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## Traumatic spinal fractures the fall and rise

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# CHAPTER 2

## **EPIDEMIOLOGY OF SPINAL FRACTURES IN A LEVEL ONE TRAUMA CENTER IN THE NETHERLANDS: A 10 YEARS REVIEW**

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## Abstract

### Background

Spinal fractures may have large socioeconomic consequences. The prevalence and outcomes likely change over the years due to improved traffic safety, increasing population age and improved medical treatment. This is the first study to address the epidemiology of spinal fractures in a level 1 trauma center in the Netherlands over a large time period.

### Methods

All patients with a cervical, thoracic or lumbar spine fracture admitted to a level 1 trauma center from 2007 to 2016 were prospectively registered and retrospectively analyzed. In addition to patient-, accident- and associated injury characteristics, radiological and surgery data were obtained from the hospital's Electronic Patient File system.

### Results

Between 2007 and 2016, 1479 patients with a total of 3029 spinal fractures were admitted. 40,8% were female and 59,2% were male, with a mean age of 52,0 years. 4,9% of fractures occurred at a juvenile age (0-18) and 63,6% at the age of 19-64 years. Most fractures occurred in the thoracic spine, followed by the lumbar- and cervical spine. The most common cause of injury was a fall from height, followed by traffic accidents. Spinal cord injury occurred in 8,5% and associated injuries were reported in 73% of the patients. Sixteen percent of the admitted patients were treated operatively. Over time, there was a larger increase in amount of spine fractures in elderly (>65 years) compared to younger people.

### Conclusion

The total amount of spine fractures per year increased over time. Additionally, there was a larger increase in amount of spine fractures in patients over 65 years of age compared to younger patients. Despite this increase, a considerable amount of spine fractures still occur in the age-group 19-64 years. Most fractures were located in the thoracic spine. This study might stimulate development of policy on precautionary actions to prevent spine fractures.

## Introduction

Although spinal fractures are not the most frequent traumatic injuries, they can severely influence both social as well as financial aspects of patients and society<sup>1</sup>. Patients suffering a spine injury, are less likely to re-integrate after absenteeism, especially if the spinal cord is involved<sup>2,3</sup>. Since spinal injuries frequently occur at a relatively young age, the social-economic impact on society is significant<sup>1,4</sup>.

The studies on spinal fractures that have been conducted in recent years mainly emphasized appropriate treatment and surgical techniques. Despite wide scientific interest in treatment of spinal fractures, only a few epidemiology studies on spine fractures have been conducted<sup>5-10</sup>. Van Asbeck et al. found that between 1987 and 1991, on average 2254 patients per year have been hospitalized nationwide with diagnoses of traumatic spine fractures in the Netherlands. This equals approximately 150 patients per one million residents<sup>11</sup>. Compared to the United States, this number is relatively low. In the United States, a mean incidence of 233-350 patient per one million residents is described<sup>11</sup>. The data used in these epidemiologic studies are however no longer representative for modern times, especially when taking into account the aging population and associated share of osteoporotic fractures<sup>12-14</sup>.

Epidemiological research in previous studies has shown that a fall from height is the most common cause of spinal fractures, followed by traffic accidents<sup>4,5</sup>. It is important to describe recent epidemiological data to provide insight in causes and characteristics of spine fractures for the implementation of preventative measures by governments and to optimize diagnosis and treatment processes in hospitals. Especially when taking into account the increasing life span and less sedentary lifestyles of the elderly. This epidemiologic study is conducted to provide up to date data on patient and fracture characteristics throughout the years in a University hospital in the Netherlands.

## Materials & Methods

### Data collection

All patients that suffered a spinal fracture between 2007 and 2016 that were presented and admitted to a level 1 trauma center were further analyzed. All patients from all age groups with cervical, thoracic or lumbar fractures were included, there were no exclusion criteria. Data were derived from the local trauma registration. The collected data consisted of; patient characteristics, accident characteristics, emergency department admissions, trauma mechanism, survival status and duration of hospital stay. In addition, data collection was complemented with data recorded in the hospital's Electronic Patient File system for each patient. Data collected from the patient file system and radiographs consisted of: fracture

location and surgery (yes or no) and if yes; posterior and/or anterior stabilization. The study was approved by the local IRB (METc VUmc) under case number 2017.464.

Data was assessed for differences in prevalence of spinal fractures between age groups, gender, fracture level, mortality and mechanism of injury. The proportion of operative versus conservatively treated patients was described. Multiple fractures were defined as fractures in more than one vertebra. If there were more fractures in a single vertebra (e.g. spinous process and transverse process), these were defined as one fracture. In-hospital mortality was defined as death during hospitalization or in the emergency department. The most common areas of additional injuries to spinal fractures were analyzed using Abbreviated Injury Scale (AIS) codes. Intra-thoracic organ injury was registered as thoracic injury. Poly-trauma was defined by an Injury Severity Score (ISS) of 16 or higher 15. In-hospital mortality and duration of hospitalization was stratified for ISS (ISS < and  $\geq$  16). Patients were described in three age categories; juveniles (0-18 years), adults (19-64 years) and elderly ( $\geq$  65 years). The prevalence of spinal fractures over time in patients under and over 65 years will be described.

### Statistical Analyses

Continuous data will be shown as mean with standard deviation (SD), or if not normally distributed as median with interquartile range (25th–75th percentile). Categorical data will be shown as absolute values with frequencies or percentages. Dichotomous variables will be compared with a Chi-square test with absolute frequencies. To compare skewed data non-parametric tests will be used. Normally distributed continuous data will be compared between two groups with a T-test. Differences between regression coefficients of two groups will be tested for significance using an interaction variable in linear regression analysis.  $P < 0.05$  will be regarded as statistically significant. Statistics were performed using IBM SPSS 22.0.

## Results

### Age and gender

From 2007 until 2016, 1479 patients with a spinal fracture were hospitalized. Of these 603 (40.8%) were female and 876 (59.2%) were male, with an overall female to male ratio of 1:1.5. The mean age was  $52.0 \pm 22.1$  years. Spinal fractures occurred at a juvenile age (0-18) in 72 patients (4.9%) and in 940 (63.6%) adults (19-64). Overall patient characteristics are shown in table 1. The age distribution of females and males was different (Fig 1). At the time of injury, women were significantly older ( $56.4 \pm 23.4$  years) than men ( $48.9 \pm 20.7$  years) ( $p < 0.01$ ). Forty-two percent of all females that suffered a spine fracture was  $\geq 65$  years of age, this is significantly more ( $p < 0.01$ ) compared to the amount of males (24%) that were  $\geq 65$  years of age while they

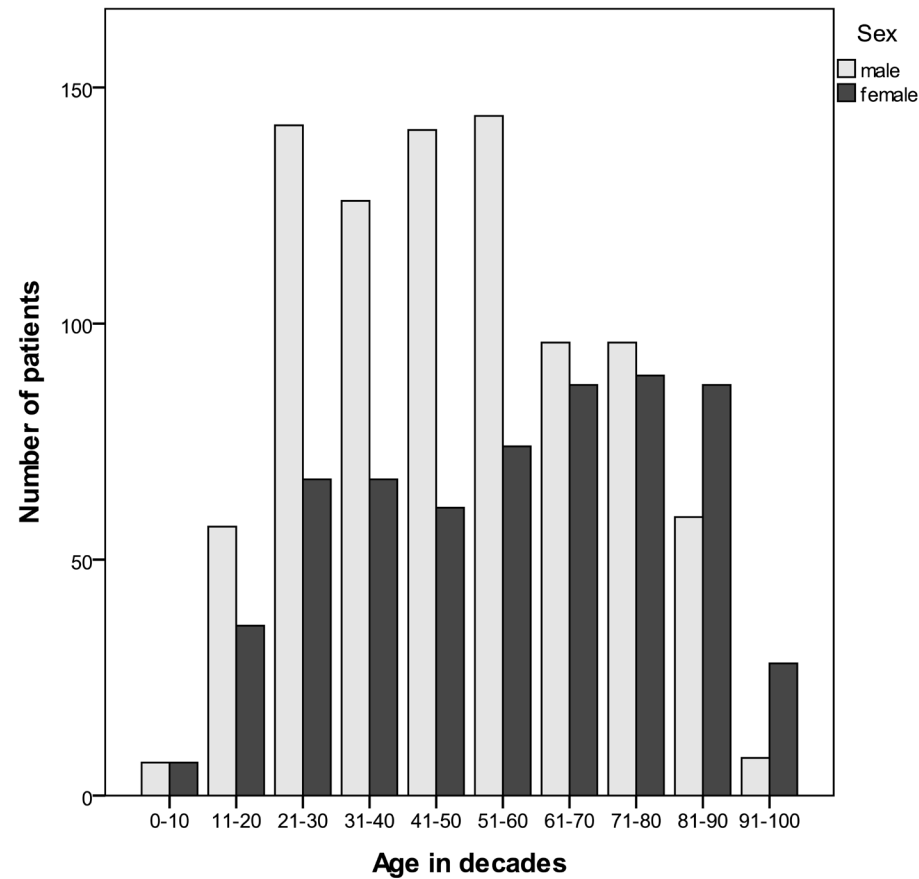
suffered a spine fracture. Over time, there was a significant larger increase in spine fractures in the elderly ( $\geq 65$  years) compared to younger people (linear regression analysis;  $p < 0.01$ ), Fig 2. The total amount of spinal fractures increased over time from 2007 to 2016 with 44% (from 120 to 173 respectively.)

**Table 1.** Patient characteristics

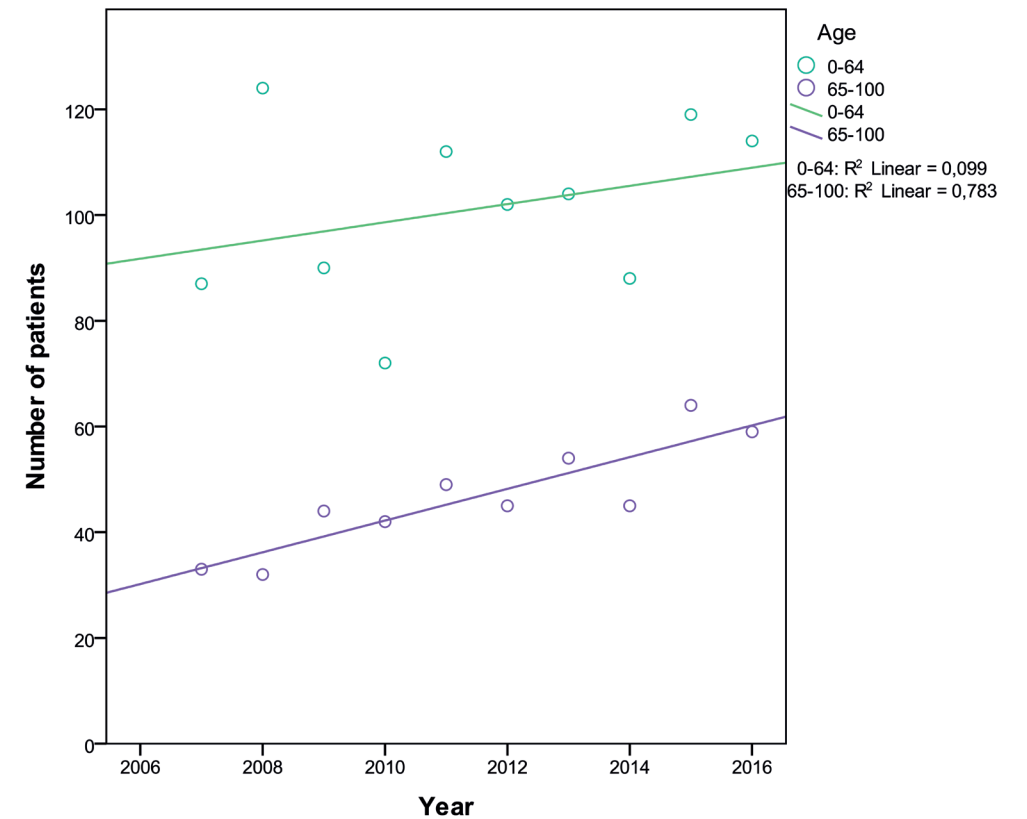
n	1479
Gender (male:female)	1.5:1
Age (mean $\pm$ SD)	52.0 $\pm$ 22,1 years
<b>Affected vertebra; n (%)</b>	
Cervical	745 (24,6%)
Thoracic	1262 (41,7%)
Lumbar	1022 (33,7%)
<b>Mechanism of injury; n (%)</b>	
Fall from height	474 (44,7%)
Traffic accidents	371 (35,0%)
Industrial accidents	78 (7,4%)
Sports	55 (5,2%)
Self-mutilation/suicide	55 (5,2%)
Others	28 (2,5%)
<b>Associated injury; n (%)</b>	
Head	629 (25,8%)
Thoracic	578 (23,8%)
Lower-extremity	387 (15,9%)
Upper-extremity	385 (15,8%)
Face	264 (10,9%)
Abdomen	159 (6,5%)
Neck	32 (1,3%)
<b>Treatment; n (%)</b>	
Conservative	1240 (83,8%)
Surgery	239 (16,2%)

SD; standard deviation

**Figure 1.** Age at the time of spinal fracture



**Figure 2.** Number of patients with a spinal fracture per year stratified for patients aged over- and under 65 years.



Significant difference in increase (linear regression analysis;  $p < 0,01$ )

**Mechanism of injury**

*Fall from height*

Data on mechanism of injury was available for 1061 patients, registration started only in 2010. The most common cause of spinal fractures was a fall from height (474; 44.7%) followed by traffic accidents (371; 35.0%). Falls from height increased with age until the age of 70, Fig 3. Additionally, the number of patients with a fall from height increased between 2010 and 2016, Fig 4. Starting from 2014, falls from height were further specified in two subgroups in the registration; low energetic fall (fall from the same level) and high energetic fall (fall from a higher level). From 2014, the most common cause of all spine fractures was a low energetic fall (176; 36.4%) followed by high energetic fall (112; 23.1%). There was a significant difference in mean age between low energetic fall ( $65.5 \pm 20.6$  years) and high energetic fall ( $51.2 \pm 19.8$  years) ( $p < 0.001$ ). In patients aged  $\geq 65$  years the majority of spine fractures were caused by low energetic falls (102; 60.7%).

Traffic accidents

In males the majority of spinal fractures were caused by traffic accidents (249; 67.1%), which was twice as much compared to females (122; 32.9%). Overall, in juveniles (0-18) and adults (19-64), the most common mechanism of injury was a traffic accident (18; 25% and 176; 47.2%, respectively). Traffic accidents decreased from the age of 21-30 with two dips at the ages of 31-40 and 61-70, Fig 3. Traffic accidents increased slightly over the years with a dip in 2014. Traffic accidents were further specified since the registration of 2014 and consisted of 6 subgroups; motorized vehicle (motorcycle excluded), motorcycle, moped/scooter, bicycle, pedestrian or others. From 2014, bicycle accidents were the most common cause of spine fractures (59; 12.2%) followed by motorized vehicles (58; 12.0%) and moped vehicles (27; 5.6%).

Figure 3. Number of patients per mechanism of injury for age in decades.

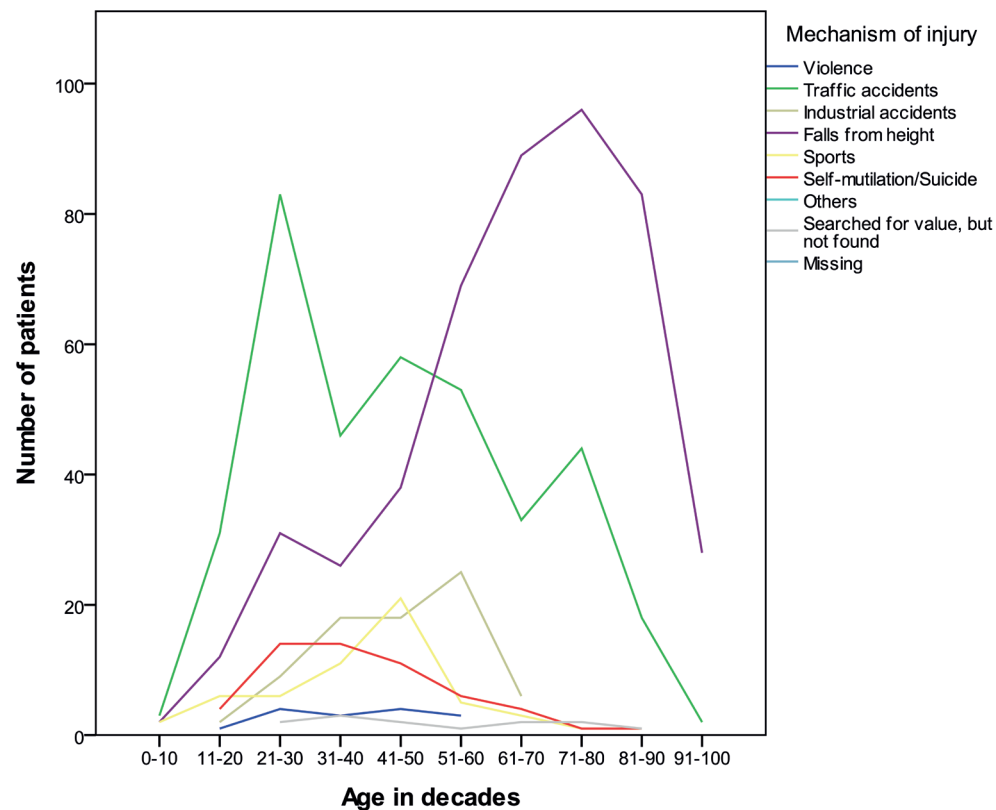
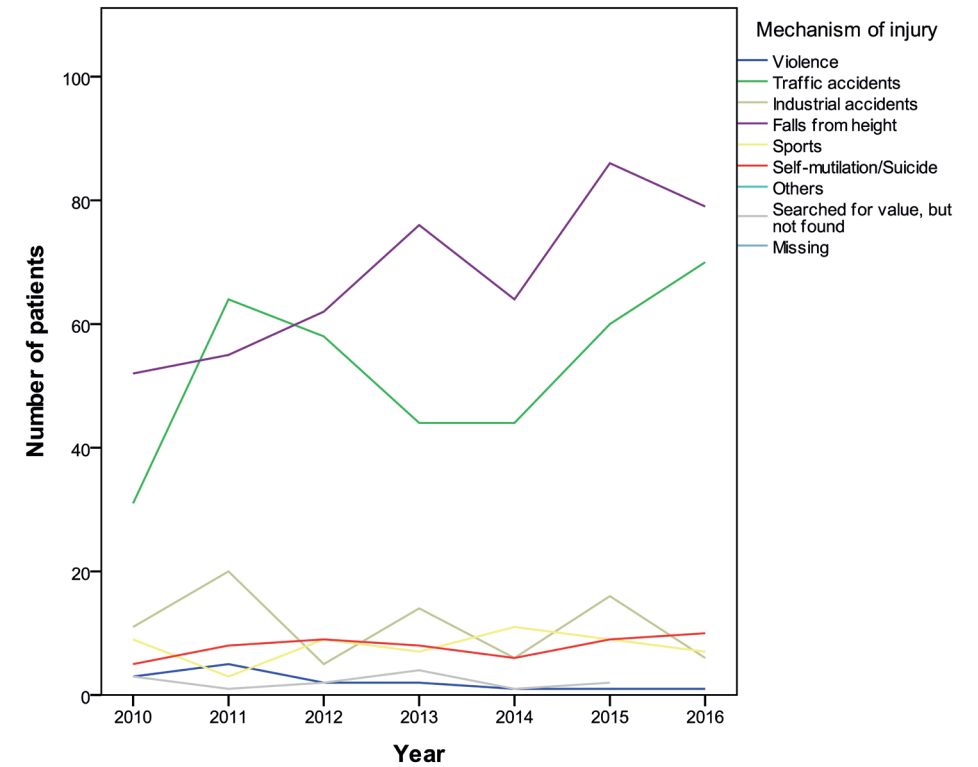


Figure 4. Number of patients per mechanism of injury over the years.



Fracture region and associated injury

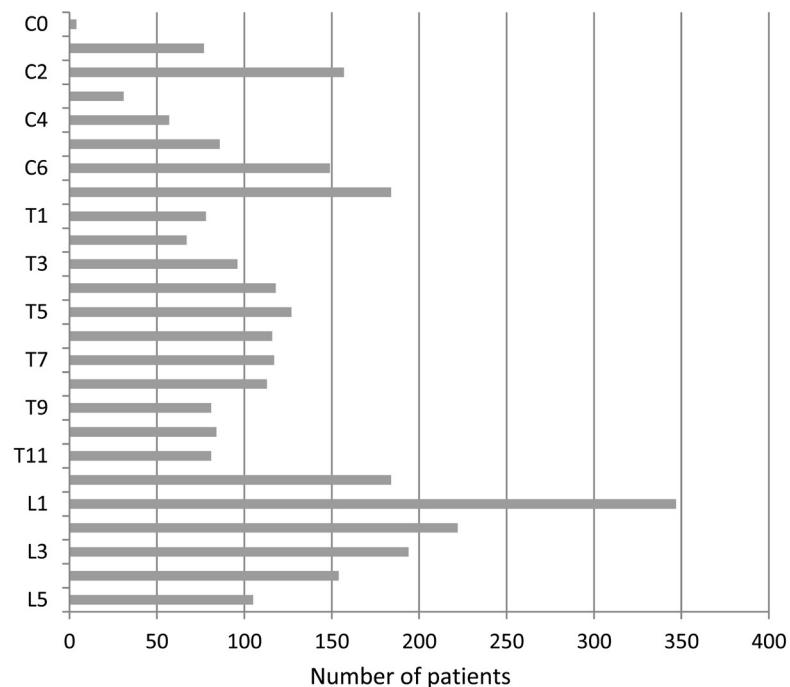
A total of 3029 spinal fractures were registered with an average of 2,1 fractures per patient. Most fractures occurred in the thoracic spine (1262; 41.6%), followed by the lumbar spine (1022; 33.7%) and the cervical spine (745; 24.6%). The most affected vertebra was the first lumbar vertebra (347; 13.7%) followed by the second lumbar vertebra (222; 8.8%), Fig 5 shows the distribution of fractures over all vertebrae. Single vertebral fractures were reported in 720 (48.7%) patients and 759 patients (51.3%) suffered multiple fractures. Polytrauma patients (ISS ≥ 16) suffered significantly more multiple fractures compared to non-polytrauma patients (ISS < 16), 64% vs 43% respectively (p<0,01).

The mean overall ISS was 17.1 ± 12.3 and significantly higher for males (19.0 ± 12.9) compared to females (14.4 ± 10.9) (p<0.01). Thoracic spine fractures were associated with the highest mean ISS (19.2 ± 12.4), followed by the cervical spine (18.5 ± 10.9). Associated injuries were registered in 1082 (73.2%) patients. The cervical spine was the most common region with at least one associated injury (82%). The most frequently associated injuries consisted of

head injury (629; 25.8%) followed by thoracic injury (578; 23.8%). The most common associated injury of the cervical spine was head injury (181; 48.0%), followed by facial injury (88; 23.5%). All associated injuries are shown in table 1. The majority of spinal fractures in the thoracic and lumbar region were associated with thoracic injury (340; 30.9% and 245; 22.2%, respectively).

Spinal cord Injury (SCI) occurred in 127 (8.6%) of the 1479 patients. Mostly in addition to a cervical spine fracture (75; 59.1%) followed by thoracic- (33; 26.0%) and lumbar spine fractures (19; 14.9%).

**Figure 5.** The distribution of spinal fractures per spine region.



### Hospital care

Of the 1479 patients, 1240 (83.8%) were treated conservatively and 239 (16.2%) operatively. Posterior stabilization was the most common surgical treatment (124; 51.9%) followed by the combined anterior and posterior approach (58; 24.2%). The single anterior (38; 15.9%) approach was only used in fractures of the cervical spine. The surgical to conservative ratio remained constant over the years (1:5.3). The median duration from arriving at the emergency department to surgery was three days (IQR 1-6) and did not differ between mono or poly-trauma patients. Patients with an ISS <16 were hospitalized for a median duration of four days

(IQR 2-10) and patients with an ISS  $\geq$  16 for a median of 16 days (IQR 7-31). The total mortality (in-hospital and at emergency department) for patients with an ISS < 16 was 1.4% (12 patients) and for patients with an ISS  $\geq$  16 14.0% (96 patients). The mean age of deceased patients was  $63.6 \pm 22.6$  years.

## Discussion

In the past ten years 1479 patients with a spinal fracture were admitted at our level one trauma center. Adults are often affected, an economically active age group. The majority of the fractures were located at the thoracic spine followed by the lumbar and cervical spine. The first lumbar vertebra was most affected. The most frequent mechanism of injury was a fall from height followed by traffic accidents. There was a significant larger increase in spine fractures per year in the elderly ( $\geq$  65 years) compared to younger people.

### Registration methods

Compared to other epidemiology studies, considerably more spinal fractures were registered per patient in this study<sup>5,16</sup>. Studies conducted in China and Ireland reported 1.46 and 1.28 fractures per patient, respectively<sup>5,16</sup>, while in this study 2.1 fractures per patient were found. This is possibly due to different registration methods. These other studies identified traumatic spinal injury with the International Classification of Diseases, Ninth Revision or tenth Revision (ICD-9 and ICD-10)<sup>5,9,16</sup>. The ICD classification system is an international list of diseases maintained by the World Health Organization, it is used to give an overview of the most frequently treated diseases per hospital. The ICD classification might be imprecise while it uses several different codes to define lumbar spine fractures (e.g. S32.0, S32.7, S32.8). Research conducted with this type of registration might therefore be prone to errors, since differentiation between the pelvis and lumbar spine, is not possible if there are multiple fractures. Therefore the use of the ICD classification may lead to an underestimation of traumatic lumbar spine injuries. Therefore in this study information from radiology reports and patient files was used, as this is far more detailed and more likely to represent the true fracture prevalence.

### Fracture region

The percentage of thoracic fractures (42.8%) registered in our study was higher compared to other studies<sup>4,5,10,16</sup>. Chinese<sup>5</sup> and German<sup>4</sup> studies reported the lumbar region as the most common region of spinal fractures (47.8% - 50.4%) followed by the thoracic region (30.49% - 28.8%). Also a Finnish study reported the majority of fractures in the lumbar region (33.3%)<sup>10</sup>. The high number of thoracic fractures may also be explained by different methods of registration. Single fractures occurred less frequent in this study compared to other studies

(48.4 % of the patients had single fractures versus 51.6 % with multiple fractures). An Irish study<sup>16</sup> showed that 56.8% of vertebral fractures were solitary and a Finnish study reported 60.4% solitary vertebral fractures<sup>10</sup>. Since our study was performed in a University level-one trauma center. It is likely that the most severely injured trauma patients were presented at this emergency department. The mean ISS was 17.1 which is higher compared to other studies that report an ISS of 11.7 and 12.3 respectively<sup>16,17</sup>. This might explain the high number of patients with multiple fractures registered in this study and also the higher number thoracic fractures.

### Spinal fractures among elderly

Age has been described to be an important independent risk factor to sustain traumatic fractures with an increasing risk after the age of 50<sup>18,19</sup>. While only traumatically injured patients were registered, osteoporosis may have played an important role in this study population. There were significantly more spinal fractures in females aged over 65 than in males ( $p < 0.01$ ). The mean age of patients that were injured by a low energetic fall, was  $65.5 \pm 20.6$  years. The mean age of the populations with a spine fracture from Germany<sup>4</sup> (43.8) and China<sup>5</sup> (45.7) were slightly lower compared to the population in this study (50.3). This study shows a larger increase in amount of spine fractures in patients  $\geq 65$  years of age compared to younger patients. While recent studies have shown a relative stable overall fracture incidence among elderly, these studies merely aimed to find an association between bone mineral density and fracture risks<sup>13,14,20</sup>. Even though this study only emphasizes traumatic vertebral fractures, it is possible that osteopenia due to an increasing lifespan, contributes to a larger increase of spine fractures in patients aged  $\geq 65$  years. Additionally, this increase could be caused by an improved health at an older age which leads to a more active, fit and mobile lifestyle with additional higher risk of injury. The total amount of spinal fractures also increased compared to ten years ago. This might be due to aging of the Dutch population, improved fracture diagnostic techniques (Computed Tomography and MRI) in the last decade or due to a change in mentality causing patients to report to a doctor more often.

### Strengths and limitations

This study used data from the local trauma database, which prospectively registered patients that were hospitalized after presentation at the emergency department. Patients that returned back home after presentation (and treatment) at the emergency department were not registered in this database. Although most patients with a traumatic spine fracture will be hospitalized due to pain and discomfort, this may cause an underestimation of the total amount of spine injuries. Moreover, in the first years of the local trauma database, not all variables, such as mechanism of injury, were registered, or in less detail.

One of the strengths of this study is the 10 years' experience in a large level one trauma center in the capital of the Netherlands, which provides results of spinal fractures from all treating specialties (trauma-, neuro-, and orthopedic surgery). Due to the specialized knowledge the center serves as a tertiary reference center which creates a relatively high exposure to spine fractures

## Conclusion

This epidemiological study provides up to date and representative information of traumatic spine injuries in a level 1 trauma center in the Netherlands. A large part of fractures occur in adults. Falls from height and traffic accidents are the most common causes of spine fractures. Most fractures are treated conservatively. SCI was seen in 8.6% of the patients and mostly occur with cervical fractures. There is a significant increase of traumatic spinal fractures in patients with an age of  $\geq 65$  years over the past ten years. This study could help to develop policy on possible preventative measures for spine fractures.



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