Epidemiological Trends of Spine Trauma: An Australian Level 1 Trauma Centre Study

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Abstract

Knowledge of current epidemiology and spine trauma trends assists in public resource allocation, fine-tuning of primary prevention methods, and benchmarking purposes. Data on all patients with traumatic spine injuries admitted to the Alfred Hospital, Melbourne between May 1, 2009, and January 1, 2011, were collected from the Alfred Trauma Registry, Alfred Health medical database, and Victorian Orthopaedic Trauma Outcomes Registry. Epidemiological trends were analyzed as a general cohort, with comparison cohorts of nonsurvivors versus survivors and elderly versus nonelderly. Linear regression analysis was utilized to demonstrate trends with statistical significance. There were 965 patients with traumatic spine injuries with 2,333 spine trauma levels. The general cohort showed a trimodal age distribution, male-to-female ratio of 2:2, motor vehicle accidents as the primary spine trauma mechanism, 47.7% patients with severe polytrauma as graded using the Injury Severity Score (ISS), 17.3% with traumatic brain injury (TBI), the majority of patients with one spine injury level, 7% neurological deficit rate, 12.8% spine trauma operative rate, and 5.2% mortality rate. Variables with statistical significance trending toward mortality were the elderly, motor vehicle occupants, severe ISS, TBI, C1–2 dissociations, and American Spinal Injury Association (ASIA) A, B, and C neurological grades. Variables with statistical significance trending toward the elderly were females; low falls; one spine injury level; type 2 odontoid fractures; subaxial cervical spine distraction injuries; ASIA A, B, and C neurological grades; and patients without neurological deficits. Of the general cohort, 50.3% of spine trauma survivors were discharged home, and 48.1% were discharged to rehabilitation facilities. This study provides baseline spine trauma epidemiological data. The trimodal age distribution of patients with traumatic spine injuries calls for further studies and intervention targeted toward the 46- to 55-year age group as this group represents the main providers of financial and social security. The study’s unique feature of delineating variables with statistical significance trending toward both mortality and the elderly also provides useful data to guide future research studies, benchmarking, public health policy, and efficient resource allocation for the management of spine trauma.

Keywords
► spine trauma
► epidemiology
► demographics
► spinal injury characteristics
► neurological status
► registry
► prevention

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The variable spine trauma epidemiology study sources, ranging from dedicated clinical-quality spine trauma registries to databases of inpatient rehabilitation facilities, have the ability to create potential bias in epidemiology reporting. There is also potential for variability of spine trauma epidemiology reporting from country to country due to socioeconomic circumstances. Apart from judicious resource allocation, public health policy making, and benchmarking, knowing country- and region-specific spine trauma epidemiology is useful for the optimization of spine trauma management.

Studies have been performed to address this issue but one cannot help to notice that there is a propensity to concentrate more on spinal cord injuries than spine column trauma or both. Thus far, there have only been a handful of studies providing data on spine column trauma. This study aims to investigate the epidemiology and trending of mortality and both.

Methods

Site

The Victorian State Trauma System was established in 2000. This ensured that 90% of patients statewide with major trauma are treated in a Major Trauma Service annually. The Alfred Hospital consistently treats a minimum of 55% of major trauma cases per year in the state of Victoria, Australia. The Alfred Trauma Service admits on average 1,200 patients with severe polytrauma (Injury Severity Score [ISS] > 15) per year. Approximately a third of the patients have spine injuries, with approximately a third of those undergoing spine operative procedures. The Alfred Spine Trauma Service consists of a multidisciplinary team of orthopedists and neurosurgeons. The spine trauma unit is familiar with current spine trauma treatment algorithms and advocates for its use in the management of patients with traumatic spine injuries.

Study Cohort and Data Collection

The Alfred Trauma Registry, Alfred Health medical database, and Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) were used to identify all patients with traumatic spine injuries admitted between May 1, 2009, and January 1, 2011, as 1-year patient-reported outcome data became available from May 2009. Collection of demographic, spine injury characteristic, and physician-reported outcome data was performed using the Alfred Spine Trauma Registry minimum data set. The Alfred Trauma Registry has full-time clinical nurse specialists who are also staff members of the Alfred Health Trauma Department. Their main roles are to collect, verify, and enter registry data into the Alfred Trauma Registry. Spine and other orthopedic trauma data are then forwarded to the Victorian state trauma registry or VOTOR.

The retrospective clinical data and radiographic review were acquired from The Alfred Health acute care electronic medical database (PowerChart, Cerner Solutions, Kansas City, Missouri, USA).

Statistical Analyses

The data were analyzed separately as a general study cohort, and cohorts of nonsurvivors versus survivors and the elderly versus nonelderly were compared. We defined the elderly population as those aged 65 years and older, in accordance with World Health Organization definition. Variables investigated were demographics, clinical- and spine-specific characteristics, mortality (physician-reported outcome), and convalescence descriptors. All categories containing continuous variables were summarized using frequencies and percentages, and categorical variables were summarized using median and percentile values. Variables trending toward mortality and the elderly were further investigated using logistic (linear) regression analysis. Univariate analysis was utilized to demonstrate variables with statistical significance trending toward mortality and the elderly age group. Parameters used in regression analysis were odds ratios (ORs) and 95% confidence intervals (CIs), and the significance level was set as \( p < 0.05 \). All analyses were performed using the Statistical Package for the Social Sciences program (Version 20, SPSS Inc., Chicago, Illinois, USA).

Results

General Cohort: Demographics, Clinical, and Spine Injury Characteristics

During the 20-month period, a total of 965 patients with traumatic spine injuries with 2,333 spine injury levels were managed at the study hospital. The cohort comprised 68.7% males and 31.3% females, with a ratio of 2:2

Table 1 Demographics and clinical characteristics of general cohort

| Demographic and outcome variables | General cohort (n = 965) |
|----------------------------------|------------------------|
| Age, mean (± SD)                | 50.9 (± 20.1)          |
| Sex                              |                        |
| Male                             | 663 (68.7%)            |
| Female                           | 302 (31.3%)            |
| Ratio                            | 2:2                    |
| Mechanism of injury              |                        |
| Motor vehicle occupants          | 436 (45.2%)            |
| Unprotected road users            | 121 (12.5%)            |
| Low falls (<1 m)                 | 150 (15.5%)            |
| High falls (>1 m)                | 183 (20%)              |
| Significant collision (non-road-related) | 64 (6.6%) |
| Other causes                     | 11 (0.2%)              |
| ISS                              |                        |
| Median                           | 14                     |
| 25th/75th centile                | 9/22                   |
| Severe (ISS > 15)                | 460 (47.7%)            |
| Traumatic brain injury           |                        |
| Yes                              | 167 (17.3%)            |
| No                               | 798 (82.7%)            |

Abbreviations: ISS, Injury Severity Score; SD, standard deviation.
in favor of males. The mean age was 50.9 years. Fig. 1 shows a trimodal peak distribution of these patients in terms of age in groups of 16 to 25 years, 46 to 55 years, and more than 75 years. Motor vehicle accidents (45.2%) and falls from more than 1 m (20%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 47.7% had severe injury with ISS of more than 15; 17.3% of the patients with traumatic spine injuries had traumatic brain injury (TBI). In terms of spine injury characteristics, 42% of the patients had single-level spine injuries with 34% having three levels or more of spine injury (Fig. 2). In all, 93% were neurologically intact with 3% having nerve root injury and 4% having spinal cord injury (SCI) secondary to spine trauma. There were 189 (8.1%) high cervical spine (C0–C2) injuries with the most common injury being type 2 odontoid fractures. There were 497 (21.3%) subaxial cervical spine (C3–C7) injuries, 893 (38.3%) thoracic spine injuries, and 691 (29.6%) lumbar spine injuries with compression fractures being the most common injury morphologically. There were 63 (2.7%) sacrococcygeal injuries. There was a 12.8% spine trauma operative rate with 87.2% treated conservatively.

### Table 2: Spine injury characteristics of 965 trauma patients with spine injuries

| Spine injury characteristics (per segment) | Number (n = 2,333) | Incidence (per total spine injuries) |
|--------------------------------------------|-------------------|-------------------------------------|
| C0–C2                                      | 189               | 8.1%                                |
| Occipital condyle                          | 26                | 1.1%                                |
| C1 burst                                   | 35                | 1.5%                                |
| Odontoid (type 2)                          | 47                | 2%                                  |
| Odontoid (types 1 and 3)                   | 17                | 0.7%                                |
| C2 Hangman’s                               | 18                | 0.8%                                |
| C1–2 dissociation                          | 11                | 0.5%                                |
| C1–2 misc.                                 | 35                | 1.5%                                |
| C3–C7                                      | 497               | 21.3%                               |
| DLC only                                   | 76                | 3.3%                                |
| Compression                                | 344               | 14.7%                               |
| Burst                                      | 5                 | 0.2%                                |
| Distraction                                | 28                | 1.2%                                |
| Translation or rotation                     | 44                | 1.9%                                |
| T1–T12                                     | 893               | 38.3%                               |
| DLC only                                   | 3                 | 0.1%                                |
| Compression                                | 792               | 33.9%                               |
| Burst                                      | 44                | 1.9%                                |
| Distraction                                | 42                | 1.8%                                |
| Translation or rotation                     | 12                | 0.5%                                |
| L1–L5                                      | 691               | 29.6%                               |
| DLC only                                   | 0                 | 0                                   |
| Compression                                | 612               | 26.2%                               |
| Burst                                      | 61                | 2.6%                                |
| Distraction                                | 15                | 0.6%                                |
| Translation or rotation                     | 3                 | 0.1%                                |
| Sacrococcygeal                             | 63                | 2.7%                                |
| Management                                  |                    |                                     |
| Operative                                  | 124               | 12.8%                               |
| Nonoperative                               | 841               | 87.2%                               |

Abbreviations: C1–2 misc., miscellaneous fractures affecting the C1–C2 lamina, body, lateral mass, or spinous process; DLC, discoligamentous complex.

### General Cohort: Age Distribution

Fig. 1 Distribution of age in 965 patients with traumatic spine injuries.

### General Cohort: Injury Levels

Fig. 2 Distribution of injury levels in 965 patients with traumatic spine injuries.

### Nonsurvivor versus Survivor Cohorts (with Spine Trauma): Demographics, Clinical, and Spine Injury Characteristics

During the 20-month period, 50 fatalities and 915 spine trauma survivors with a spine trauma mortality rate of 5.2% were managed at the study hospital (Tables 3 and 4).

### General Cohort: Neurological Status

Fig. 3 Neurological status secondary to spinal injury in 965 patients with traumatic spine injuries.
Table 3 Comparison of demographics between trauma nonsurvivors and survivors with spine injuries

| Demographic and outcome variables | Nonsurvivors (n = 50) | Survivors (n = 915) | Odds ratio; 95% CI | p value |
|----------------------------------|-----------------------|--------------------|-------------------|--------|
| **Age**                          |                       |                    |                   |        |
| Mean (± SD)                      | 62.6 (± 24.1)         | 50.3 (± 21.8)      | 3.82; 2.13–6.85   | < 0.01 |
| Elderly (≥65 y)                  | 30 (60%)              | 258 (28.2%)        | –                 | –      |
| **Sex**                          |                       |                    |                   |        |
| Male                             | 40 (80%)              | 620 (67.8%)        | 1.9; 0.94–3.86    | 0.07   |
| Female                           | 10 (20%)              | 295 (32.2%)        | –                 | –      |
| Ratio                            | 4:1                   | 2:1                | –                 | –      |
| **Mechanism of injury**          |                       |                    |                   |        |
| Motor vehicle occupants          | 30 (60%)              | 405 (44.3%)        | 1.89; 1.06–3.38   | 0.03   |
| Unprotected road users            | 0                     | 121 (13.2%)        | –                 | –      |
| Low falls (< 1 m)                | 12 (24%)              | 138 (15.1%)        | 1.78; 0.91–3.49   | 0.09   |
| High falls (> 1 m)               | 5 (10%)               | 178 (19.5%)        | –                 | –      |
| Significant collision (non-road-related) | 3 (6%)            | 61 (6.7%)          | –                 | –      |
| Other causes                     | 0                     | 12 (1.2%)          | –                 | –      |
| **ISS**                          |                       |                    |                   |        |
| Median                           | 30                    | 14                 | 14                | –      |
| 25th/75th centile                | 17/43                 | 9/22               | 9/22              | –      |
| Severe (ISS > 15)                | 40 (80%)              | 420 (45.9%)        | 4.71; 2.33–9.54   | < 0.01 |
| Traumatic brain injury, yes      | 28 (56%)              | 139 (15.2%)        | 7.11; 3.95–12.78  | < 0.01 |
| Mortality rate                   | 5.2%                  | –                  | –                 | –      |

Abbreviations: CI, confidence interval; ISS, Injury Severity Score.
Note: Variables in bold demonstrates trend (with statistical significance; p < 0.05) toward mortality.

The nonsurvivor cohort comprised 80% males and 20% females, with a ratio of 4:1 in favor of males. The mean age was 62.6 years. Motor vehicle accidents (60%) and falls from less than 1 m (24%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 80% were severely injured, with ISS of more than 15, and 56% of the patients with traumatic spine injuries had TBI. In terms of spine injury characteristics, 42% of the patients had single-level spine injuries and 35% had three or more levels of spine injury. Ninety percent were neurologically intact with 10% having SCI secondary to spine trauma. There were 17 high cervical spine (C0–C2) injuries with the most common injury being occipital condyle (C0) fractures. There were 37 subaxial cervical spine (C3–C7) injuries, 48 thoracic spine injuries, and 35 lumbar spine injuries with compression fractures being the most common injury morphologically. There were five sacrococcygeal injuries. There was a 10.3% spine trauma operative rate with 89.7% treated conservatively.

Non survivor versus Survivor Cohorts (with Spine Trauma): Significant Trends to Mortality

Table 5 shows the univariate associations between spine trauma variables and mortality. Six univariate variables trending toward spine trauma mortality with statistical significance (p < 0.05) were identified. They were elderly patients (OR = 3.82; CI = 2.13 to 6.85), motor vehicle occupants (OR = 1.89; CI = 1.06 to 3.38), severe ISS (OR = 4.71; CI = 2.33 to 9.54), TBI (OR = 7.11; CI = 3.95 to 12.78), C1–2 dissociation (OR = 4.39; CI = 1.05 to 18.44), and American Spinal Injury Association (ASIA) grades A, B, and C (OR = 7.71; CI = 2.64 to 22.57).

Elderly versus Nonelderly Cohorts (with Spine Trauma): Demographics, Clinical, and Spine Injury Characteristics

During the 20-month period, 289 elderly and 676 nonelderly patients were managed at the study hospital (Tables 6 and 7). The mortality rate was 10.4% for the elderly cohort and 3% for the nonelderly cohort. The elderly cohort comprised 58.5% men and 41.5% women, with a ratio of 1:4 in favor of males. The mean age was 78.6 years. Falls from less than 1 m (39.1%) and motor vehicle accidents (31.8%) were the
most common injury mechanisms. Of the patients with traumatic spine injuries, 40.5% were severely injured with ISS of more than 15, and 14.9% of the patients with traumatic spine injuries had TBI. In terms of spine injury characteristics, 50.2% of the patients had single-level spine injuries with 27.1% having three or more levels of spine injury. In all, 95.8% were neurologically intact with 0.7% having nerve root injury and 3.3% having SCI secondary to spine trauma. There were 110 high cervical spine (C0–C2) injuries with the most common injury being type 2 odontoid fractures. There were 139 subaxial cervical spine (C3–C7) injuries, 180 thoracic spine injuries, and 148 lumbar spine injuries with compression fractures being the most common injury morphologically. There were 15 sacrococcygeal injuries. There was a 6.6% spine operative rate with 93.4% treated conservatively.

The nonelderly cohort comprised 73.7% males and 26.3% females, with a ratio of 2:8 in favor of males. The mean age was 39.1 years. Motor vehicle accidents (53.8%) and falls from more than 1 m (18.9%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 50.7% were males, with a ratio of 2:8 in favor of males. The mean age was 39.1 years. Motor vehicle accidents (53.8%) and falls from more than 1 m (18.9%) were the most common injury mechanisms.

### Table 4

Comparison of spine injury characteristics between trauma nonsurvivors and survivors with spine injuries

| Spine injury characteristics | Nonsurvivors (n = 50) | Survivors (n = 915) | Odds ratio; 95% CI | p Value |
|-----------------------------|-----------------------|---------------------|-------------------|---------|
| Total injury levels         | 142                   | 2191                | –                 | –       |
| Injury levels per patient   |                       |                     |                   |         |
| Mean                        | 2.8                   | 2.4                 | –                 | –       |
| 1                           | 21 (42%)              | 384 (42%)           | –                 | –       |
| 2                           | 8 (16%)               | 222 (24.3%)         | –                 | –       |
| 3                           | 6 (12%)               | 117 (12.8%)         | –                 | –       |
| 4                           | 7 (14%)               | 79 (8.6%)           | 1.72; 0.75–3.96   | 0.20    |
| 5 or more                   | 8 (16%)               | 112 (12.3%)         | 1.37; 0.63–2.98   | 0.43    |
| C0–C2 injuries (total)      | 17 (100%)             | 172 (100%)          | –                 | –       |
| Occipital condyle           | 4 (23.5%)             | 22 (12.8%)          | 2.1; 0.63–7.01    | 0.23    |
| C1 burst                    | 2 (11.8%)             | 33 (19.2%)          | –                 | –       |
| Odontoid (type 2)           | 2 (11.8%)             | 45 (26.2%)          | –                 | –       |
| Odontoid (types 1 and 3)    | 3 (17.6%)             | 14 (8.1%)           | 2.42; 0.62–9.44   | 0.20    |
| C2 Hangman’s                | 0                     | 18 (10.5%)          | –                 | –       |
| C1–2 dissociation           | 3 (17.6%)             | 8 (4.7%)            | 4.39; 1.05–18.44  | 0.04    |
| C1–2 misc.                  | 3 (17.6%)             | 32 (18.6%)          | –                 | –       |
| C3–C7 injuries (total)      | 37 (100%)             | 460 (100%)          | –                 | –       |
| DLC only                    | 3 (8.1%)              | 73 (15.9%)          | –                 | –       |
| Compression                 | 28 (75.7%)            | 316 (68.7%)         | 1.42; 0.65–3.08   | 0.38    |
| Burst                       | 1 (2.7%)              | 4 (0.9%)            | 3.17; 0.34–29.08  | 0.31    |
| Distraction                 | 3 (8.1%)              | 25 (5.4%)           | 1.54; 0.44–5.34   | 0.50    |
| Rotation/translation        | 2 (5.4%)              | 42 (9.1%)           | –                 | –       |
| T1–T12 injuries (total)     | 48 (100%)             | 845 (100%)          | –                 | –       |
| DLC only                    | 0                     | 3 (0.4%)            | –                 | –       |
| Compression                 | 44 (92%)              | 748 (88.5%)         | 1.43; 0.50–4.06   | 0.51    |
| Distraction                 | 1 (2.1%)              | 43 (5.1%)           | –                 | –       |
| Rotation/translation        | 2 (4.2%)              | 41 (4.9%)           | –                 | –       |
| L1–L5 injuries (Total)      | 35 (100%)             | 656 (100%)          | –                 | –       |
| DLC only                    | 0                     | 0                   | –                 | –       |
| Compression                 | 28 (80%)              | 584 (89%)           | –                 | –       |
| Distraction                 | 4 (11.4%)             | 57 (8.7%)           | 1.36; 0.46–3.98   | 0.58    |
| Rotation/translation        | 2 (5.7%)              | 13 (2%)             | 3; 0.65–13.83     | 0.16    |
| Sacrococcygeal injuries     | 5                     | 58                  | –                 | –       |
| Neurological status (total) | 50 (100%)             | 915 (100%)          | –                 | –       |
| Intact                      | 45 (90%)              | 851 (93%)           | –                 | –       |
| NRI only                    | 0                     | 31 (3.4%)           | –                 | –       |
| ASIA D                      | 0                     | 20 (2.2%)           | –                 | –       |
| ASIA A, B, and C            | 5 (10%)               | 13 (1.4%)           | 7.71; 2.64–22.57  | < 0.01  |
| Spine operative rate        | 5 (10%)               | 94 (10.3%)          | –                 | –       |

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval; C1–2 misc., miscellaneous fractures affecting the C1 or C2 lamina, body, or transverse process; DLC, discoligamentous complex; NRI, nerve root injury only.

Note: Variables in bold demonstrates trend (with statistical significance; p < 0.05) toward mortality.
severely injured with ISS of more than 15. Of the patients with traumatic spine injuries, 18.3% had TBI. In terms of spine injury characteristics, 15.2% of the patients had single-level spine injuries with 37.1% having three or more levels of spine injury. In all, 91.6% were neurologically intact with 4.3% having nerve root injury and 4.1% having SCI secondary to spine trauma. There were 79 high cervical spine (C0–C2) injuries with the most common injury being occipital condyle (C0) and C1 burst or Jefferson-type fractures. There were 358 subaxial cervical spine (C3–C7) injuries, 713 thoracic spine injuries, and 543 lumbar spine injuries with compression fractures being the most common injury morphologically. There were 48 sacro-coccygeal injuries. There was an 11.8% spine trauma operative rate with 88.2% treated conservatively.

Elderly versus Nonelderly Cohorts (with Spine Trauma): Significant Trends to Mortality

Table 8 shows the univariate associations between spine trauma variables and the elderly age group of more than 65 years. Seven univariate variables trending toward the elderly with statistical significance ($p < 0.05$) were identified. They were females (OR = 1.99; CI = 1.49 to 2.65); falls of less than 1 m (OR = 11.09; CI = 7.38 to 16.66); one level of spine injury (OR = 1.58; CI = 1.20 to 2.09); type 2 odontoid fractures (OR = 4.88; CI = 2.13 to 11.17); subaxial cervical spine (C3–7) distraction injury (OR = 4.36; CI = 2.02 to 9.41); ASIA A, B, and C neurological grades (OR = 2.99; CI = 1.17 to 7.66); and patients without neurological deficits (OR = 2.13; CI = 1.12 to 4.02).

### Table 5

| Univariate variables     | Odds ratio | 95% CI       | p value |
|--------------------------|------------|--------------|---------|
| Elderly                  | 3.82       | 2.13–6.85    | <0.01   |
| Motor vehicle occupants  | 1.89       | 1.06–3.38    | 0.03    |
| Severe ISS               | 4.71       | 2.33–9.54    | <0.01   |
| Traumatic brain injury   | 7.11       | 3.95–12.78   | <0.01   |
| C1–2 dissociation        | 4.39       | 1.05–18.44   | 0.04    |
| ASIA A, B, and C         | 7.71       | 2.64–22.57   | <0.01   |

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval; ISS, Injury Severity Score.

### Table 6

| Demographic and outcome variables | Elderly (n = 289) | Nonelderly (n = 676) | Odds ratio; 95% CI | p value |
|-----------------------------------|-------------------|----------------------|--------------------|---------|
| Age, mean (± SD)                  | 78.6 (± 8.3)      | 39.1 (± 14.1)        | –                  | –       |
| Sex                               |                   |                      |                    |         |
| Male                              | 169 (58.5%)       | 498 (73.7%)          | –                  | –       |
| Female                            | 120 (41.5%)       | 178 (26.3%)          | 1.99; 1.49–2.65    | <0.01   |
| Ratio                             | 1:4               | 2:8                  | –                  | –       |
| Mechanism of injury               |                   |                      |                    |         |
| Motor vehicle occupants           | 92 (31.8%)        | 364 (53.8%)          | –                  | –       |
| Unprotected road users            | 22 (7.6%)         | 79 (11.7%)           | –                  | –       |
| Low falls (<1 m)                  | 113 (39.1%)       | 37 (5.5%)            | 11.09; 7.38–16.66  | <0.01   |
| High falls (>1 m)                 | 55 (19%)          | 128 (18.9%)          | 1; 0.71–1.43       | 0.97    |
| Significant collision (non-road-related) | 1 (0.4%) | 56 (8.3%) | –                  | –       |
| Other causes                      | 6 (2.1%)          | 12 (1.8%)            | 1.17; 0.44–3.16    | 0.75    |
| ISS                               |                   |                      |                    |         |
| Median                            | 13                | 17                   | –                  | –       |
| 25th/75th centile                | 9/20              | 9/24                 | 9/24               | –       |
| Severe (ISS > 15)                 | 117 (40.5%)       | 343 (50.7%)          | –                  | –       |
| Traumatic brain injury, yes       | 43 (14.9%)        | 124 (18.3%)          | –                  | –       |
| Mortality rate                    | 10.4%             | 3%                   | 3.8; 2.12–6.81     | <0.01   |

Abbreviations: ISS, Injury Severity Score; SD, standard deviation.

Note: Variables in **bold** demonstrates trend (with statistical significance; $p < 0.05$) toward the elderly.
Table 7 Comparison of spine injury characteristics between elderly (65 y and above) and nonelderly patients with traumatic spine injuries

| Spine injury characteristics | Elderly (n = 289) | Nonelderly (n = 676) | Odds ratio; 95% CI | p value |
|-----------------------------|-------------------|----------------------|--------------------|---------|
| Total injury levels         | 599               | 1,734                |                    |         |
| Injury levels per patients  |                   |                      |                    |         |
| Mean                        | 2.1               | 2.6                  |                    |         |
| 1                           | 145 (50.2%)       | 263 (15.2%)          | 1.58; 1.2–2.09     | <0.01   |
| 2                           | 66 (11%)          | 162 (24%)            |                    |         |
| 3                           | 32 (11.1%)        | 91 (13.5%)           |                    |         |
| 4                           | 23 (8%)           | 63 (9.3%)            |                    |         |
| 5 or more                   | 23 (8%)           | 97 (14.3%)           |                    |         |
| C0–C2 injuries (total)      | 110 (100%)        | 79 (100%)            |                    |         |
| Occipital condyle           | 5 (4.5%)          | 21 (26.6%)           |                    |         |
| C1 burst                    | 14 (12.7%)        | 21 (26.6%)           |                    |         |
| Odontoid (type 2)           | 39 (35.5%)        | 8 (10.1%)            | 4.88; 2.13–11.17   | <0.01   |
| Odontoid (types 1 and 3)    | 10 (9.1%)         | 7 (8.9%)             | 1.03; 0.37–2.83    | 0.96    |
| C2 Hangman’s                | 12 (10.9%)        | 3 (3.4%)             | 3.1; 0.85–11.38    | 0.09    |
| C1–2 dissociation           | 9 (8.2%)          | 5 (6.7%)             | 1.32; 0.43–4.10    | 0.63    |
| C1–2 misc.                  | 21 (19.1%)        | 14 (17.7%)           | 1.1; 0.52–2.31     | 0.81    |
| C3–C7 injuries (total)      | 139 (100%)        | 358 (100%)           |                    |         |
| DLC only                    | 19 (13.7%)        | 57 (15.9%)           |                    |         |
| Compression                 | 93 (67%)          | 251 (70.1%)          |                    |         |
| Burst                       | 1 (0.7%)          | 4 (1.1%)             |                    |         |
| Distraction                 | 15 (10.8%)        | 13 (3.6%)            | 4.36; 2.02–9.41    | <0.01   |
| Rotation/translation        | 11 (7.8%)         | 33 (9.3%)            |                    |         |
| T1–T12 injuries (total)     | 180 (100%)        | 713 (100%)           |                    |         |
| DLC only                    | 0                 | 3 (0.4%)             |                    |         |
| Compression                 | 160 (88.9%)       | 632 (88.6%)          | 1.02; 0.61–1.72    | 0.92    |
| Burst                       | 10 (5.6%)         | 34 (4.8%)            | 1.17; 0.57–0.243   | 0.66    |
| Distraction                 | 9 (5%)            | 33 (4.6%)            | 1.08; 0.51–2.31    | 0.83    |
| Rotation/translation        | 1 (0.5%)          | 11 (1.5%)            |                    |         |
| L1–L5 injuries (total)      | 148 (100%)        | 543 (100%)           |                    |         |
| DLC only                    | 0                 | 0                    |                    |         |
| Compression                 | 130 (87.8%)       | 482 (88.8%)          |                    |         |
| Burst                       | 14 (9.5%)         | 47 (8.7%)            | 1.10; 0.59–2.06    | 0.76    |
| Distraction                 | 2 (1.4%)          | 13 (2.4%)            |                    |         |
| Rotation/translation        | 2 (1.4%)          | 1 (0.1%)             | 7.42; 0.67–82.46   | 0.10    |
| Sacrococcygeal injuries (total) | 15                  | 48                    |                    |         |
| Neurological status (total) | 289 (100%)        | 676 (100%)           |                    |         |
| Intact                      | 277 (95.8%)       | 619 (91.6%)          | 2.13; 1.12–4.02    | 0.02    |
| NRI only                    | 2 (0.7%)          | 29 (4.3%)            |                    |         |
| ASIA D                      | 0                 | 20 (3%)              |                    |         |
| ASIA A, B, and C            | 10 (3.3%)         | 8 (1.1%)             | 2.99; 1.17–7.66    | 0.02    |
| Spine operative rate        | 19 (6.6%)         | 80 (11.8%)           |                    |         |

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval; C1–2 misc., miscellaneous fractures affecting the C1 or C2 lamina, body, or transverse process; DLC, discoligamentous complex; NRI, nerve root injury only. Note: Variables in bold demonstrates trend (with statistical significance; p < 0.05) toward the elderly.

Elderly versus Nonelderly Cohorts (with Spine Trauma): Descriptors of Convalescence

Of the 258 elderly spine trauma survivors, 26% were admitted to the intensive care department with 55.2% of them requiring ventilation (<Table 9>). The elderly cohort had a mean hospital length of stay of 12.9 days. The majority (69.4%) was discharged to rehabilitation facilities, 28.3% were discharged home, and only 0.8% discharged to high-level nursing care facilities.

Of the 657 nonelderly spine trauma survivors, 29.1% were admitted to the intensive care department with 78.5% of them requiring ventilation. The nonelderly cohort had a mean hospital length of stay of 10.7 days. The majority of patients (58.9%) were discharged home, 39.7% discharged to rehabilitation facilities, and none required high-level nursing care.

Discussion

Our general cohort epidemiological findings concur with current literature. The reported annual incidence of spine column trauma and SCI is 640 and 10 to 83 cases per million
In Australia, the age-adjusted rate of persisting SCI from traumatic causes was similar to previous years at an estimated 15 new cases per million populations. Using these figures, spinal cord injuries are ~1.6 to 13% of total patients with traumatic spine injuries. Our study with 4% incidence of SCI falls within this range.

We also showed male predominance and motor vehicle accidents and falls being the main injury mechanisms. We also found the thoracic and lumbar spine segments as the most common spine injury segments, compression injuries as the most common subtype of fracture in the cervicothoracolumbar axis, and an overall low incidence of neurological deficit in patients with spine trauma.

Interestingly, we found that there were three peaks in the age distribution of our spine trauma cohort of 965 patients. These peaks corresponded to age groups 16 to 25 years, 46 to 55 years, and more than 75 years, altogether representing almost 50% of our patient cohort. This finding validates our observations in a pilot study of a spine trauma clinical quality registry. Spine trauma has been generally reported as a decreasing trend in early adulthood and the elderly are easily explained. The first peak, secondary mainly to motor vehicle accidents, is explainable by the more prevalent risk-taking behavior in this age group, and the secondary peak in the elderly, mainly due to falls from standing height, is commonly due to polypharmacy and normal age-related physiological changes such as failing eyesight and incoordination. Also, as medical knowledge and medication improves, so do the average life span of the society. This leads to an increase in the elderly population compared with previous decades. This finding is unlikely to be simply inherent in our study population, as it has also been shown in a recent spine trauma epidemiology study. The reason for the middle peak, however, is not obvious, and one that requires further study.

### Table 8: Significant univariate spine injury variables trending toward the elderly

| Univariate variables                        | Odds ratio | 95% CI    | p value |
|--------------------------------------------|------------|-----------|---------|
| Female                                     | 1.99       | 1.49–2.65 | <0.01   |
| Low falls (<1 m)                           | 11.09      | 7.38–16.66| <0.01   |
| 1 spine injury level                       | 1.58       | 1.20–2.09 | <0.01   |
| Type 2 odontoid injury                     | 4.88       | 2.13–11.17| <0.01   |
| Subaxial cervical spine (C3–7) distraction injury | 4.36   | 2.02–9.41 | <0.01   |
| ASIA A, B, and C                           | 2.99       | 1.17–7.66 | 0.02    |
| No neurological deficits                   | 2.13       | 1.12–4.02 | 0.02    |

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval.

### Table 9: Descriptors of convalescence in trauma survivors with spine injuries

| Descriptors of convalescence | Elderly (n = 258) | Nonelderly (n = 657) |
|------------------------------|-------------------|----------------------|
| Intensive care               |                   |                      |
| Admission                    | 67 (26%)          | 191 (29.1%)          |
| Ventilation/admission        | 37 (55.2%)        | 150 (78.5%)          |
| Hospital LOS (d)             |                   |                      |
| Mean                         | 12.9              | 10.7                 |
| Median                       | 9.1               | 6.2                  |
| 25th/75th centile            | 5.7/15            | 3.4/12.7             |
| Discharge destination        |                   |                      |
| Home                         | 28.3%             | 58.9%                |
| Rehabilitation               | 69.4%             | 39.7%                |
| High-level care              | 0.8%              | 0                    |
| Others                       | 1.6%              | 1.4%                 |

Abbreviation: LOS, length of stay.
spine precautions are recommended until the absence of injury is confirmed. It is also known that severe TBI raises the likelihood of mortality in patients with traumatic spine injuries. Our practice is to maintain spinal precautions in all TBI patients with unstable spine trauma requiring surgery until they demonstrate ability to survive. Also, surgery is usually contraindicated in this group of patients as the majority will have high intracranial pressures and be at risk of herniation syndromes and sudden death. These findings are not novel; however, they emphasize the need for more funding and research into improving primary prevention of motor vehicle accidents and falls, the treatment of traumatic brain injuries, and medical management of the ever-growing population of elderly patients with traumatic spine injuries.

**Spine Trauma Elderly Trend**

When comparing elderly and nonelderly patients with spine trauma, there were seven main findings: (1) elderly females were four times more likely to have spine trauma than their male counterparts, (2) low falls were the most common injury mechanism, (3) the elderly had a lower rate of severe polytrauma and TBI but higher mortality rate, (4) nonsurvivors had a higher rate of TBI, (5) the elderly had more single-level spine injuries, (6) the elderly had more odontoid type 2 and subaxial cervical spine distraction injuries, and (7) the elderly had fewer neurological deficits and more significant spinal cord injuries. The elderly patient with spine trauma is at risk not only from high-energy trauma mechanisms but also low-energy ones such as falls from less than 1 m. The elderly are also more likely to have multiple medical comorbidities leading to decreased physiological ability and reserve. This would explain why an elderly patient with spine trauma has a higher mortality rate despite having less severe polytrauma, less TBI, and less multilevel spine injuries. Also, the injury pattern commonly associated with elderly patients and low falls are type 2 odontoid fractures and cervical distraction injuries. An interesting observation is the lower operative rate despite a higher proportion of patients with significant SCI. In our center, this is likely due to our conservative approach to elderly patients with central cord syndrome without spine fractures and discoligamentous injuries.

Elderly patients show a lower rate of admission and treatment in the intensive care department when compared with nonelderly patients, despite a higher mortality rate most likely due to a practice of conservative approach to medical management with importance placed on prognostication of outcome. Elderly patients also have a longer mean and median hospital length of stay as they are more disabled due to a slower convalescence from a poorer premorbid physical condition and insufficiency of social support for independent living. A large proportion will then require inpatient rehabilitation rather than be discharged home. This finding further corroborates the need for more geriatric research into the primary prevention of falls and development of age-specific spine trauma management guidelines to increase and improve geriatric convalescence facilities.

**Study Strength and Limitations**

This study is a single-center epidemiological study. Despite treating the majority of spine trauma in our state, this study is unable to determine the incidence and prevalence of SCI and spine trauma in southeastern Australia or the Victoria State. A study with the base population (denominator) of the entire catchment area or the Victoria State is the logical next step.

A retrospective observational study was performed on the patient cohort, which was recruited by the Alfred Trauma Registry in a prospective manner. The patient cohort is a well-defined patient population with collection of spine trauma demographic, clinical characteristic, and spine injury characteristic variables based on the Alfred’s spine trauma clinical-quality registry minimum data set.17

The use of linear logistic regression analysis allowed the identification of epidemiological trends with statistical significance to mortality and the elderly age group. Multivariate analysis was not performed, as the purpose of this study was to delineate the epidemiology and spine trauma trends at a level 1 trauma center.

**Future Directions**

Statistically significant variables identified in this study should be considered for inclusion in future spine trauma studies investigating mortality and the elderly population of patients with traumatic spine injuries.

Data from the study are also essential for benchmarking purposes (e.g., mortality rate and convalescence data) and invaluable as the data give insight into the recovery and discharge parameters of such patients. Similar studies will greatly assist in primary prevention, policy making, and resource allocation.

**Conclusion**

This study provides baseline spine trauma epidemiological data as seen in a state service level 1 trauma center. The trimodal age distribution of patients with traumatic spine injuries calls for further studies and intervention targeted toward the 46- to 55-year age group as this group represents the main providers of financial and social security. The study’s unique feature of delineating variables with statistical significance trending toward both mortality and the elderly also provides useful data to guide future research studies, benchmarking, public health policy, and efficient resource allocation for the management of spine trauma.

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