

**Mortality and morbidity of stairlift injuries: analysis of the UK TARN Database**

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## **Abstract**

*Aims:* To investigate the incidence and pattern of injury in patients with a diagnosis of a fall from a stairlift.

*Methods:* Data was analysed from the Trauma Audit and Research Network (TARN) database from 2000 to 2018 for those recorded suffering stairlift related injuries between the ages of 40-100 years. Patient demographics, injury mechanism and pattern, mortality rate and height of fall were analysed.

*Results:* 1069 patients were identified in the initial search with 651 having an eligible mechanism of injury. The mean age was 82 (range 41.4-100.1) years. The most common site of injury was the limbs (49.2%) with the most severe injuries to the head (mean AIS 3.1). The mean ISS was 12.5 (Range 1-75). There was no relationship between height of fall and ISS ( $r_s$  0.054  $p=$  0.4). Individuals were 78% more likely to have an ISS score of 15 or more if they had a head injury, (OR: 0.12; 95% CI: 0.06-0.24) and 79% more likely to have sustained an injury to the thorax (OR: 0.21; 95% CI: 0.11-0.41). Injury to the head was 95% more likely in individuals with an ISS score greater than 25 points or more (OR: 0.05; 95% CI: 0.01-0.16) and 69% more likely for those who sustain injury to the thorax. Individuals with an ISS score of 25 points or more were 18 times more likely to have sustained injury getting off their stair lift compared to any other method of falling from their stair lift. Mortality was associated with injuries to the thorax in those aged 70 years or below, injuries to the face, spine and limb for those aged 71 to 85 years and with head injury in those over 85 years. The overall mortality rate was 15.7%.

*Conclusion:* Falls from stairlifts commonly result in limb injuries and most severe injuries are sustained to the head. When patients fall getting off from a stairlift, have injuries to their head or thorax they have a higher ISS. The overall mortality is 15.7%. Given the increasing use of stairlifts in our ageing population, strategies should be considered to make these safer.

## Highlights

- 16% of falls from a stairlift result in mortality.
- Mortality is associated with injuries to the thorax in those aged 70 years or below, injuries to the face, spine and limb for those aged 71 to 85 years and with head injury in those over 85 years.
- The most common injury from a stairlift is a limb injury whilst the most severe injuries are head injuries.
- Higher injury severity is associated with injuries from falling getting off a stairlift

## Introduction

The population of the United Kingdom (UK) is ageing at an increasing rate [1]. Although the most common causes of death in the elderly in the UK are dementia and Alzheimer's disease, accounting for 12.7% of all registered deaths, trauma in the elderly resulting in injury and mortality is increasing [2]. A profound change in the demographics of recorded major trauma has been observed between 1990 and 2013 [3]. In 1990, the mean age of major trauma patients was 36 years with the largest age group being 0–24 years (39%) and the most common mechanism was road traffic collisions. By 2013, the mean age had increased to 54 years, the single largest age group was 25–50 years (27%), closely followed by those >75 years (27%), with the most common mechanism found to be low energy falls (39%).

With increasing age comes a reduction in mobility [4]. Reduced mobility is associated with falls and it is the most common cause of death from injury in the over 65 year age range. The average length of stay for those admitted with falls is four to 15 days, costing the NHS £2 billion per year and four million bed days [5,6]. The elderly population have the highest risk of falling, around a third of people aged 65 years and over, and around half of people aged 80 years and over, fall at least once a year [7]. Twenty-five percent of falls result in injury that can range from minor to severe with hip fractures being a particularly severe consequence with a 25% mortality rate [8]. Mortality in patients admitted to hospital following a fall has been estimated as high as 16% [7].

To prevent injury by reducing the risk of falls, aids are used to assist mobilising, such as walking sticks, frames and stairlifts. In the UK, approximately 290,000 people are seriously injured and over 500 people die every year as a result of a fall on steps or stairs [8]. One such aid to reduce the risk of falling on stairs is a stairlift. One UK-based company installs on average 15,000 stairlifts a year with an average price found to be £3,369 [9]. Stairlifts are advertised as providing a 'perfect choice to help you rediscover your independence at home' [10].

Currently no evidence is available assessing the incidence or patterns of injury associated with stairlifts. To address this, we used the Trauma Audit and Research Network (TARN) to find data on this topic for a retrospective cohort study.

The aim of our study was to determine the types and severity of injuries sustained and the mortality rate of these injuries.

## Patients and Methods

We aimed to determine the demographics of morbidity and mortality of falls from stairlifts using a retrospective cohort analysis of data collected from the TARN database. TARN data is collected from the Directory of Clinical Care that contains information from every trust in the UK. ICD10 (S or T code) is used to identify TARN patients with inclusion criteria as follows: greater than three day admission, died, transferred in, transferred out or admitted to clinical care [11]. Our request was for data from 2000 to 2018 for all those suffering 'stairlift' related injuries between the ages of 40 to 100 years. The data sent to us by TARN included the patients' age, injury pattern with associated Abbreviated Injury Scale (AIS) of those specific injuries, the total Injury Severity Score (ISS) and the mortality rate. AIS code ranges from one (minor injury) to six (an injury that is thought to be 'incompatible with life') and the ISS score ranges from one to 75. ISS score is calculated by adding together the squares of the three highest AIS scores in three predetermined regions of the body. Both AIS and ISS scores form part of the standard dataset recorded on the TARN database [12].

The data was anonymised and entered into a standardised spreadsheet (MS Excel, Microsoft, Washington, US). The initial database search included 1069 patients. The mechanism of injury was screened for each patient in the data set and those that had been incorrectly identified, for example as having 'stair' or 'lift' injuries were excluded (*Figure 1*). From the incident description for patients, we estimated their height of fall and determined the mechanism of injury (getting on to the stairlift, from the stairlift or getting off the stairlift). The height of fall was estimated using the minimum rise height of an individual stair (0.15m) and a full flight of stairs was calculated as 4.14m [10,13].

Primary outcomes included the types and frequency of injuries sustained, the overall mortality rate and predictors of injury severity and mortality. Secondary outcomes included the average height of fall and association between type of injury and height of fall.

### Data Analysis

We calculated an overall mortality rate. The data was stratified by age to explore the relationship between the most common mechanism of injury (fall from the moving stairlift) and mortality, and the relationship between age and ISS score analysed by

ANOVA and 95% confidence intervals (Cis). We undertook multivariate regression analysis to investigate the variables: mortality (yes/no), severe (ISS  $\geq 15$  points) and very severe injuries (ISS  $\geq 25$  points) with the predictors: site of injury, type of fall, age and height [14]. Multivariate analyses were presented as odds ratio (OR) and 95% CI. We calculated the incidence of injury in each anatomical area (limb, spine, head thorax, face, pelvis and abdominal) and the severity of these injuries (using mean AIS score). The relationship between height of fall and injury severity was assessed using Spearman's correlation coefficient, ISS was used to measure combined severity of injuries. Type of injury and height fallen was analysed using logistic regression analysis. This was presented with mean difference values and 95% confidence intervals (CI).

For all tests, a  $p < 0.05$  deemed *a priori* as reaching statistical significance. All statistical tests were calculated using the SPSS statistics package (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY).

## Results

There were 1069 patients found in the initial TARN database search with 651 patients remaining after exclusion of 418 patients not addressing the primary research question (*Figure 1*). Patients had a mean age of 82 (range 41.4 to 100.1) years.

### Mortality

Overall there were 102 deaths due to injuries sustained (15.7%). When stratified by age, mortality was associated with injuries to the thorax for those aged 70 years or below ( $p=0.04$ ) and injuries to the face ( $p=0.02$ ), spine ( $p=0.05$ ) and limb ( $p=0.02$ ) for those aged 71 to 85 years. Mortality was only associated with head injury in the over 85 year old subgroup (*Table 1*).

### Mortality and ISS Multivariate Analysis

On multivariate analysis of mortality on independent predictors, there were no independent associations between the predictors to mortality (*Table 3*). There was no significant correlation between age and severe injuries (*Figure 4*). However, individuals were 78% more likely to have an ISS score of 15 or more if they had a head injury, (OR: 0.12; 95% CI: 0.06-0.24) and 79% more likely to have sustained an injury to the thorax (OR: 0.21; 95% CI: 0.11-0.41). All other variables were non-significant (*Table 3*). Injury to the head was 95% more likely to be seen with individuals with an ISS score greater than 25 points or more (OR: 0.05; 95% CI: 0.01-0.16) and 69% more likely for those who sustain injury to the thorax. Finally, individuals with an ISS score of 25 points or more were 18 times more likely to have sustained an injury getting off their stairlift compared to any other method of falling from their stairlift (OR: 18.7; 95% CI: 1.95 to 178.4). All other predictors were non-significant (*Table 2*).

### Pattern of Injury

The prevalence of limb, spine, head, thorax, face, pelvis and abdominal injuries were calculated (*Table 3, Figure 2*). In summary, the most common site of injury was the extremities with 49.2% of patients sustaining a limb injury (320 patients) and the most severe injuries were sustained to the head (mean AIS 3.1). Mean total ISS

code was 12.5 (range one to 75). There was no significant difference in severity of score when analysed by age strata ( $p=0.09$ ; *Table 4*).

#### Height of fall

The mean height of fall was calculated using mean stair height and calculated to be 2.29m. Higher ISS score relates to the severity of injuries sustained and was calculated using AIS scores. When the ISS score was correlated with the height of fall there was no correlation between height of fall and injury severity ( $p=0.40$ ) (*Figure 3*). However, we found that height of fall was significantly associated when the thorax ( $p=0.01$ ) and spine ( $p=0.03$ ) were injured (*Table 5*).

## Discussion

The findings from this study indicate 16% of falls from stairlifts resulted in mortality with the most common site of injury being the limbs and the most severe injuries to the head. Injuries to the thorax in those under 70 years, face spine and limb in those 71 to 85 years and the head in over 85 years were significantly associated with mortality. Individuals were 78% more likely to have an ISS score of 15 or more if they had a head injury and 79% more likely to have sustained an injury to the thorax. Injury to the head was 95% more likely to be seen with individuals with an ISS score greater than 25 points or more 69% more likely for those who sustain injury to the thorax. Finally, individuals with an ISS score of 25 points or more were 18 times more likely to have sustained injury getting off their stair lift. These are important findings as previous studies have shown an estimated 230,000 of home accidents occur on stairs with approximately 500 resulting in fatality in the UK per year [15,16]. Stairs are the location in the home where most deaths and major injuries occur, with the most serious injuries being sustained when individuals fall whilst descending stairs [16].

Compared to falls whilst walking on level ground, falls on stairs pose a disproportionately high risk of mortality or for major injury such as traumatic brain injury (TBI) and hip fracture. The elderly are over three times more likely to sustain a moderate to severe TBI when falling on stairs as compared to when falling while walking. Furthermore, use of stairs is a significant predictor of hip fracture over other fall-related injuries for older adults [17]. Given the risk of injury organisations have provided guidance to minimise these such as the Health and Safety Executive and the British Woodworking Federation [18,19].

The UK has an ageing population with around 18% of the UK population aged 65 years or over at a census point of mid-2017, compared with 16% in 2007, this is projected to grow to 21% by 2027 [1]. An ageing population results in an increasing need for mobility aids. Stairlifts are both widely used and advertised as a safe aid that encourages independence. There is currently no published data on injuries sustained from the use of stairlifts. This study has addressed that limitation with a retrospective review of the TARN database. The findings of this study indicate that stairlift injuries are prevalent in the older age group. There are also differences in the types of injuries, severity and frequency of injuries seen. Whilst injuries to the head and thorax were associated with increased injury severity across population, there is

a greater likelihood of mortality due to head injury for those over 85 years, and a greater mortality risk attributed to thoracic injuries for those under 70 years of age.

In terms of patterns of injuries identified, a study investigating fatal injuries from falls at ground level found injury to the brain and/or spinal cord was responsible for the vast majority of the most severe injuries [20]. These results are similar to those seen when falling from stairlifts. These present the most severe injuries to the head and a significant relationship to mortality in those with injuries to the spine, head, thorax, abdomen or limbs. This was further shown in a study looking at falls on stairs showing head-injured patients had a significantly higher mortality rate than non-head-injured patients [10]. We have shown in our study that the limbs were also the most common site of injury followed by the spine and head respectively (49%, 37%), this agrees with current literature where the lower extremities (42%) and the head or neck (22%) are most commonly injured [21].

In relation to the height of the fall, the literature quotes that severity of injuries sustained is closely related to height of fall as well as risk of death although other factors (such as the surface landed upon and impact position of the body) are important [20]. We did not show that the higher the fall on the stairs the more severe the combined injuries (using ISS code) however height of fall was directly related to severity of the injury to the thorax and spine. Furthermore injuries sustained whilst getting off from a stair lift were associated with higher injury severity score, suggesting improving the transfers from a stair lift, may be important.

The subgroup analysis indicated that injuries were prevalent for those aged over 70 years. Whilst there was a difference in occurrence, there appeared limited evidence for a difference in severity within the age groups. However, there were differences in mortality risk associated with falls from stairlifts. Older people (greater than 85 years) were more likely to die following a stairlift fall compared to younger people. This is reflected in the evidence in the literature on falls and head injury mortality in the elderly [22]. Given the magnitude of this injury with increasing age, further consideration as to whether the information provided to individuals on avoiding specific injuries may be warranted based on age.

A limitation to consider for this study was that it was a retrospective study that relied on accurate data collection from centres that was then recorded in the TARN

database. This leaves the study liable to missing data if admissions from stairlift injuries were not entered or accurately recorded.

There was no data provided on medication such as those on anticoagulation. With 10% of those over 80 years of age having atrial fibrillation, the most frequently encountered indication for anticoagulation, their use in our population may have been prevalent [23]. Elderly patients on anticoagulation suffering a head injury have a mortality rate of 50%, which far exceeds that of those with similar injuries that are not anticoagulated [24]. This information would have been useful to further analyse those that died as a result of head injury to see if this could be attributed to anticoagulation or injury from stairlift.

The data did not address if the patient had recurrent falls. With a third of those attending accident and emergency with a fall revisiting or dying within one year, this data could have been used to analyse those at higher risk or mortality on stairlifts for example those with recurrent falls [25].

The frailty-index would have also been a useful measure to include in the data to assess if there was a relationship between mortality when falling from stairlifts and frailty as it is well documented that frailty is associated with recurrent falls [26].

## **Conclusion**

Falls from stairlifts result in mortality in 16% of patients, irrespective of height of the fall. Falls from getting off a stairlift, injuries to the head and thorax were associated with greater injury severity. Overall, the most common injury from a stairlift is a limb injury with the most severe injuries being sustained to the head. Given the increasing use of stairlifts in our ageing population do we need more safety measures put in place?

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## Tables and Figures

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Figure 1: Flowchart of patients screened in TARN database

Figure 2: Prevalence of injuries sustained by body site

Figure 3: Correlation between ISS code and height of fall

Figure 4: Correlation between Age and ISS code

**Table 1:** Analysis of location of injury when falling from stairlift and mortality, stratified by age.

	<70 years (N=78)		71 to 85 years (N=320)		>85 years (N=253)	
	Frequency (n)	P-value	Frequency (n)	P-value	Frequency (n)	P-value
Head	<b>14</b>	0.08	65	0.06	<b>57</b>	<b>0.02</b>
Face	<b>7</b>	0.17	<b>26</b>	<b>0.02</b>	16	0.42
Thorax	<b>14</b>	<b>0.04</b>	65	0.08	46	0.64
Abdomen	0	-	2	0.24	3	0.96
Spine	<b>16</b>	0.22	<b>80</b>	<b>0.05</b>	59	0.62
Limb	<b>25</b>	0.66	<b>80</b>	<b>0.02</b>	65	0.15
Pelvis	2	0.24	13	0.95	13	0.98

**Table 2:** Multivariate analysis to investigate the association between mortality and severity on type of injury, age, location of injury

	Odds Ratio	P-value	95% CI
<b>Mortality</b>			
Age	0.97	0.14	0.93-1.01
Head	0.72	0.48	0.30-1.75
Face	1.06	0.92	0.37-3.00
Thorax	0.71	0.39	0.32-1.56
Abdomen	0.55	0.54	0.08-3.78
Spine	1.00	1.00	0.47-2.12
Limb	1.21	0.62	0.56-2.63
Pelvis	3.66	0.23	0.45-30.0
ISS Score	0.96	0.07	0.91-1.00
Standing injury	1.28	0.75	2.85-5.72
Getting On Injury	2.43	0.35	0.37-15.8
Getting Off Injury	0.75	0.73	0.15-3.70
Height	1.00	0.94	1.00-1.00
<b>ISS &gt;14</b>			
Age	0.97	0.05	0.93-1.00
Head	0.12	<b>&lt;0.01</b>	<b>0.06-0.24</b>
Face	1.76	0.25	0.68-4.60
Thorax	0.21	<b>&lt;0.01</b>	<b>0.11-0.41</b>
Abdomen	0.31	0.33	0.03-3.32
Spine	0.54	0.07	0.28-1.05
Limb	0.55	0.08	0.28-1.08
Pelvis	1.59	0.48	0.44-5.83
Standing injury	0.97	0.97	0.23-4.15
Getting On Injury	1.91	0.44	0.37-9.78
Getting Off Injury	1.16	0.85	0.25-5.44
Height	1.00	0.72	1.00-1.00
<b>ISS &gt;24</b>			
Age	0.97	0.19	0.92-1.02
Head	<b>0.05</b>	<b>&lt;0.01</b>	<b>0.01-0.16</b>
Face	1.54	0.46	0.49-4.83
Thorax	<b>0.31</b>	<b>0.01</b>	<b>0.12-0.79</b>
Abdomen	0.30	0.28	0.04-2.58
Spine	0.44	0.08	0.18-1.10
Limb	0.84	0.72	0.33-2.17
Pelvis	3.09	0.35	0.29-32.7
Standing injury	2.91	0.22	0.51-16.5
Getting On Injury	4.08	0.18	0.53-31.8
Getting Off Injury	<b>18.67</b>	<b>0.01</b>	<b>1.95-178.4</b>
Height	1.00	0.37	1.00-1.00

CI – confidence intervals; ISS: Injury Severity Score

**Table 3:** Pattern of injury showing most common site of injury is the limbs and the most severe injuries are sustained to the head

<b>Site Of Injury</b>	<b>Number of Patients</b>	<b>Mean AIS (SD)</b>
Limb	320 (49.2%)	2.6 (0.6)
Spine	242 (37.2%)	2.5 (0.6)
Head	197 (30.3%)	3.1 (1.6)
Thorax	196 (30.1%)	2.7 (1.0)
Face	66 (10.1%)	1.5 (0.5)
Pelvis	50 (7.7%)	2.3 (0.7)
Abdomen	7 (1.1%)	1.9 (0.7)

AIS: Abbreviated Injury Scale; SD: Standard deviation

**Table 4:** Analysis of association between age strata and ISS score

Total Cohort		<70 years (N=78)		71 to 85 years (N=320)		>85 years (N=253)		P- Value*
Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
12.49	11.87- 13.11	10.78	9.38- 12.18	12.43	11.42- 13.43	13.00	12.09- 13.92	0.09

\*ANOVA

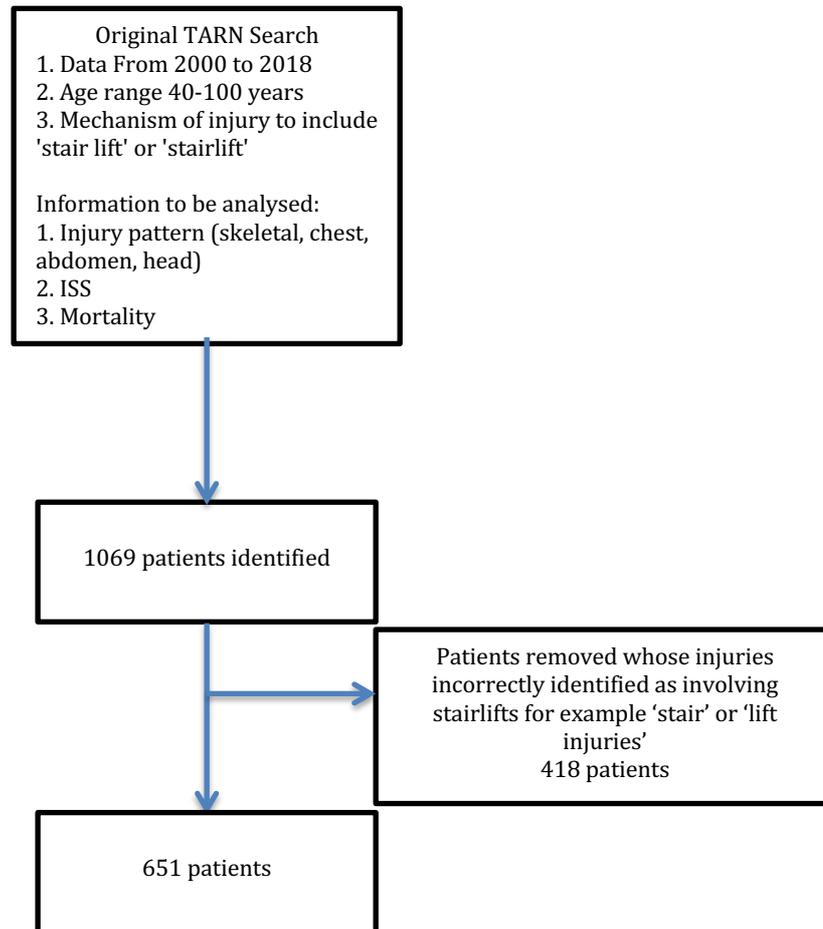
CI – confidence interval; N – number of participants

**Table 5:** Logistic regression analysis showing relation between height of fall and incidence of thoracic and spinal injuries

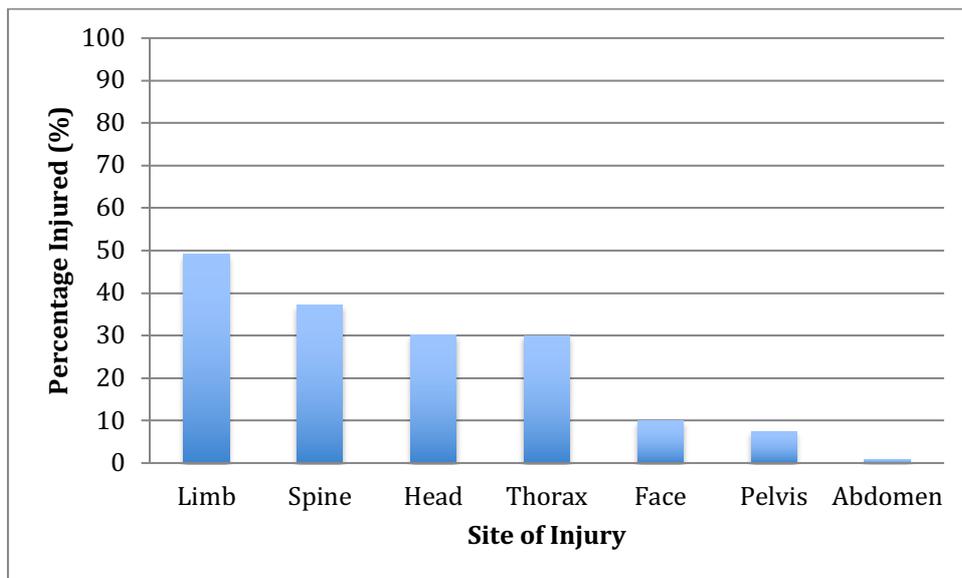
	Injured Mean Height of Fall (m)	Mean Difference (m)	95% CI	P-value
Head	2.47 (1.46)	0.30	-0.69 to 0.09	0.13
Face	2.44 (1.35)	0.17	-0.73 to 0.38	0.54
Thorax	<b>2.61 (1.52)</b>	<b>0.55</b>	<b>-0.93 to -0.17</b>	<b>0.01</b>
Abdomen	2.56 (1.78)	0.27	-1.78 to 1.24	0.73
Spine	<b>2.52 (1.51)</b>	<b>0.43</b>	<b>-0.81 to -0.05</b>	<b>0.03</b>
Limb	2.26 (1.52)	0.06	-0.33 to 0.45	0.76
Pelvis	2.27 (2.01)	0.06	-0.62 to 0.75	0.86

CI – confidence intervals; M - meters

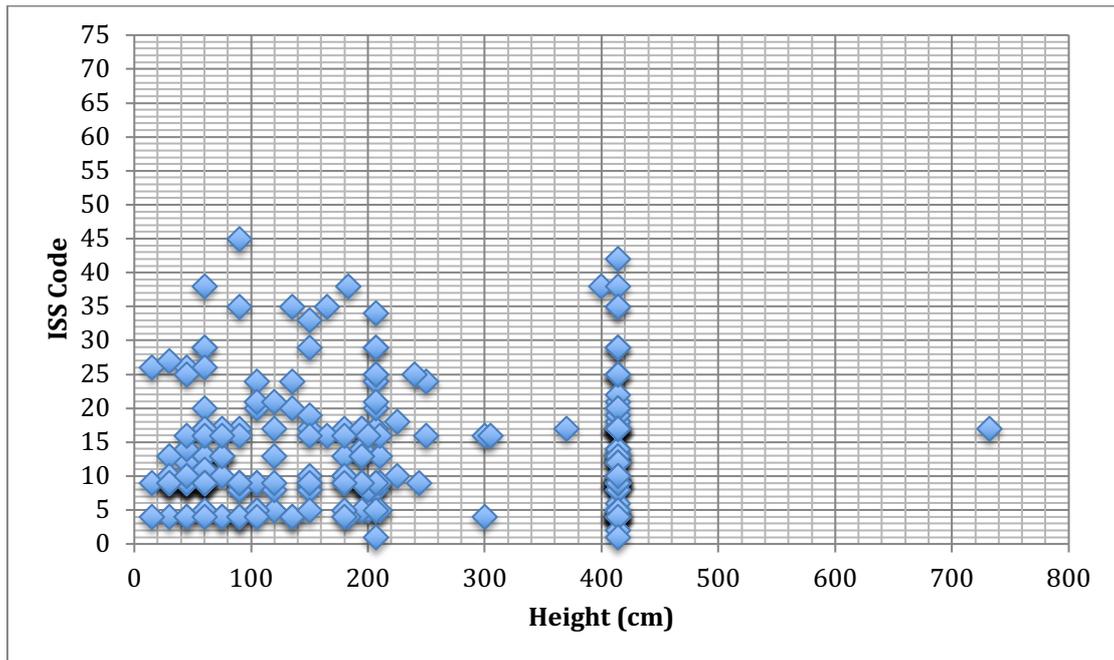
**Figure 1:** Flowchart of patients screened in the TARN Database



**Figure 2:** Prevalence of injuries sustained by body site



**Figure 3:** Correlation between ISS code and height of fall



**Figure 4:** Correlation between Age and ISS code

