Epidemiology and estimated economic impact of musculoskeletal injuries in polytrauma patients in a Level One trauma centre in Singapore

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ABSTRACT

Introduction: Musculoskeletal injuries are the most common reason for surgical intervention in polytrauma patients.

Methods: This is a retrospective cohort study of 560 polytrauma patients (injury severity score [ISS] > 17) who suffered musculoskeletal injuries (ISS > 2) from 2011 to 2015 in the National University Hospital, in Singapore.

Results: 560 patients (444 [79.3%] male and 116 [20.7%] female) were identified. The mean age was 44 (range 3–90) years, with 45.4% aged 21–40 years. 39.3% of the patients were foreign migrant workers. Motorcyclists were involved in 63% of road traffic accidents. The mean length of hospital stay was 18.8 (range 0–273) days and the mean duration of intensive care unit (ICU) stay was 5.7 (range 0–253) days. Patient mortality rate was 19.8%. A Glasgow Coma Scale (GCS) score < 12 and need for blood transfusion were predictive of patient mortality (p < 0.05); lower limb injuries, road traffic accidents, GCS score < 8 and need for transfusion were predictive of extended hospital stay (p < 0.05); and reduced GCS score, need for blood transfusion and upper limb musculoskeletal injuries were predictive of extended ICU stay. Inpatient costs were significantly higher for foreign workers and greatly exceeded the minimum insurance coverage currently required.

Conclusion: Musculoskeletal injuries in polytrauma remain a significant cause of morbidity and mortality, and occur predominantly in economically productive male patients injured in road traffic accidents and falls from height. Increasing insurance coverage for foreign workers in high-risk jobs should be evaluated.

Keywords: epidemiology, length of stay, mortality, musculoskeletal trauma, polytrauma
INTRODUCTION

The treatment of polytrauma patients is expensive, as it may require emergency care, advanced imaging and diagnostic studies, multiple surgical operations, extended postoperative hospital stay with or without intensive care unit (ICU) stay, and prolonged rehabilitation.\(^{(1)}\) Musculoskeletal injuries are the most common reason for surgical intervention in polytrauma patients. Balogh et al reported that up to 70% of all patients with multiple trauma require an orthopaedic surgical procedure.\(^{(2)}\) The presence of extremity injuries in polytrauma patients has been shown to be associated with increased lengths of hospital and ICU stay as well as increased number of surgical procedures.\(^{(3)}\) These patients also have a lower quality of life and functional outcomes\(^{(4-6)}\) after treatment. Despite recent attempts to improve road safety and reduce workplace injuries, polytrauma patients with musculoskeletal injuries are still common. As there is a paucity of data on the epidemiology of musculoskeletal injury in polytrauma patients in Singapore, we aimed to present the characteristics of these patients as well as the factors predictive of patient stay, ICU stay and mortality. We hypothesise that the presence of severe head injuries, as evidenced by a lower Glasgow Coma Scale (GCS) score, and hypovolaemic shock, as evidenced by the need for blood transfusions, would correlate with increased ICU/hospital stay and mortality. We also aimed to estimate the bill size incurred by polytrauma patients and compare the bill sizes in local versus foreign patients.

METHODS

This is a retrospective cohort study of all polytrauma patients with musculoskeletal injuries admitted to the National University Hospital in Singapore between January 2012 and December 2015. Ethics approval was obtained from a domain-specific review board prior to the initiation of the study. We defined a polytrauma patient as a patient with an abbreviated injury scale (AIS) score of 2 or more in at least two body regions and a total injury severity
score (ISS) of more than 17.\(^7\) In total, we identified 1,250 patients who had an ISS of 17 or more, of which 560 patients had a musculoskeletal injury. We defined a musculoskeletal injury as an injury to the lower or upper extremity, the pelvic ring and the spine, with an AIS score of 2 or more. The ISS is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an AIS score and allocated to one of six body regions, namely the head, face, chest, abdomen, extremities (including the pelvis) and external. Only the highest AIS score in each body region is used. The three most severely injured body regions have their score squared and added together to produce the ISS, which ranges from 1 to 75, and its value correlates with the risk of mortality.\(^8,9\) We did not include patients who had low energy mechanisms of injury such as a fall from standing height or pathological fractures due to metabolic disease, infection or tumour/metastases.

The data of each patient was captured in our institutional trauma registry, and it included demographic data; including patient’s age, sex, race; and injury-related data such as the mechanism of injury, location of injury, AIS score of each injury and ISS. Emergency room data such as the GCS score, systolic blood pressure (BP), heart rate and revised trauma score (RTS) was also recorded. The RTS is a physiological scoring system consisting of the GCS, systolic blood pressure and respiratory rate. The values for RTS range from 0 to 7.8408,\(^10\) and a higher score indicates a better prognosis. Inpatient treatment data included need for blood transfusion, need for major orthopaedic surgical treatment, need for and duration of ICU stay, length of hospital stay and mortality. We defined major orthopaedic surgical treatment as requirement of fracture fixation, arthroplasty and amputation. Patients who required only soft tissue debridement procedures without any need for fracture stabilisation or flap coverage were not considered as having undergone a major orthopaedic surgical procedure.

The predictive factors for increased duration of ICU stay, hospital stay and mortality were calculated using univariate and logistic regression analysis. Mann-Whitney \(U\) test was
used for numerical factors and the chi-square test was used for categorical factors, where appropriate. Statistical significance was defined as \( p < 0.05 \) throughout the study and all analyses were performed using SPSS version 22.0 (IBM Corp, Armonk, NY, USA).

To achieve a more accurate estimate of the difference in costs between local and foreign patients, we used a representative sample of 20 patients from each of the four patient groups to assess the average hospital bill size. The four groups were local patients with an ISS less than 25, those with an ISS more than 25, foreign patients with an ISS less than 25 and those with an ISS more than 25.

**RESULTS**

In total, 560 patients were identified, of which 444 (79.3%) were male and 116 (20.7%) were female. Their mean age was 44 (range 18–90) years, with the majority of patients (254 [49.5%]) aged 21–40 years and the second most common age group being 41–60 years (146 [26.1%]). As seen in Table I, 400 (75.1%) patients in the economically productive age group of 21–60 years were male. 220 (39.3%) patients were non-resident foreign nationals working in Singapore.

The most common mechanisms of injury were road traffic accidents and falls from a height, affecting 324 (57.8%) and 192 (34.2%) patients, respectively. Motorcycles were the most common vehicle type and were involved in 208 (63%) of all road traffic accident cases, while 79 (23.9%) of the road traffic accident patients involved pedestrians who had been injured by vehicles.

<table>
<thead>
<tr>
<th>Clinical parameter</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (yr)</td>
<td>44</td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
</tr>
<tr>
<td>0–20</td>
<td>23 (4.1)</td>
</tr>
<tr>
<td>21–40</td>
<td>254 (45.4)</td>
</tr>
</tbody>
</table>

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40–60 | 146 (26.1)  
> 60  | 137 (24.5)  

**Gender**  
Male | 444 (79.3)  
Female | 116 (20.7)  

**Nationality**  
Local | 340 (60.7)  
Foreign | 220 (39.3)  

**Mechanism of injury**  
RTA | 324 (57.8)  
Fall | 192 (34.2)  
Others | 44 (7.9)  

**Type of RTA**  
Motorcyclist | 208 (63)  
Car/lorry | 35 (10.6)  
Pedestrian/cyclist | 79 (23.9)  
Others | 2 (0.4)  

**Location of injury**  
Spine | 270 (48.2)  
Upper limb | 295 (52.7)  
Pelvis | 177 (31.6)  
Lower limb | 218 (39.0)  
Femur | 131 (23.4)  
Tibia | 71 (12.7)  

**Heart rate on arrival**  
< 100 | 395 (70.5)  
> 100 | 165 (29.5)  

**Blood pressure on arrival**  
< 100 | 131 (23.4)  
> 100 | 429 (76.6)  

**Glasgow Coma Scale score**  
< 12 | 443 (79.1)  
> 12 | 117 (20.9)  

**Blood transfusion**  
Received | 219 (39.1)  
Not received | 321 (60.9)  

All data taken from polytrauma patients with musculoskeletal injuries requiring orthopaedic intervention between 2011 and 2015 at our institution. RTA: road traffic accident.

On arrival at the emergency department, 165 (29.5%) patients were tachycardic (HR > 100), 131 (23.4%) were hypotensive (systolic BP < 100 mmHg), and the mean GCS score was 12 (range 3–15). The mean RTS was 6.48 (range 1.47–7.84).

The mean ISS was 28.0 (range 17–75). The most common non-musculoskeletal injuries were head injuries, with 392 (70.0%) patients having a head AIS score of 2 or more, followed...
by chest region injuries in 384 (68.6%) patients and abdominal injuries in 251 (44.8%) patients. Orthopaedic injuries of the limbs, pelvis and spine were mostly fractures, with 482 (85.9%) patients having injuries of AIS score 2 or more. The most common locations of orthopaedic injuries were the upper limbs in 295 (52.7%) patients, spine in 270 (48.2%) patients, lower limbs in 218 (39.0%) patients and pelvis in 177 (31.6%) patients. 271 (48.3%) patients had orthopaedic injuries in more than one area and 96 (17.1%) patients had injuries involving three or more areas among the spine, upper limb, lower limb and pelvis. The femur was the most commonly fractured long bone in 131 (23.4%) patients. In total, 260 (46.4%) patients required a surgical procedure for their musculoskeletal injuries. These operations mainly involved open reduction internal fixation or external fixation, while the other patients were managed conservatively. 231 (41.3%) patients required a blood transfusion in the course of their treatment, 90 (39.0%) had pelvic injuries, 61 (26.4%) had femur fractures and 42 (18.2%) had tibia fractures. 43 patients had concurrent femur and pelvic fractures, 24 (55.8%) of whom required blood transfusion. The mean length of stay was 18.8 (range 0–273) days, mean duration of ICU stay was 5.7 (range 0–253) days and the overall mortality was 19.8% (111 patients).

On both univariate and multivariate analysis, GCS score < 12 and need for blood transfusion were found to be predictive of mortality (p < 0.05) (Table II). On multivariate analysis, the presence of lower limb musculoskeletal injuries, GCS score < 12 and the need for blood transfusion were found to be significant predictive factors for longer hospital stay in polytrauma patients with musculoskeletal injuries (Table III). GCS score < 12, need for blood transfusion and presence of upper limb musculoskeletal injuries were found to be significant predictive factors of increased duration of ICU stay on both univariate and multivariate analysis in our cohort of patients (Table IV).
Table II. Factors affecting mortality.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.248</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Local vs. foreign</td>
<td>0.231</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Gender</td>
<td>0.360</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mechanism</td>
<td>0.118</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Spinal fracture</td>
<td>0.204</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Lower limb fracture</td>
<td>0.204</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Upper limb fracture</td>
<td>0.289</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>0.493</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Femur fracture</td>
<td>0.946</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>0.017</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0.898</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>GCS score &lt; 12</td>
<td>p = 0.000</td>
<td>p = 0.018</td>
<td>0.302 to 0.893</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>p = 0.000</td>
<td>p = 0.000</td>
<td>0.156 to 0.391</td>
</tr>
</tbody>
</table>

Predictive factors for increased patient mortality were calculated using univariate and logistic regression analysis. Mann-Whitney U test was used for numerical factors and the chi-square test was used for categorical factors, where appropriate. Statistical significance was defined as p < 0.05. CI: confidence interval; GCS: Glasgow Coma Scale.

Table III. Factors affecting length of hospital stay.

<table>
<thead>
<tr>
<th>Factor</th>
<th>p-value</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.401</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Gender</td>
<td>0.474</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Foreign vs local</td>
<td>0.873</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Road Traffic Accident</td>
<td>0.006</td>
<td>&gt; 0.050</td>
<td>0.302 to 0.893</td>
<td></td>
</tr>
<tr>
<td>Glasgow Coma Scale score &lt; 12</td>
<td>0.006</td>
<td>0.020</td>
<td>0.069 to 0.081</td>
<td></td>
</tr>
<tr>
<td>Lower limb injury</td>
<td>0.050</td>
<td>0.005</td>
<td>−0.711 to −0.127</td>
<td></td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>0.197</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Femur fracture</td>
<td>0.738</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>0.214</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0.300</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>0.008</td>
<td>0.000</td>
<td>0.205 to 0.793</td>
<td></td>
</tr>
</tbody>
</table>

Predictive factors for increased patient length of stay were calculated using univariate and logistic regression analysis. Mann-Whitney U test was used for numerical factors and the chi-square test was used for categorical factors, where appropriate. Statistical significance was defined as p < 0.05. CI: confidence interval.

Table IV. Factors affecting duration of stay in the intensive care unit.

<table>
<thead>
<tr>
<th>Factor</th>
<th>p-value</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
<th>df</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.002</td>
<td>0.036</td>
<td>3</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>Foreign vs. local</td>
<td>0.076</td>
<td>–</td>
<td>1</td>
<td></td>
<td>–</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Mechanism</th>
<th>0.067</th>
<th>–</th>
<th>1</th>
<th>–</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>0.124</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>GCS score &lt; 12</td>
<td>0.000</td>
<td>0.033</td>
<td>1</td>
<td>0.334 to 0.954</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>0.000</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0.307</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>0.008</td>
<td>0.000</td>
<td>1</td>
<td>0.102 to 0.246</td>
</tr>
<tr>
<td>Upper limb injuries</td>
<td>0.013</td>
<td>0.010</td>
<td>1</td>
<td>0.361 to 0.870</td>
</tr>
<tr>
<td>Spinal fracture</td>
<td>0.387</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Lower limb injury</td>
<td>0.555</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>0.203</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Femur fracture</td>
<td>0.368</td>
<td>–</td>
<td>1</td>
<td>–</td>
</tr>
</tbody>
</table>

Predictive factors for increased patient duration of ICU stay were calculated using univariate and logistic regression analysis. Mann-Whitney U test was used for numerical factors and the chi-square test was used for categorical factors, where appropriate. Statistical significance was defined as \( p < 0.05 \). CI: confidence interval; df: degree of freedom; GCS: Glasgow Coma Scale

From our representative sample, we found that the mean hospital bill size for foreign patients was much higher than that for local patients. The mean bill size for foreign patients with ISS less than 25 was SGD 51,664.64, which was more than three times the mean bill for local patients with the same ISS.

This ratio was even greater when the bill size for local vs foreign patients with ISS over 25 was compared. Local patients paid an average of SGD 15,719.01 which was less than a quarter of the average bill size for foreign workers at SGD 65,795.96.

**DISCUSSION**

Butcher and Balogh\(^7\) defined a polytrauma patient as one with an AIS score of 2 or more in at least two body regions. Musculoskeletal trauma is extremely common in polytrauma patients and is the most common reason for surgery.\(^2\) These patients often have poor functional outcomes after treatment.

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We found a preponderance of male patients in our study (3.8 times more male than female patients), which was consistent with the findings in other studies.\(^{(3,11,12)}\) This was also similar to other studies that reported the epidemiology of polytrauma in Singapore.\(^{(13-15)}\) This may be attributable to the larger number of male patients who drive and work in high-risk occupations.\(^{(13,15)}\) Previous studies in Singapore have shown that motorcycle riders involved in road traffic accidents are predominantly male, with both studies reporting that more than 95% of the patients were male.\(^{(16,17)}\) In our study, only 5.7% of the patients involved in motorcycle accidents were female.

Foreign nationals working in Singapore made up a significant proportion (220 [39.3%]) of our patients. A possible reason for this could be the larger numbers of foreign patients involved in high-risk occupations such as construction. In December 2015, 326,000 foreign workers were involved in construction.\(^{(18)}\) Of the 220 foreign workers, 124 were involved in road traffic accidents, while 67 were involved in falls from a height. All 67 patients who suffered falls from a height were industrial accidents. Unfortunately, it was not possible for us to determine whether the injuries sustained in road traffic accidents were industry related or non-industry related, as this was not recorded.

In our study, the most common mechanism of injury was non-penetrating or blunt injury, with road traffic accidents and falls from a height making up 526 (92%) cases. While previous studies suggest that falls are the main cause of multiple trauma in patients, this is not so in patients with musculoskeletal injuries. This may be attributable to the workplace safety and health (work at heights) regulations 2014.\(^{(19)}\) In a review of 14,583 patients in the Trauma Register of the German Society for Trauma Surgery with multiple trauma and extremity injuries, traffic accidents make up 69.2% of cases, which is similar to our study, where traffic accidents cases make up 57.8% of all cases.\(^{(3)}\) In 2015, there were 6985 traffic accidents in Singapore where injuries occurred, of which 162 were fatal.\(^{(19)}\) While there has been a decrease

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in road traffic accidents from 2012 (7,335 patients) to 2015 (6,985 patients)\(^{(20)}\) and high compliance to road safety measures such as seat belts.\(^{(21)}\) there is still a need to improve road safety in Singapore.

In our cohort, 70.6% of patients with lower limb injuries and 43.0% of patients with upper limb injuries required major orthopaedic surgical treatment. Despite improvements in implant design and understanding of the science of fracture healing, patients with fractures of the lower limbs and pelvis continue to have poor outcomes. In a review of 4,986 patients by Gabe et al, 83% of patients with fractures of the pelvis or lower limb had not returned to pre-injury function two years after injury, 35% had not returned to work and 30% still had moderate to severe persistent pain.\(^{(4)}\) This is especially significant in these patients, who are largely of working age, with 75.6% of our patients aged between 21 and 60 years.

The predictors of mortality in our group of patients were a GCS score < 12 and the need for blood transfusion. Injuries to the brain, which could account for the fall in GCS score, are still the most common cause of death in polytrauma patients.\(^{(24,25)}\) Evans et al reported that up to 30% of pre-hospital and in-hospital deaths after trauma were because of exsanguination. Femur and pelvis fractures are two common sources of this haemorrhage.\(^{(27)}\) Early management of these patients with damage control resuscitation and early orthopaedic intervention for haemorrhage control are crucial. A meta-analysis by Patel et al\(^{(29)}\) revealed an increase in mortality for each additional unit of blood transfused as well as an increased risk of multiorgan failure (MOF) and ARDS. Early orthopaedic surgical haemorrhagic control via external fixation, reduction and splintage of fractures, and application of pelvic binders is still the gold standard of treatment and can reduce the need for blood transfusion and its associated complications.\(^{(30)}\) Low GCS and need for blood transfusion were also significant in predicting longer duration of hospital stay and ICU stay. This could be due to the increased incidence of complications such as MOF and ARDS leading to increased need for intensive care monitoring.

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and longer duration of hospital stay.\(^{(29)}\) The presence of extremity injuries has been shown to be associated with higher number of operative procedures, a higher rate of blood transfusion and a longer hospital length of stay, which could explain the higher rates of ICU and hospital stay observed in patients with upper-extremity and lower-extremity injuries, respectively.\(^{(30)}\)

As almost 60% of road traffic accidents treated at our institution involved motorcyclists, it is in our best interests to address the causes of accidents involving motorcyclists to reduce the economic burden of care resulting from these patients. This is particularly salient in the case of foreign workers who may routinely ride motorcycles for long distances as part of their job or daily commute. It is, therefore, worthwhile to consider methods for reducing this kind of accident. In Sweden, flexible barriers at the roadside have been shown to reduce fatality rates by 90% on treated roads.\(^{(32)}\) To reduce the incidence of multi-vehicle crashes, we propose a physical separation of motorcyclists from mixed traffic via the implementation of a motorcycle lane on expressways delineated by a milling surface or the use of ‘cat’s-eyes’.\(^{(33)}\) This reduces the temptation for motorcyclists to split lanes and weave through traffic, which is a common risk-taking behaviour in Singapore and around Southeast Asia. Other possible methods include the implementation of rules requiring motorcyclists to wear protective riding gear such as motorcycle pants, jackets or gloves, which have been shown to significantly reduce soft tissue injury\(^{(34)}\) and to have brightly coloured clothing or stripes painted on vehicles to increase visibility in low light situations, which have been shown to reduce the risk of crash-related injury by 37%.\(^{(35)}\)

Advances in automobile safety and improvements in acute resuscitation strategies have led to improved survival in polytrauma patients; however, this is associated with high societal costs owing to medical and related costs as well as costs incurred owing to loss of productivity in patients who experience polytrauma. In a study of costs in high-income countries, the median per patient cost of acute trauma treatment was SGD 24,481 in 2011, while in Singapore, the

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average cost of stay for each patient was SGD 11,000 in patients with any workplace injuries.\textsuperscript{(15)} From our sample, it is clear that hospital bills for foreign workers are much higher than those for local workers across the board. This is understandable owing to the multiple sagacious measures taken by the Singapore government to ensure adequate healthcare for its citizens.

As of January 2010, it has become a requirement that each foreign worker is insured up to a minimum of SGD 15,000. Since then, Singapore has undergone a compound average annual rate of inflation of 2.37\%\textsuperscript{(36)} which would correspond to SGD 18,090 in 2018, with no change in the minimum insurance coverage to reflect this. The amount insured can be increased subject to a contractual agreement between the employer and the employee. Foreign workers can also be required to bear a portion of the bill if explicitly agreed to in the contract; however, this sum must be less than 10\% of a worker’s monthly salary\textsuperscript{(36)} which is unlikely to be sufficient in cases of polytrauma.

It is clear that the current SGD 15,000 minimum insurance coverage is inadequate for foreign patients who suffer polytrauma. Even patients with relatively low ISS (< 25) incur an average hospital bill of SGD 51,664.64, which increases to SGD 65,795.96 for foreign patients with ISS > 25. This leaves an average remaining bill of SGD 43,730.30 for foreign patients with polytrauma that is not covered by insurance. This also does not take into account the potential cost of prolonged stay in a rehabilitation facility after discharge or the costs of prolonged follow-up care.

As most foreign patients are from low socioeconomic status backgrounds\textsuperscript{(37)} it is usually impossible for them to afford these hospital bills. Therefore, these bills will either have to be paid for by the employer or be absorbed by the hospital. In many cases, the employer also has difficulty finding funds to pay for healthcare. This results in significant bad debt for the hospital, which, in turn, results in an increased burden on the taxpayer. Another negative effect

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of this is that employers may elect to prematurely transfer patients to seek healthcare in their own countries owing to lower costs. In some cases, this may lead to inadequate early care and stabilisation of foreign patients.

One possible solution would be to increase the minimum insurance coverage for foreign workers performing high-risk jobs such as construction, those operating heavy machinery or those who are required to travel extensively, especially on motorcycles. Based on our sample averages, we would propose an increase to SGD 60,000 for these groups to ensure that the majority of foreign patients will be appropriately covered for their treatment without exerting an added strain on their employers or the hospital.

It is also important to note that these insurance pay-outs would also cover post-discharge treatment such as wound dressing changes, clinic appointments and follow-up investigations, which are not reflected in our study. We should be cognizant of these extra costs that often serve as obstacles for adequate follow-up and compliance after discharge. By increasing the minimum insurance pay-outs, we can ensure that these patients receive adequate healthcare, allowing them to have earlier return to the work force and higher re-employability to continue contributing to the work force.

Based on information from income.sg,\(^{(38)}\) a website affiliated to the National Trade Union Congress, which is the sole national trade union in Singapore and one of the largest insurance providers in Singapore, the premium for a group of 21–50 employees increases from SGD 64.20 to SGD 96.30 for an increase from SGD 15,000 to SGD 30,000 per disability. For a group of 51–100 employees, this decreases to SGD 80.25. Based on this, assuming an employer employs 100 workers, we can gain significantly more coverage for foreign workers in high-risk jobs, with a total increase in premiums of SGD 1,600 for the employer, and this relative increase in premiums compared to compensation is likely to continue to decrease as the number of workers/coverage requirements increases.

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This relatively small increase in employer cost seems a small price to pay to ensure the safety of our workers, a reduction in the load on our overburdened healthcare systems and shows that Singapore regards foreign workers as valued members of the workforce. This will also increase the attractiveness of Singapore as a workplace of choice for foreign workers.

This study has some limitations. Our sample was limited to patients who were admitted to our institution and may not reflect the incidence and outcome of polytrauma patients with musculoskeletal injuries at other institutions in Singapore. Our estimated cost was also based on a sample rather than the entire population. We hope to be able to address these issues in a future prospective study.

In summary, this study presents the epidemiology of polytrauma patients with musculoskeletal injuries treated at our institution. These patients were predominantly economically productive male patients injured in road traffic accidents and falls from a height. Femur and tibia fractures were the most common fractures encountered, and 46.4% of all patients required surgical treatment. Risk factors predictive of mortality, ICU stay and duration of hospital stay included GCS score < 12, need for blood transfusion and extremity injuries. We have suggested some measures to reduce polytrauma in motorcyclists, such as improved defensive driving, appropriate attire and other road safety measures. We found that the bill size in foreign workers was significantly higher than what they are insured for; we suggest that insurance requirements for this vulnerable group of patients be adjusted in view of this.
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