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Characteristics and Outcomes of Serious Traumatic Injury in Older Adults

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Abstract

Objectives: The aims were to: 1) describe the seriously injured older adult; 2) characterize and compare the differences in injury characteristics and outcomes in three subgroups of seriously injured older adults: 65-74 years, 75-84 years, and >85 years of age; 3) identify risk factors for death, complications, and discharge placement at hospital discharge.

Design: A retrospective secondary analysis of a statewide trauma data set from 1988-1997.

Setting: Data submitted from all designated trauma centers in Pennsylvania.

Participants: The data set yielded 38,707 patients with a mean age of 77.5 years with serious injury (mean number of injuries = 3.6, mean number of body systems involved = 2).

Measurements: Key outcomes were mortality, complications, and discharge placement. Abbreviated Injury Score categorized injuries and Injury Severity Score (ISS) quantified anatomic severity of injury.

Results: Mortality was 10%. Mean length of stay 11.5 days. 52.2% of survivors were discharged home and 25.4% to a skilled nursing facility. Injury severity, total number of injuries, complications and increasing age were predictors of mortality (p<.01). The presence of pre-existing co-morbid medical conditions increased the odds of experiencing a complication over three-fold. Increasing age, total number of injuries, injury to extremities or abdominal contents, injuries due to falls, and lower functional level predicted discharge to a skilled nursing facility (p<.01).

Conclusions: Traumatic injury in older adults are typically multisystem, life-threatening, and affects older adults of all ages. The standard ISS does not fully capture the potential for mortality in older adults and does not predict discharge placement. The majority of older adults survive multisystem injury. Our findings indicate the need to examine outcomes beyond mortality and to make the identification and management of co-morbid conditions a priority. A geriatric consultation service could be an important additional to the interdisciplinary trauma team.

Keywords

older adults, serious injury, outcomes, mortality, complications, discharge placement

Disciplines

Geriatric Nursing | Medicine and Health Sciences | Nursing

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Header: Traumatic injury in older adults

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Until recently, trauma in older adults has been considered almost exclusively from the perspective of hip fractures or other skeletal injuries. These injuries, generally associated with frailty and declining function, can signal a downward trajectory resulting in institutional placement or death. Yet, far more serious multi-system injury occurs frequently in older adults. In this population, the mechanism of unisystem hip fracture differs considerably from serious traumatic injury,[1,2,3] as does the proportion of multisystem injuries[4,5,6] and the more equal distribution between men and women.[5,6,7,8,9] Mortality following serious injury is higher in older adults in contrast to their younger counterparts. Thus, the examination of serious injury in older adults is worthy of attention.

Serious injury is defined as the anatomic and physiologic derangements induced by the application of external physical forces to the body, resulting in injuries that threaten limb loss or death. Although serious injury is viewed principally as a problem for younger persons, older adults comprise 23% of total hospital traumatic admissions and account for 28% of total hospital charges.[10] The personal, societal, and economic costs of caring for seriously injured older adults are substantial.

A growing body of work now focuses on the characteristics of serious injury and outcomes other than mortality. Typically, these studies include all age groups[11,12] or limit entry to young and middle aged adults.[13] Because older trauma patients are likely to represent only a small subset of study samples, the unique characteristics and effects of serious injury in the older population are diluted by the larger numbers of young, previously healthy individuals.

The impact of serious injury on the physiology of an aging person is not adequately understood. Early studies of older trauma patients report limited return to previous levels of function[6] and less likelihood of discharge to home. [5,9] Findings, however, are conflicting. In a study of older adults with serious injury from blunt trauma, 87% were independent or returned to home with minimal assistance in activities of daily living.[7] Age itself is not consistently a strong predictor of return to function, but many studies are limited by sampling frames containing constricted age spans,[13] or having only few subjects over the age of 65 years.[11,12] Age does not necessarily contribute to negative outcomes,[14] nor does it always negatively influence quality of life.[15] For the reasons cited, analysis of a large subgroup of seriously injured older adults is vital to direct specific therapeutic initiatives aimed at improved outcomes.

The Pennsylvania Trauma Systems Foundation (PTSF), the agency responsible for designating trauma centers in Pennsylvania, maintains a central statewide data base of injured patients admitted to all certified trauma centers. We used this data set to explore the characteristics and outcomes of serious injury in older adults over a ten year period. The aims of this study were to 1) describe the seriously injured older adult population; 2) characterize and compare the differences in injury characteristics and outcomes in three subgroups of seriously injured older adults: 65-74 years, 75-84 years, and $\geq$85 years of age; and 3) identify risk factors for death, complications, and discharge placement at hospital discharge.

Methods

A retrospective secondary analysis of data from the PTSF was performed. The data base contains all trauma patients from every designated trauma center in the state with injuries of sufficient severity to require treatment in an intensive care unit, surgical intervention, or a length of stay greater than 72 hours. All trauma center deaths are included. Individuals with unisystem hip fractures resulting from falls from a standing position are excluded from the data base according to entry criteria determined at the state level. Hip fractures from other mechanisms or fractures associated with injuries to other body systems are included in this data set. These criteria for entry (and the resultant exclusions) are set by the state in order to capture only the most seriously injured and those with multisystem injuries. The data set includes standard demographics, pre-hospital data (i.e., vital signs, Glasgow Coma Score, time from injury to trauma center arrival), injury elements (i.e., mechanism of injury, type of injury, physiologic and anatomic markers of injury severity), patient management data (i.e., operative and non-operative procedures, intensity of care provided), and outcomes (i.e., complications, death, discharge placement). Data are extracted from the medical record by trained trauma center abstractors and submitted for centralized management and analysis. Abstractors attend mandatory training sessions conducted by the PTSF semi-annually, one of which focuses on inter-abstractor reliability. Each trauma center is required to have an internal abstraction check for coding accuracy and on-site registry audits are performed to monitor coding accuracy of records submitted.

Outcome variables were: mortality, complications, and discharge placement. *Mortality* encompassed all deaths that occurred between trauma center arrival and discharge from the trauma center. *Complications*, defined as unforeseen events directly affecting patient care, were extracted from the medical record and recorded only if they matched standard operational definitions. Complications were classified into 14 discrete categories, requiring the presence of one of the 45 medical diagnoses to be documented in the medical record. *Discharge placement* was defined as disposition from the acute care of the trauma center, including transfer to other acute care facilities. Discharge to a skilled nursing facility (SNF) was chosen as a key indicator of discharge placement because it indicated a level of dependence that required professional support, although the level and range of dependence were not discernable from the PTSF data. Nonetheless, a substantial level of dependence can be assumed, given the operational definition of the SNF used in this data base, specifically "a facility which offers long term care to patients whose functions return very slowly, very slightly, or not at all." [16]

Injury descriptors, extracted from autopsy reports, operative findings, and/or diagnostic tests, were submitted in narrative form. *The number of injuries* and the *number of body systems injured* provided indications of injury severity. To further depict the significance of injuries, injury type and severity were quantified. *Injury type* was classified according to the Abbreviated Injury Score'90 (AIS),[17] the most widely used anatomical injury rating scale.[18] The AIS ranks and compares injuries by severity according to six body regions (head/neck, face, chest, abdomen/pelvic contents, extremities/pelvic girdle, and external), with relative severity ranked on a scale of 1 (minor) to 6 (incompatible with life). *Injury severity* was measured by the Injury Severity Score (ISS).[19] Derived from the AIS, the ISS allows comparison of injury severity among heterogeneous injuries. The ISS is the sum of the squares of the highest AIS grade in each of the three most severely injured regions. For example, an older adult with the following three injuries would be scored this way: laceration of the aorta, AIS = 5; fractured femur, AIS = 3; splenic laceration, AIS = 3. The ISS would then be calculated by the formula $5^2 + 3^2 + 3^2 = 43$. Scores of the ISS range from 1 (least severe) to 75 (most severe).[20] Ability to perform *activities of daily living* was measured at acute care discharge with the Functional Independence Measure (FIM).[21,22,23]

Statistical Analysis

Multivariate logistic regression models identified the statistically significant risk factors for each of the three outcomes of interest (death, complications, and discharge to SNF). Bivariate t-tests for differences in means were used to identify potential continuous risk factors for inclusion in the multivariate models. Categorical risk factors were assessed through cross tabulation analysis (and Chi-square tests). The model building strategy employed for the development of all final multivariate models consisted of testing all potential predictors of interest, eliminating the least significant predictor one at a time, testing all possible combinations, and assessing comparative models through Wald statistics for individual predictors and model likelihood ratio tests. Since the purpose of the model was prediction, maximizing each model's ability to correctly classify cases (complications vs. no complications), was used as a third benchmark strategy.

All risk factors presented in the final models are statistically significant at the $p<.01$ level. The large sample size (N = 38,707) allowed for a unique opportunity to validate statistical results. A 10% simple random sample was selected for model development (estimation sample). Models developed on the estimation sample were subjected to the remaining data set as a validation. The final risk factors were statistically significant and consistent in outcome classification in both samples. Additionally, each selected model was compared to the constant-only model to verify that the selected model improved classification. All three models were significantly better at correctly classifying cases a $p<.01$.

Finally, to determine if the risk of outcomes differed by patient groups, all possible interactive effects among the final risk predictors were assessed for each model. Of particular interest was the interaction between age group and other risk factors. Two interaction terms were statistically significant (ISS*complications in the mortality model, and ISS*surgery in the complications model).

Nevertheless, the interactions did not significantly improve the model, as assessed through likelihood ratio tests, and did not improve the models' classification ability. Therefore, interaction terms were excluded from the final models.

Results

The data set yielded 38,707 patients aged 65 years and older over a ten year period (1988-1997), representing 20.7% of all patients in the data base. Descriptors are shown in Tables 1 and 2. Mean age was 77.5 years (range 65-110 years), with 39% between 65-74 years, 40% between 75-84 years, and 21% at age 85 and older. Over half of the injuries resulted from falls (61.7%), followed by motor vehicle crashes (22.6%). The mean number of injuries was 3.6, with an average of 2 body systems involved. Surgery was performed in 28% of cases. Thirty-seven percent of the sample had pre-existing co-morbid conditions. The mean length of stay (LOS) of 11.5 days (range 1 – 574 days) indicates a sizeable resource consumption. Intensive care was necessary for one-third of the group, with a mean LOS in the intensive care unit of 6.7 days. Ten percent of all seriously injured adults alive at the time of trauma center arrival subsequently died.

As seen in Table 2, those in the ≥85 years age group were more likely to have their most serious injury to the extremities/pelvic girdle (54.9%), in contrast to their younger counterparts. Significant differences in mortality were found, greatest in the ≥ 85 age group and lowest for those aged 65-74 years. Unexpectedly, those 75-84 years of age experienced the most complications. Discharge to home dropped markedly for those in the oldest age group (≥85 years). Moreover, even those aged 75-84 years were less likely to return home (48.4%) than their younger counterparts (66.7%). Discharge to a SNF is an important outcome, but must take into consideration residence at time of admission. For this study, if place of injury was coded as “residential institution” we used this as a proxy that the individual was living in a SNF at the time of injury. Some residential institutions may not be SNFs, thus making this proxy a conservative approach. For 65-74 year olds, 2.8% were admitted from a SNF but 11.3% discharged to a SNF, escalating for other age groups (8.3% of 75-84 year olds were admitted from a SNF and 27% discharged to SNF, and for >85 year olds 24.5% and 50.8% respectively).

Bivariate analysis was used to explore the effect of selected variables on mortality (Table 3). Differences between those who died and those who survived revealed that the death group experienced more injuries, more body systems injured, higher maximal AIS scores, and higher ISS (p<.01). These same variables, however, were significantly different (p<.01) for those who developed complications and those who did not. Interestingly, the number of co-morbidities (medical conditions present on admission and documented on the medical record) did not differ between survivors and those who died).

Dividing the sample into three subgroups (65-74 years, 75-84 years, and ≥ 85 years of age), injury severity was found to decrease as age increased (for age 65-75, ISS = 12.2; for age 75-84, ISS = 11.9; for age ≥ 85, ISS = 10.3, F=104.3, p<.0001). Despite the decreasing injury severity as age increased, mean LOS was comparable among all ages (ranging from 11.1 to 11.8 days). Length of ICU stay, however, was significantly shorter for those in the > 85 age group (5.2 days) as compared to 65-74 year olds (7.3 days) and 75-84 year olds (7.1 days; p<.01). This may be due to the shorter time to death in the oldest cohort (an average of 3 days more quickly) than in the youngest cohort.

To identify predictive risk factors for the outcomes of death, complications, and discharge placement, we constructed a series of multivariate regression models. Injury severity was the major risk factor for death (Table 4). The severely injured (ISS ≥26) were 25 times more likely to die than those in the least injured group. Even those with more moderate injuries (ISS 10-15) were almost five times more likely to die than the least injured cohort. The number of injuries contributed to mortality, with a 10% increase in the likelihood of mortality for each additional injury incurred. Cardiovascular complications almost tripled and pulmonary complications doubled the mortality risk. Age contributed to mortality risk to a lesser extent, with a 5% increase in the likelihood of mortality for each additional year of age. A number of factors decreased the mortality risk. The likelihood of mortality was reduced by 35% with a blunt force injury, and by 60% in the group who had surgery. This model appropriately categorized 92% of the cases.

Table 5 displays the significant risk factors for developing complications. The most severe injuries (ISS $\geq$ 26) produced a fourfold increase and an ISS between 16-25 produced more than three times the likelihood of complications compared to the least severely injured. Those with pre-existing co-morbid conditions had three times the likelihood of complications than those without them and surgery doubled the risk for complications. This model correctly categorized 86% of the cases.

Age significantly increased the odds of being discharged to a SNF, with an 11% increase in the odds for each additional year in age (Table 6). When maximal injury was to the extremities/pelvic girdle, the chance of a SNF discharge increased nearly three times, as compared to the referent, head/neck injuries. Odds for a SNF discharge were also significantly increased for maximal injuries to the abdominal/pelvic contents (Odds Ratio 2.7), external/skin (Odds Ratio 2.3) or chest/thorax (Odds Ratio 2.0). When a fall was the mechanism of injury, the odds of a SNF discharge increased by 1.7. For each additional injury, the odds of a SNF discharge increased by 10%. Not surprisingly, the higher the Functional Independence Measure (indicating less disability), the lower the odds for a SNF discharge. This model correctly classified 80% of the cases.

Discussion

This study explored the characteristics and outcomes of serious injury in older adults, thereby expanding knowledge of this growing (yet understudied) vulnerable population. The major findings of this study are: 1) traumatic injury in older adults includes an array of multisystem injuries from a variety of causes that affect the entire spectrum of older adults; 2) use of the ISS does not fully capture the potential for mortality in older adults; and 3) the majority of older adults survive multisystem injury indicating the need to examine outcomes beyond mortality.

Using ten years of data from the PTSF, we examined those older adults whose injuries were sufficiently serious to require trauma center admission. Triage to trauma centers is based on the American College of Surgeons criteria.[24] The four step field triage decision scheme identifies the triage of vulnerable populations (specifically <5 and >55 years of age) as an important criterion.[24] We are therefore confident that the most seriously injured older adults were triaged to the 26 trauma centers in the state. The use of these field triage criteria most likely result in an over-triage rate of 30-50% and an under-triage of only 5-10%.[24] The additional filters used by the PTSF trauma registry eliminates from the database those with no or minor injuries (expected due to over-triage), to capture only the injuries defined as serious within this state. With data from more than 38,000 patients, it was possible to examine this population critically, as the percentage of older patients in any single trauma center represents only a minority, where the unique characteristics of seriously injured older adults are overshadowed by their younger counterparts.

Traumatic injury in older adults is more complex than previously understood and extends well beyond minor or single system injury. This sample was typified by injuries resulting from a variety of physical forces that caused numerous injuries (M = 3.6) affecting more than one body system (M = 1.9). Despite the exclusion from this data set of single system hip fractures due to falls from a standing position, falls prevailed as the major cause of injury (61.7% of all cases) and ranged from falls on a level surface resulting in multisystem injury to falls from significant heights (i.e., off a ladder or down steps). The mean age of 77.5 years (range 65-110 years), indicates that all older adults are affected. During this ten year study period, a total of 186,929 trauma patients were entered into the state registry, 38,707 of whom were older adults, accounting for 20.7% of all seriously injured trauma center admissions. The Pennsylvania Department of Health Vital Statistics notes that individuals age 65 and older accounted for 15.5% of the Pennsylvania population from 1988 through 1997.[25] This indicates that older adults account for a disproportionate number of serious injuries in Pennsylvania. Further, the mean ISS of 11.5 indicates that injuries are more serious than unisystem hip fractures (scored at an ISS of 9). The mean length of stay (11.5 days) indicates considerable acute care resources are required to care for seriously injured older adults.

Mortality was chosen as an outcome of central importance, because improved survival is a chief criterion upon which trauma centers are judged. It is a clear-cut, easily measured outcome. The 10% mortality rate in the Pennsylvania data set is consistent with other reports in the literature.[7,26] In studies reporting higher levels of mortality, the focus on specific subsets of seriously injured older adults (i.e., motor vehicle crashes[27] or severe head injuries[2]) are substantively different than the full range of injuries included in this analysis. The multivariate model indicated that many factors increase the risk for dying, but the severity of physical injury is by far the greatest risk. This too is consistent with other studies.[7,28] It is notable that pre-existing co-morbid medical conditions did not contribute to mortality risk. This finding diverges from previous reports of significant associations between severe pre-existing medical disease and death following trauma.[29,30] Working within the confines of a secondary data analysis, we were unable to stratify our pre-existing medical conditions by severity, which may account for these divergent findings.

Our data indicated that the standard injury severity score does not fully capture the potential for mortality in older adults. Despite the predictive power of ISS, a major finding of this study is that when controlling for ISS, total number of injuries was a significant predictor of mortality and discharge placement. For each additional injury there was an 11% increase in mortality risk. This counters customary perceptions and beliefs suggesting those body systems with the most severe injuries, rather than the number of individual injuries, are the most important determinants of death. Instead, these data indicate that the presence of more than one injury in a given body region is an independent and significant contributor to mortality in older adults. Our findings support the movement towards the development of the New Injury Severity Score (NISS), which departs from the conventional ISS by taking the three most serious injuries of any body system to predict mortality.[31,32,33]

Approximately 15% percent of older adults in our sample sustained one or more complications, similar to the findings of DeMaria and colleagues[5] who found that 33% of 67 survivors of blunt trauma had complications. Although a relatively small number of injured older adults had complications (15.3%), the presence of any complication significantly increased the odds of dying. In an important early study of elderly trauma, Oreskovich and colleagues[6] found that pulmonary sepsis was the cause of death in 80% of multi-injured older adults. It is important to note that the presence of co-morbid conditions increased the risk of experiencing complications over threefold. Although co-morbid conditions did not directly contribute to mortality, our findings indicate that the relationship is much more complex, with co-morbid conditions indirectly influencing mortality by placing patients at risk for complications. The findings from our analysis, in tandem with other studies, suggest that specific variables, namely ISS, total number of injuries, and complications along with increasing age, can theoretically be used to target at-risk groups.

An important finding of this study is that 90% of our sample of seriously injured older adults survived. Survival itself is a central and positive outcome, but outcomes beyond survival must also be considered. The sheer numbers of survivors indicate the pressing need to understand fully the risk factors for negative outcomes in survivors, in order to systematically design and test interventions to improve those outcomes. Patients who developed complications were a specific subset of the larger group. In this group, injury severity was a compelling risk factor, with increased severity substantially increasing the odds of having complications. Chronological age did not predict complications, but the presence of pre-existing, co-morbid medical conditions increased the odds of experiencing a complication over three-fold. Taken together, these findings suggest injury severity and co-morbidities are risk factors for complications in older adults. Despite the demand and priorities in trauma resuscitation, these findings are sufficiently compelling to underscore the need for obtaining as complete a medical history as possible during resuscitation, with a commitment to complete this history as soon as feasible after admission. Further, greater attention to the immediate identification and comprehensive management of co-morbid conditions is a priority. A role for a geriatric consultation service could be crucial to this care and an important part of the interdisciplinary trauma team.

Although only 25% of all patients were discharged to a SNF, it was important to construct a model predicting this discharge placement as discharge to a SNF group is considered a negative outcome of trauma care.[26] Relative to the referent of head/neck injuries, all injuries except facial injuries increased the odds of a SNF discharge, with extremity/pelvic girdle carrying the highest odds (OR 2.9), though closely followed by abdominal/pelvic content injuries. It is not surprising that orthopedic injuries in the older adult were risks for SNF discharge. It is interesting, however, that while severity of injury did not predict SNF discharge, the number of injuries did. A striking parallel between numbers of injuries and death, and the number of injuries and discharge placement, might be drawn. Again, our analysis indicates that using ISS does not fully capture the impact of injury on outcomes. In our older adult sample, the number of injuries, even if only unisystem, is an independent predictor of likelihood of discharge to a SNF.

In building the regression models, we chose to take the conservative approach of confirming the final model by using a 10% random sample. We did this to minimize the possibility that findings were statistically significant only by virtue of the sample size. As noted earlier, outcome data are limited to acute care discharge, negating our ability to examine survival and recovery over time. Nevertheless, our findings do serve to identify at-risk populations for outcomes of importance and suggest the need for prospective studies, as well as targeted interventions.

The findings of this study verify that seriously injured older adults admitted to trauma centers are a distinct and high-risk group. It is thus important to uncover problems that surface in seriously injured older adults and develop an interdisciplinary approach aimed at meeting both the needs associated with the injuries and co-morbid health problems. Such a dual-pronged and integrated approach is most likely the best way to prevent and treat complications, and enhance independence and return to function. Survival of seriously injured older adults and the consequent patterns of disability are important if we are to understand and evaluate the burden to the individual and community, and plan for appropriate health care services.[34] Studies that examine the integration of physical medicine and rehabilitation into the trauma team for geriatric trauma demonstrate earlier acute care discharge, but no significant differences in dependence on care provider, nursing home placement or functional status.[35] Our findings suggest that while early integration of rehabilitation is meritorious, effective interventions cannot be limited solely to the inclusion of physical medicine and rehabilitation.

Clearly, older adults with severe injuries, co-morbid conditions, and increased numbers of injuries are at risk for poor outcomes. One must note, however, that the collection of these injury data (number and severity of injuries) is done by a retrospective medical record review after patient death or discharge. In order for these variables to be used effectively in defining intervention strategies aimed at improving outcomes, they must be collected *concurrently*. While a scoring system that accurately predicts mortality in the elderly trauma victim exists,[5] a method that provides an injury profile predicting mortality, non-lethal complications, discharge destination, and level of disability would be invaluable. Such data could then guide a more comprehensive approach including a cohesive acute care team of surgeons, physicians and nurses with geriatric expertise, social workers, physiatrists, and occupational and physical therapists dedicated to maximizing recovery and returning severely injured older adults successfully to the community. Such models have been tested with other very ill elderly populations[36] and could be applied to this vulnerable group as well.

Despite our compelling results, this analysis barely uncovers the significance of an ever-burgeoning health issue. As the population over 65 years grows larger, severe injury will increase accordingly. New, innovative, and holistic interventions in the care of the injured older adult are needed, with the simultaneous goals of decreased mortality and return to a level of function that minimizes disability and maximizes independence.

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Disclaimer

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Table 1: Sample Descriptors

Variable	Mean	SE of Mean	Range
Age in Years	77.5	.04	65-110
Total Number of Injuries	3.6	.02	1-27
Number of Body Systems Injured	1.9	.05	1-6
ISS	11.7	.05	1-75
Maximum Injury Severity Score Across all Body Systems Injured	2.9	.05	1-6
Length of Acute Care Stay (in days)	11.5	.07	1-574
Length of ICU Stay (in days)	6.7	.001	1-193
FIM at Acute Care Discharge	16.3	.03	2-20

*N = 38,707. Length of ICU stay includes only those admitted to the ICU

Table 2: Demographic and Injury-Specific Information by Age Group

Variable	65-74 years n (%)	75-84years n (%)	>85years n (%)	Total n (%)
Mechanism of injury				
Fall	7,508 (49.2)	9,921 (64.2)	6,470 (81.1)	23,899 (61.7)
Motor vehicle crash	4,648 (30.4)	3,349 (21.7)	735 (9.2)	8,732 (22.6)
Other	1,928 (12.6)	1,242 (8.0)	452 (5.7)	3,622 (9.4)
Pedestrian	845 (5.5)	713 (4.6)	229 (2.9)	1,787 (4.6)
Hit by object	172 (1.1)	127 (0.8)	49 (0.6)	348 (0.9)
Assault	168 (1.1)	112 (0.7)	39 (0.5)	319 (0.8)
Body Region with Most Severe Injury*				
Extremity/Pelvic girdle	6,612 (44.5)	7,020 (46.4)	4,291 (54.9)	17,923 (47.4)
Head/neck	3,310 (22.3)	3,518 (23.3)	1,531 (19.6)	8,359 (22.1)
Chest/thorax	2,662 (17.9)	2,399 (15.9)	987 (12.6)	6,048 (16.0)
External/Skin	1,181 (8.0)	1,112 (7.4)	583 (7.5)	2,876 (7.6)
Abdomen/Pelvic contents	743 (5.0)	720 (4.8)	246 (3.1)	1,709 (4.5)
Face	340 (2.3)	347 (2.3)	180 (2.3)	867 (2.3)
Complications*				
None	13,084 (85.7)	12,942 (83.7)	6,759 (84.8)	32,785 (84.7)
Yes	2,185 (14.3)	2,522 (16.3)	1,215 (15.2)	5,922 (15.3)
Surgery				
No	10,865 (71.2)	11,270 (72.9)	5,921 (74.3)	28,056 (72.5)
Yes	4,404 (28.8)	4,194 (27.1)	2,053 (25.7)	10,651 (27.5)
In-Hospital Mortality*				
Alive	13,917 (91.1)	13,748 (88.9)	7,052 (88.4)	34,717 (89.7)
Died	1,352 (8.9)	1,716 (11.1)	922 (11.6)	3,990 (10.3)
Discharge Status*				
Home	9,091 (66.7)	6,445 (48.4)	2,050 (30.5)	17,586 (52.2)
Skilled Nursing Facility	1,538 (11.3)	3,599 (27.0)	3,415 (50.8)	8,553 (25.4)
Rehabilitation Center	2,573 (18.9)	2,892 (21.7)	1,121 (16.7)	6,586 (19.6)
Another hospital	393 (2.8)	342 (2.5)	126 (1.9)	861 (2.5)
Other	43 (0.3)	29 (0.2)	6 (0.1)	78 (0.2)

*Pearson Chi-Square test, $p < .01$

Table 3: Mean Differences in Complications and Mortality by Pre-Existing Co-Morbid Conditions and Injury Specific Factors.

Outcome	# of Pre-existing Co-morbid Conditions	# of Injuries	# of Body Systems Injured	Most Severe AIS score	ISS
Complications					
No	0.7*	3.2*	1.8*	2.8*	10.7*
Yes	1.8	5.4	2.3	3.4	16.7
Mortality					
Live	0.8	3.2*	1.8*	2.7*	10.1*
Die	0.9	6.7	2.5	4.1	25.1

*t-test for differences in means, $p<.01$

Table 4: Risk Factors for Death Following Serious Injury in Older Adults (n = 3,702)*

Variable	Odds Ratio	95% CI
Age in Years	1.05	1.03-1.07
Injury Severity		
≥ 26	25.51	14.5-44.8
16-25	4.65	2.9 – 7.4
10-15	2.76	1.7 – 4.4
0 – 9 (Referent)		
Complications		
Cardiovascular	2.85	1.6 – 5.0
Other/unclassified	2.15	1.3 – 3.5
Pulmonary	2.01	1.1 – 3.7
Infectious	1.05	1.0 – 1.1
None (Referent)		
Mechanism of Injury		
Blunt	0.35	0.2 - 0.7
Penetrating (Referent)		
Surgery		
Yes	0.59	0.4 - 0.8
No (Referent)		
Number of Injuries	1.11	1.1 – 1.2
Body System with Most Severe Injury		
Abdominal/Pelvic contents	0.55	0.3 – 1.1
Extremity/Pelvic Girdle	0.58	0.4 – 0.9
Skin/External	0.76	0.4 – 1.6
Chest/Thorax	1.0	0.7 – 1.4
Head/Neck (Referent)		
Number of Body Regions Injured	0.69	0.6 – 0.8

Classification: 91.8% of cases
-2LL 1640.126
NagelKerke $R^2 = 0.329$
-2LL 1640.126 (constant only model –2LL 2239.157, Chi-Square change p<.01)

*Logistic regression, statistically significant predictors, p<.01.

Note: Number of pre-existing conditions and type of injury were removed from the final model due to non-significance in testing this 10% random sample of the population.

Table 5: Risk Factors for Development of Complications Following Serious Injury in Older Adults (n= 3,793)*

Variable	Odds Ratio	95% CI
Injury Severity		
≥26	4.0	2.7 – 5.9
16-25	3.3	2.5 – 4.4
10-15	1.3	1.0 – 1.8
≤9 (Referent)		
Pre-existing Health Conditions		
Yes	3.4	2.7 – 4.3
No (Referent)		
Surgical Intervention		
Yes	2.2	1.8 – 2.8
No (Referent)		
Number of Injuries	1.09	1.05 – 1.13

Classification: 86.4% of cases
-2LL = 2604.273
Nagelkerke $R^2 = 0.254$
-2LL 2604.273 (constant only model –2LL 3196.419, Chi-Square change p<.01)

*Logistic regression, statistically significant predictors, p<.01.

Note: Mechanism of Injury and Body System with Maximal AIS were removed from the final model due to non-significance in testing this 10% random sample of the population.

Table 6: Predictors of Discharge to SNF (n = 2,197)*

Variable	Odds Ratio	95% CI
Body System With Most Severe Injury		
Extremity/pelvic girdle	2.9	2.1 – 4.1
Abdominal/pelvic contents	2.7	1.5 – 4.7
External/skin	2.3	1.3 – 4.0
Chest/thorax	2.0	1.3 – 3.1
Face	0.8	0.3 – 2.1
Head/neck (Referent)		
Mechanism of Injury		
Fall	1.7	1.0 – 2.6
Hit by an object	1.6	0.4 – 6.4
Pedestrian	1.1	0.6 – 2.2
Motor vehicle accident	0.9	0.5 – 1.5
Assault	0.7	0.2 – 3.0
Unspecified (Referent)		
Presence of Pre-existing Health Conditions	1.2	1.1 – 1.3
Age in Years	1.1	1.09-1.12
Number of Injuries	1.1	1.0 – 1.1
Functional Independence Measure	0.8	0.8 – 0.9

Classification: 80.0% of cases
-2 LL = 1847.629
Negelkerke R^2 = .341
-2LL 1847.629 (constant only model –2LL 2413.857, Chi-Square change p<.01)

*Logistic regression, statistically significant predictors, p<.01.

Note: Blunt vs. penetrating trauma, requirement for surgical intervention, and type of complications were removed from the final model due to non-significance in testing this 10% random sample of the population.