.1%). The mortality rates differed in males and females (Fig. 3). This difference was more pronounced in patients older than 75 years, with a higher mortality among males ($P < 0.01$) (Fig. 5).

Discussion

Our study shows that patients admitted for trauma in French hospitals had a 5.9% mortality rate within 30-days with regional variations from 4.2 to 6.2%. The patients' age and severity of injuries were strong predictors for mortality, while being female and requiring surgery were protective factors. To our knowledge, these findings are reported for the first time in a large-scale study. Professionals can use them in order to provide accurate and relevant information to patients and relatives. An estimation of the burden of disease is critical to inform policy making and to devise a national strategy.

This study was not focused on the most severe patients who are directly admitted from scene to ICU. Our choice was to include a large, consistent, but relatively severe population since the mortality rate exceeded 5%. The observed 30-day mortality rate underlines the high disease burden generated by trauma, in particular compared to ST-segment elevation myocardial infarction [16]. However, our findings confirm the high burden represented by trauma at the national level. They suggest that progress is required in the management of all trauma patients.

The median age of our cohort was 64 years. Our results show a continuum of worsening from the age category of ≤ 15 years to ≥ 75 years, which suggests that aging is a deleterious process in terms of mortality risk. A major increase in mortality was found among the patients older than 75 years. In a Spanish cohort including 2700 patients, mortality rates increased with age while injury severity scores were similar across age categories, ranging from 7.7% in patients ≤ 55 years to 29.5% in those ≥ 75 years [17]. Same results were reported elsewhere [18,19]. Interestingly, comorbidities were reported in 35% of our cohort, which was

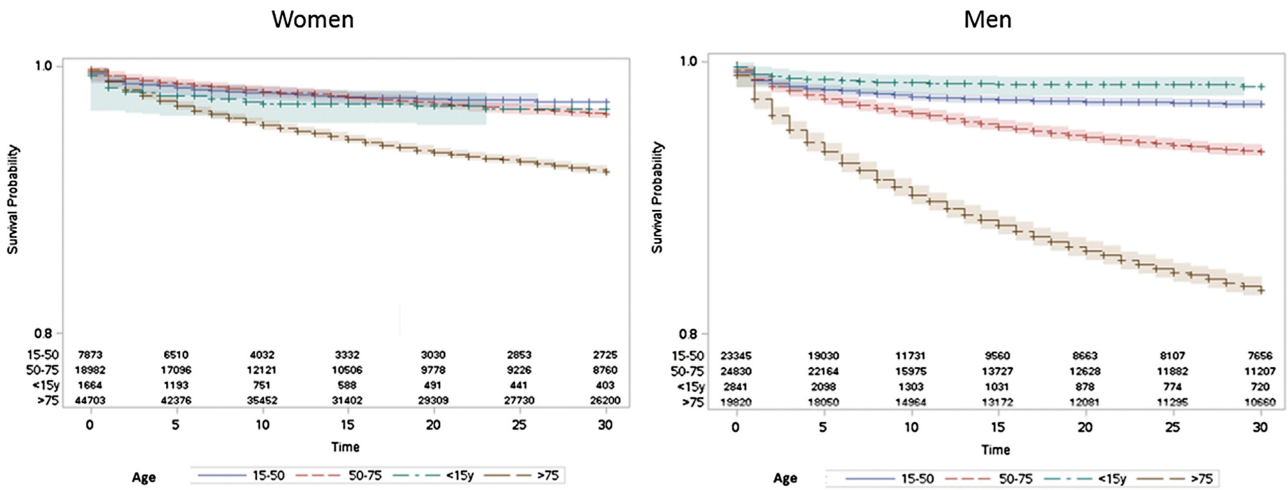

Fig. 5. Kaplan–Meier cumulative survival curves of patients with trauma patients by age and gender.

unexpected for this population. As elsewhere, the severity scores, reflecting the severity of injury, were strongly associated with mortality. Of note, we re-computed a score (ICISS) [14], a-posteriori, mimicking the injury severity score (ISS). However, ICISS seems to predict mortality better than ISS or the Trauma and Injury Severity Score (TRISS) [20].

In our study, although males and females were equally distributed, strong gender disparities were suggested. Females are over-represented after 75 years. This can reflect the prolonged life expectancy in women, as compared to men [1–3]. With respect to trauma, females were at lesser risk of mortality, especially after 75 years. This can be due to less severe trauma. Indeed, extremity injuries were more frequent in females, while head injuries were predominant in males. Differences in outcomes between gender are quite complex to understand; they can be due to societal factors, gene differences, and hormone production [21]. Our findings are in line with those of a meta-analysis showing that males are associated with an increased risk of mortality after trauma [22]. In general, male over mortality is found in physiologic and most pathologic states [1–3,21].

Our findings suggest an effect of the area-level deprivation index as a variable associated with mortality. This variable was constructed from the ZIP code of patient housing [23], reflecting the socioeconomic status of each patient. Here, we showed that the most advantaged patients, according to the area-level deprivation index, had better outcomes. This important finding is in line with a systematic review suggesting that, in the US, both race/ethnicity and insurance are clearly associated with disparate outcomes following trauma [24]. In Germany, education was associated with life expectancies: lower educated individuals face greater uncertainty about the age at which they will die [25]. To our knowledge, in France, this is the first study reporting disparities in the outcomes of patients according to their socioeconomic status. However, this association requires a careful interpretation. Other variables, like the level of health structures in the area of injury or the marital status may affect this association. Future studies should explore this issue.

The strengths of our study are the inclusion of more than 144,000 patients. To our knowledge, it is the largest epidemiological study performed in the field of trauma in France. We used a dedicated method of patient selection, which has been validated by the TARN [10]. It therefore makes sense to compare the present study with previous studies from the TARN database. Indeed, the 5.9% 30-day mortality rate is similar to the 7% 30-day mortality rate in a 129,786 patient TARN study between 2010 and 2013 [26]. This suggests a similar trauma management effectiveness. Similar mortality rates have also been reported in other registries. The mortality rate was 6.9% in the American National Trauma Databank [27] and 7% in a Quebec study [28]. The determination of international selection criteria may be a way forward for broad international comparisons between trauma registries.

The limitations of the study are those inherent to a large database. Several factors were lacking, including physiological parameters at admission and radiological assessment. The criteria of inclusion remain a matter of debate. Hospitalisation of at least three days is needed in order to select trauma patients with a minimal level of severity. The lack of a national register for trauma in France can be viewed as a weakness of our study. However, the national database includes relevant data, as underlined in other studies [29,30]. Lastly, previous studies highlighted the limitations of the PMSI system to identify trauma epidemiology [12]. For this reason, we used the TARN methodology for the first time on French data. Future study should confirm the relevance of this approach in the French context.

In conclusion, this epidemiological study including 144,000 trauma patients over a single year showed that 30-day mortality associated with hospitalisation for trauma in France was around 6% with regional variations. Striking differences are noted between age categories and gender. These findings underline the high burden represented by trauma for the French population.

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None.

Author contributions

TB: Conceptualisation; Writing – original draft;
VP: Methodology, Formal analysis, Software, Validation, Review and Editing;
VO: Methodology, Formal analysis, Software;
LB: Conceptualisation, Methodology, Project administration, Supervision, Writing - original draft, Review and Editing;
ML: Conceptualisation, Supervision, Writing - original draft; Review and Editing.

Disclosure of interest

ML disclosed competing interest with MSD, Pfizer, Amomed, Aguettant, and Octapharma (lectures).
The other authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at https://doi.org/10.1016/j.accpm.2019.02.007.

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