Counting the costs of major trauma in a provincial trauma centre
Helena Lee, Rowan Croft, Olivia Monos, Christopher Harmston

ABSTRACT

AIMS: Trauma is an important cause of morbidity and mortality in New Zealand, and also represents a significant financial and resource burden on the healthcare system. Understanding local costs and factors that affect them is important for planning of trauma services and obtaining funding for quality improvement projects. The aim of this study was to assess actual costs and influencing factors in patients treated for major trauma in Northland, New Zealand.

METHODS: Adult patients admitted to Whangarei Hospital suffering from major trauma for three years from 1 January 2015 to 31 December 2017 were identified from the hospital’s prospectively maintained trauma database. Major trauma was defined as an Injury Severity Score (ISS)>12, admission to intensive care or death secondary to trauma. Patients >50 years old with isolated neck of femur fractures, hangings, poisonings and drownings were excluded. Immediate or early (<24 hours) transfers to tertiary hospitals were excluded from costing analysis.

Actual costs were calculated using in-house, patient-level costing utilising CostPro software. Case-weight costs, based on DRG codes used nationally, were also calculated using standard techniques. Factors affecting costs were analysed.

RESULTS: Two hundred and sixty-one patients suffering from major trauma were identified, 62 patients were transferred early leaving 199 patients for analysis. The mean ISS was 18 (IQR=14–22) and average length of stay was 8.5 days. Fifty-one percent of the cohort required intensive care and 36% underwent operative intervention in Whangarei Hospital.

Total actual cost was NZ$4,614,652 with an average cost of NZ$23,189 per patient. There was a significant difference in actual vs case-weight cost for the patients in the ISS 13–24 group who formed the bulk of the cohort. There was also extremely significant difference between the costs for patients requiring either intensive care or operative intervention versus those who did not (p=0.0001).

CONCLUSIONS: This is the first study in New Zealand describing actual costs in patients suffering from major trauma and variation to case-weight costs. Intensive care admission and operative intervention have been identified as the two main drivers of cost.

Further studies are needed in New Zealand, particularly in major trauma centres, to better understand the true cost of major trauma within the country.

Morbidity and mortality due to major trauma is an important health problem worldwide, with the World Health Organization (WHO) estimating that 5.8 million individuals die each year with injuries, accounting for approximately 10% of the world deaths. In New Zealand, approximately 27,000 people are admitted to public hospitals due to trauma and roughly 270 people die in hospital each year. Data from the New Zealand trauma registry suggests that around 8% of patients admitted to hospital with injuries have suffered major trauma, and the mortality in this group is 9%. There is, however, variation in the rate of major trauma between regions, and hospitals, within New Zealand.

The economic burden of trauma is also significant with the WHO estimating that US$518 billion is spent treating patients suffering from trauma. Costs associated with major trauma have been reported in Europe, the US and Australia, with common
drivers of cost emerging. No previous studies reporting costing of major trauma in New Zealand have been published.

Accurate data on costs in public hospitals in New Zealand is essential in guiding quality improvement initiatives as well as ensuring appropriate allocation of resources in the face of increasing demands. This is particularly important in assessment of trauma, which is potentially preventable and in the face of health budget constraints. The aim of this study is to assess costs and factors influencing costs in patients treated for major trauma in Northland, New Zealand.

Methods

All adult patients admitted to Whangarei Hospital with major trauma between 1 January 2015 and 31 Dec 2017 were included for analysis. Adult major trauma patients were defined as those aged 16 or over with an Injury Severity Score (ISS)>12, intensive care (ICU) admission or death secondary to trauma. In line with the national trauma registry, injury secondary to hangings, poisonings and drownings were excluded. Immediate or early (<24 hours) transfers to other hospitals were excluded from costing analysis.

The primary cohort was identified from a prospectively maintained trauma database generated weekly by a trauma coordinator. Using the 2008 revision of the 2005 edition of the Abbreviated Injury Scale (AIS08), AIS08 were calculated for all the patients, using coding and the patient clinical notes. The three most severely injured body regions have their scores squared and added together to retrospectively produce the ISS score.

Further information on the primary cohort was obtained from the hospital’s clinical results reporting system, CONCERTO; including outcomes of pathological and radiological investigations as well as operative interventions. Patient demographics including ethnicity and residence data were obtained from the hospital data warehouse, along with length of stay and readmission rates. Patients were defined as residents if their primary residence was within Northland and non-residents if their primary residence was outside Northland.

Actual patient level costs in this study use New Zealand Common Costing Standards Version 17. The standards have been developed for use in the public health sector to provide common standards for the costing of DHB services. Actual costs were calculated using in-house, patient-level costing utilising CostPro software with adjustment for nursing cost-acuity based on data from TrendCare. Specialty-specific costs were used for physician contact times and overhead and allied health costs were included as an average of overall throughput.

Diagnosis Related Groups (DRG) case-weight costs, based on DRG codes used nationally, were also calculated using standard techniques.

After testing for normality, Mann-Whitney U tests were conducted to compare the patient-level and case-weight costs calculated for patients in different ISS groups, those admitted to intensive care and those requiring operative intervention against those who did not.

The study was performed as part of a review of major trauma at Northland District Health Board. Health and Disability Ethics Committee opinion was sought via the HDEC scope of review process and ethical approval was deemed unnecessary.

Results

Basic demographics

Two hundred and sixty-one patients were identified as suffering from major trauma, 62 patients (24%) had an early transfer to a tertiary centre. One hundred and ninety-nine patients therefore formed the primary cohort. Median age was 45 years (Range: 16–89 years); male to female ratio was 2.4. Thirty-three percent of patients identified as Māori, which is slightly higher compared to the 2013 census data of 29.6% Māori.

Eighty-eight (44%) of patients resided in Whangarei, 82 (41%) resided in a rural area in Northland and 29 (15%) from outside the DHB catchment.

Total number of admissions in each season and mechanism of injury are outlined in Figures 1 and 2 respectively.
Clinical characteristics and outcomes

One hundred and eighty-three patients had an ISS>12, 85 (46%) of whom needed ICU admission. Sixteen patients with an ISS≤12 were included due to ICU admission alone. Overall 101 (51%) of the total cohort required intensive care.

Mean ISS was 18 with interquartile range (IQR) of 14 to 22. Average length of stay (LOS) was 8.5 days (IQR: 2.8–10.8 days), total number of bed days was 1,676.

Admitting teams are outlined in Figure 3, with most patients being admitted primarily under the care of a general surgeon.

Seventy-one (36%) of patients required operative intervention in Whangarei.

Overall mortality was 25 patients (12.5% of cohort).

Costs

Total actual cost was NZ$4,614,652, with a mean of NZ$23,189 per patient (IQR: $5,597–$31,082).

Total case-weight costs were NZ$3,391,350, with mean of NZ$17,042 per patient (IQR: $6,021–$25,371). The deviation of total actual cost to total case-weight cost was NZ$1,223,302. There was no significant difference between actual cost and case-weight costs. Costs per ISS group are outlined in Table 1.

Costs, both actual and case-weight, were significantly higher in patients requiring operative intervention, regardless of ISS. Actual costs were significantly higher in patients requiring ICU admission than those not. There was a significant increase in LOS in both patients requiring ICU admission and operative intervention compared to those who did not (Table 2).

Figure 1: Total admissions per season over the three-year study period.

Figure 2: Mechanism of injury.
Figure 3: Major trauma admissions per speciality.

![Admitting Teams Graph]

Table 1: Mean actual costs, case-weight costs and deviation based on ISS groups.

<table>
<thead>
<tr>
<th>ISS group</th>
<th>n</th>
<th>Ave. length of stay (LOS) (Days)</th>
<th>Mean actual cost (NZ$)</th>
<th>Mean case-weight cost (NZ$)</th>
<th>Mean deviation from case-weight cost (NZ$)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;13</td>
<td>16</td>
<td>9.2</td>
<td>$24,629</td>
<td>$15,605</td>
<td>-$9,024</td>
<td>0.936</td>
</tr>
<tr>
<td>13–24</td>
<td>155</td>
<td>8.6</td>
<td>$22,684</td>
<td>$16,538</td>
<td>-$6,146</td>
<td>0.144</td>
</tr>
<tr>
<td>25–40</td>
<td>22</td>
<td>8.1</td>
<td>$29,466</td>
<td>$23,654</td>
<td>-$5,812</td>
<td>0.960</td>
</tr>
<tr>
<td>40+</td>
<td>6</td>
<td>1.1</td>
<td>$9,379</td>
<td>$9,654</td>
<td>$275</td>
<td>0.928</td>
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Table 2: Mean costs based on ICU admission and operative intervention.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Ave. LOS (Days)</th>
<th>Mean ISS (IQR)</th>
<th>Mean actual cost (NZ$)</th>
<th>Mean case-weight cost (NZ$)</th>
<th>Mean deviation from case-weight cost (NZ$)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU</td>
<td>Yes</td>
<td>10.4</td>
<td>18.6 (13–22)</td>
<td>$32,584</td>
<td>$22,801</td>
<td>-$9,782</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>6.4</td>
<td>17.6 (13–18)</td>
<td>$13,507</td>
<td>$11,106</td>
<td>-$2,401</td>
</tr>
<tr>
<td>Operation</td>
<td>Yes</td>
<td>12.2</td>
<td>18.8 (14–22)</td>
<td>$38,839</td>
<td>$28,066</td>
<td>-$10,774</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>6.2</td>
<td>17.9 (13–21)</td>
<td>$14,508</td>
<td>$10,927</td>
<td>-$3,581</td>
</tr>
<tr>
<td>p</td>
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Discussion

This study has outlined the actual and case weight costs of patients suffering major trauma treated in a provincial trauma centre and identified drivers of costs within this cohort. ICU stay and operative intervention were associated with a significant increase in costs.

In the New Zealand healthcare system, costs are estimated using either Diagnosis Related Groups (DRG) case-weights or by using patient-level costing. DRG case-weights are calculated using hospital coding to give DRGs for each condition or procedure for that patient. The weaknesses of this system, including inaccuracy in cost calculation for rarer delivered hospital services, are well recognised; and this has stimulated a shift to patient-level costing in public health systems. There is also a lack of codes specifically designed for major trauma.

Actual patient-level costing aims to directly measure costs associated with a specific patient or patient-care episode. Costs are allocated by measuring actual resources used for the patient. The objective is to provide a more accurate estimate of cost for each patient.

Several previous studies have investigated costs in patients suffering from trauma in high-income countries, including major trauma patients. Most of these studies have been discussed in two systematic reviews. Several themes emerged. Firstly, there is a wide variation in the costs of trauma worldwide, probably due to difference in index costs between different healthcare economies. Secondly, the most important cost drivers are likely to be ICU care, operative intervention and injury severity. Thirdly, there is discrepancy between actual, patient-level costs and those calculated using DRG codes.

The findings in our study mirror those outlined above. The strongest predictor of costs in our study was ICU care and operative intervention. Costs did increase with increasing injury severity, but the most severely injured patients had a paradoxical decrease in costs due to the high early death rate. The actual costs we found are comparable with the recently published data from Australia, with major trauma patients in our study costing NZ$23,189 compared to AU$28,584 per patient in Australia. If these costs are standardised to the US dollar 2017, then New Zealand major trauma cost are US$16,511 per patient and Australian costs US$22,181 per patient.

Although our study found no significant difference between the actual costs and case-weight costs for the different ISS groups, there was an overall marked deviation of total actual to total case-weight cost of NZ$1,223,302.

As New Zealand uses the same DRG system to estimate costs it is unsurprising that there is a similar discrepancy between actual and DRG calculated costs in our study due to lack of codes specifically designed for major trauma. It is interesting that the largest discrepancy occurred in the least injured patients, who required intensive care. The corollary of this is that patients with an ISS<13 included in this study due to ICU admission had similar actual costs to those with an ISS≥13, but with lower DRG costs.

Although retrospective in nature, this study examined a three-year cohort of patients in a single, provincial institution in New Zealand. This allowed robust examination of costing and injury characteristics along with accurate assessment and calculation of injury severity. The data is likely to be applicable to other hospitals in the country fulfilling a similar role, but its applicability to larger major tertiary-level trauma centres is unclear. It is likely that, due to the differences in the case-mix seen in provincial vs major trauma centres, average actual costs are likely to be higher in larger centres. Though, the exact figures are yet unknown in New Zealand.

It is important to note that the New Zealand Major Trauma National Clinical Network has defined major trauma as death secondary to injuries sustained and an Injury ISS> 12, using AIS08. In this study, we also included trauma patients who required intensive care as this was deemed a good reflection of injury severity necessitating higher level of care.

The authors accept the limitation of this study. The absolute number of patients is relatively small, especially within sub-groups; therefore, strong conclusions cannot be drawn. Furthermore, this study excluded patients who needed urgent
transfer to a tertiary centre and therefore, the calculated costs are presumably less on average compared to the whole cohort of patients initially admitted to our centre. Calculated costs for those who did require later, subsequent transfer will also not reflect the entire cost of their care. Finally, this study has only taken into consideration each patient's principal admission and not considered the cost of longer-term follow-up care required by a proportion of major trauma patients.

Despite these limitations, this is the first study in New Zealand to examine costs associated with care of major trauma patients and has identified important drivers of costs, namely intensive care admission and operative management. We have also highlighted substantial variation of actual costs to case-weight costs. Importantly, this data can help guide quality improvement projects to reduce the financial burden of major trauma on the New Zealand Healthcare system. Due to the way healthcare is funded in New Zealand, it should also enable debate about appropriate funding for major trauma due to the different burden experienced by diverse trauma centres. Further studies are needed in New Zealand, particularly in major tertiary-level trauma centres, with larger numbers of patients.

Competing interests:
Nil.

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