Elderly Trauma in Sub-Saharan Africa

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Abstract

The world is aging rapidly but it is unclear how the world's growing older population will affect health care systems in low or middle-income countries. One area of concern is traumatic injury, which is endemic at all ages, with older patients suffering worse outcomes compared to younger patients. Consequently, traumatic injury in the elderly is an emerging public health issue in resource-poor environments. Unfortunately, there is a dearth of data on the characteristics and extent of this problem in sub-Saharan Africa. This study has two aims. First, it will describe what data are available on elderly trauma in sub-Saharan Africa and access the quality of published studies. Second, it will describe the characteristics and outcomes of traumatic injury in the elderly from a tertiary trauma center in sub-Saharan Africa.

Elderly Trauma in Sub-Saharan Africa: A Literature Review

Jared R. Gallaher, MD

Introduction

It is is yet to be determined how the world's growing older population will affect health care systems in low or middle-income countries (LMIC). Globally, the number of elderly people will grow dramatically over the next 25 years and while LMIC will account for 80% of the global population older than 60 by 2050, there are limited data on potential differences in elderly health care needs.[1-3] This lack of data is especially pertinent for the management of traumatic injury because it is a significant source of morbidity and premature death in adults worldwide. Furthermore, this burden is disproportionately high in LMIC, which bear 90% of global mortality from traumatic injury.[4-6] While trauma mostly affects younger populations, given increasing life expectancy elderly trauma is emerging as a serious public heath concern. This concern has been demonstrated in high-income countries with an associated increase in morbidity and mortality compared to younger patients.[7-10]

In addition to suffering worse outcomes from injury, elderly trauma patients likely have different patterns of injury requiring specialized treatment and triage. Recognizing those patterns and their associated outcomes in LMIC, where resources are limited, allows decision makers to identify and target critical sources of morbidity and mortality for clinician training or resource allocation. Due to significant differences in the social and economic structure, we cannot assume that patterns of injury described in HIC are the same as seen in LMIC. Consequently, in sub-Saharan Africa, which bears the greatest regional burden of trauma mortality globally, there is a significant need to describe the extent and significance of the problem.

This review seeks to systematically identify data published data that has been been published from sub-Saharan Africa on elderly trauma epidemiology and outcomes.

Methods

This review of the literature focused on elderly trauma epidemiology and outcomes from sub-Saharan Africa published since 2010. Elderly is defined in developed countries as patients ≥ 65 years but several different definitions have been used in low-income countries due to a shorter life expectancy with age cutoffs as low as fifty years old.[9-13] For this review, studies were permitted to use any of these definitions. This review used the United Nations definition for sub-Saharan Africa which includes all countries on the continent of Africa except for "Northern African countries" comprising Algeria, Egypt, Libya, Morocco, Sudan, Tunisia, and Western Sahara.[14] Traumatic injury was defined as physical wounds suffered by an intentional or unintentional mechanism. Due to significant physiological differences between burn and other forms of traumatic injury, burn was excluded from this review.

Search Strategy

The review was performed using a MEDLINE search on PubMED. The MESH terms "Wounds and Injuries" and "Aged" and "Developing Countries" were initially used. Next, a search using the MESH terms "Wounds and Injuries" and "Aged, 80 and over" and "Developing Countries" was used. Lastly, each combination of these terms except "Developing Countries" was used with a text search of "sub Saharan Africa" or "Africa." Only studies published in the English language, those that used human subjects, and studies published since 2010 were included. Each abstract from the search was reviewed. Studies that only included burn patients were excluded and any study that did not publish an abstract was excluded. Studies were selected for review if their abstract reported epidemiological or outcome data for elderly trauma patients from sub-Saharan Africa. Additionally, hand searches were conducted by reviewing the bibliography of each study included in the final review. Additional studies meeting the above criteria were then subsequently added to the final review.

Data Abstraction

A standardized evidence table was used to abstract study data. This information included study year, study location, study design, study population, analysis strategy, and reported results.

Quality Assessment

Studies were assessed for quality using a standard critical appraisal template. A grade of poor, fair, or good was assigned and reported for the categories of selection bias, measurement bias, confounding, internal validity, external validity, and overall grade.

Results

The search returned 191 studies for abstract review. Four studies met inclusion criteria.[15-18] Two additional studies meeting inclusion criteria were identified using hand searches.[19,20] Three of the studies were conducted in Nigeria with the other three coming from either Kenya or Tanzania.

Study Characteristics

All studies were observational. Three studies examined general trauma epidemiology or outcomes while the other three studied specific areas of traumatic injury. Saidi et al and Chalya et al focused on the epidemiology of elderly trauma and reported injury and mechanism characteristics along with outcomes.[19,20] Saidi's study further compared elderly trauma patient characteristics to those of non-elderly patients. Both studies prospectively collected data but were one year or less in duration and had fewer than 100 elderly patients. Additionally, Chalya's study excluded any patients that were unconscious at arrival and did not have family present. Odihiambo et al performed a retrospective review of all verbal autopsy data from the western region of Kenya over five years including over 11,000 patients.[17] Trauma-related death and associated factors were stratified by age group.

The three remaining studies examine more specific areas of trauma. Idowu et al prospectively examined neurological trauma in Nigeria at an urban trauma center over a one year period.[15] 2,149 patients were included in the study with 4.8% of patients aged ≥ 60 years old. Epidemiological data was stratified by age by but clinical outcomes were not. Onakpoya et al retrospectively studied ocular trauma among the elderly over a seven year period at four tertiary eye centers in Nigeria.[17] Only 78 patients had complete records. They reported patient characteristics and factors associated with ocular injury as well as vision outcomes. All patients in the study were elderly so there was no comparison with younger patients. Lastly, Bekibele et al conducted a prospective cross-sectional survey using a stratified sampling method of households in several areas of Nigeria to examine the prevalence of falls and associated factors among the elderly.[18] No outcome data was reported and there was no younger cohort for comparison. (Table 1).

Quality Assessment

Almost all studies had significant selection bias. Most studies only selected patients from a small population and or did not make any comparison between groups at all. For example, Saidi et al only studied admitted patients excluding any patients who died pre-hospital admission or patients with less severe disease that were discharged from the emergency department. Chalya et al excluded patients that were unconscious, and thus likely sicker, who did not have family readily available for consent. Bekibele et al's falls study had the best selection process using a random sampling strategy for a survey of a large region in Nigeria. Confounding was a problem for most studies. Idowu et al and Chalya et al did not make any comparisons but provided only descriptive statistics of their elderly populations. None of the other studies made any attempt to control for confounding in their analysis providing only unadjusted ratios or simple bivariate analysis. There was minimal measurement bias in all six studies as most used a standardized measurement tool for all of their patients.

Internal validity for all the studies was either fair or poor with most studies suffering from significant selection bias and none attempted to control for any potential confounding variables in their analysis. External validity was also fair or poor. Due to very small study sizes from specific regions, it is hard to make comparisons with other populations. Several studies also excluded patients with higher acuity or patients with simpler injuries making comparisons even more challenging.

Overall, four of the studies scored as poor in quality, with two scoring as fair. Odihiambo, et al's verbal autopsy study and Bekibele, et al's fall incidence study scored higher because of their large sample size over a wide region, minimal selection bias, and fair external validity. The other studies suffered from very small study populations, bias, and a lack of analytic sophistication. (Table 2)

Significant Findings

Only two studies compared elderly patients with a younger cohort. Saidi et al reported that 4.5% of all trauma patients at their center were elderly and that this group was more likely to suffer a head injury or an unintentional injury, and were less likely to suffer a RTI-related injury (road traffic incident) compared to younger patients. Also, compared to younger patients, elderly patients were more likely to die (OR 2.1, $p<0.001$) with a 2-week mortality rate of 13.9%. Odihiambo et al's verbal autopsy study found that the proportion of trauma-related deaths was higher in older age cohorts, especially in females. Trauma was responsible for 26.6% of all deaths in women aged 65-79 years old compared to the overall rate of 4% for all ages and both genders. Idowu et al studied all cases of neuro-trauma at their center but did not report age stratified clinical outcomes. 4.8% of all cases were 60 years or older with an overall in-hospital mortality rate of 1.2% for all patients.

The three remaining studies all described elderly-specific data only with no comparisons to younger patients. Chayla et al reported that 22.7% of all trauma patients over a one-year period were elderly with assault being the most common mechanism (56.4%). Most patients had a soft tissue injury (89.4%) but extremity (72.3%) and head injuries (66.06%) were also common. Increasing age and severe head injury were associated with death with an overall mortality rate of 14.9%. Onakpoya, et al's findings in ocular trauma showed that most patients had a delayed presentation with 78.2% presenting at least three days post-injury and despite their older age, the most common associated activity was farming (35.9%). Only 11.5% of injuries were intentional and 28.2% required surgery with the rest receiving conservative management. Almost half of patients were blinded in the injured eye(s) (44.9%) and more than a third had at least some visual impairment (35.9%). Bekibele, et al revealed a fall incidence of 23% over one year among those surveyed. Females were more likely to report a fall (OR 1.4, 95% CI 1.1, 1.8) but no other demographic or comorbid conditions had statistically significant relationships with the likelihood of a reported fall. (Table 1)

Discussion

There is a dearth of information about the extent of trauma in the elderly population in sub-Saharan Africa. This review demonstrates that most published data are from limited, small observational studies with significant bias. Additionally, only two of the studies made any comparisons to younger patients in injury characteristics or clinical outcomes. Most these studies rely on data from one center with relatively low patient volumes and often excluded sicker patients or patients with less severe injuries limiting their external validity.

Available data are conflicting about the extent of the problem. Most studies that recruited their elderly subjects from a larger study base had a small proportion of elderly patients, usually less than 5%. However, this proportion is consistent with that of elderly patients from the total population in most sub-Saharan African countries. The exception was Chalya's Tanzania study which had an elderly prevalence of 22.7%, a much higher number that may be a product of a very small sample size from a small regional hospital. Bekibele's fall study showed that nearly 25% of elderly participants had suffered a traumatic fall in the last year.

Evidence from these reviewed studies concur that elderly trauma patients often have poor outcomes and that may be worse than outcomes in younger cohorts. While their study size was small, Onakpoya's ocular trauma study showed a very high proportion of patients presenting late post-injury with very poor vision outcomes. Odihiambo's verbal autopsy study, the most inclusive investigation of trauma-related death, showed that elderly patients had a higher proportion of trauma-related deaths compared to younger patients, especially for females. Considering the low prevalence of elderly patients in other studies, this may suggest that many elderly patients are not surviving long enough to receive medical care, a finding supported by other research in LMIC.[12] Saidi's Kenyan study showed a doubling of the odds of death for older patients compared to younger patients with an in-hospital mortality rate of 13.9%. They also showed that head injuries were more common for elderly patients. While head injuries are a major source of mortality in all ages, if these types of injuries are more common in the elderly population, they are an important target for resource allocation at tertiary trauma centers.

Limitations

While this literature review was systematic, it is limited by only using the PubMED search engine. Many medical journals in Africa are not listed on MEDLINE but the sheer volume of unrelated articles on Google Scholar made using this engine impractical for the scope of this study. Additionally, non-English studies were excluded. Lastly, sub-Saharan Africa is a geographically large and diverse region. It is unreasonable to treat it as homogenous but given the paucity of data from the entire area, it is practical to group these countries together for clarity.

Conclusion

There is a paucity of data on the epidemiology of elderly trauma and its associated outcomes in sub-Saharan Africa. What little data that is available comes from very limited observational studies. These studies suggest that elderly trauma outcomes are very poor and are worse than younger trauma patients. There is an imperative to study this public health issue in much greater detail.

Study	Objective	Study Design	Study Country	Study Population	Significant Results
Neurotrauma burden in a tropical urban conurbation level I trauma centre Idowu, et al, 2014[15]	Describe neurotrauma epidemiology and outcomes at single institution	Prospective observational	Nigeria	All patients with neurotrauma over 1 year period (2012-2013) presenting to surgical emergency room at a teaching hospital. 2149 patients included.	4.8% of patients 60 or older. Primary mechanism was road traffic incident (RTI). 1.9% of all patients were dead on arrival and 1.2% died in the emergency room. No age stratified clinical outcomes reported.
Trauma-Related Mortality among Adults in Rural Western Kenya: Characterising Deaths Using Data from a Health and Demographic Surveillance System Odihiambo, et al, 2013[16]	Describe trauma-related deaths in rural western Kenya	Retrospective database review	Kenya	All verbal autopsy data over five years (2003-2008) for adults > 14 years old for 385 villages in Western Kenya. 11,147 patients included.	4% of all deaths attributable to trauma. 19.1% of deaths attributable to trauma for men aged 65-79 years. For women aged 65-79 years, 26.6% of deaths due to trauma, which was the highest proportion for any female age cohort. Falls were more common for older patients and intentional injury was much less common for older patients.
Injury Outcomes in Elderly Patients Admitted at an Urban African Hospital Saidi, et al, 2013[19]	To describe common injury patterns, resource utilization, and determinants of outcomes for elderly trauma patients in an urban setting	Prospective observational	Kenya	Patients admitted for traumatic injury over one year (2009-2010) at a major tertiary center in the capital city. 1594 total patients.	72 patients (4.5%) of all trauma admissions were elderly (≥ 60 years). Traffic-related (44.4%) and falls (41.7%) were the most common mechanisms. Compared to younger patients, older patients were more likely to die (OR 2.1, $p<0.001$) with a 2-week mortality rate of 13.9%. Older patients were almost more likely to have a head injury, unintentional injury, and a non-traffic related mechanism.
Geriatric injuries among patients attending a regional hospital in Shinyanga Tanzania Chalya, et al, 2012[20]	To determine the prevalence, injury characteristics, and outcomes of elderly injury at a regional hospital	Prospective observational	Tanzania	All elderly trauma patients (≥ 60 years) that presented to the emergency department over 7 months (2010). Unconscious patients without family to consent were excluded.	22.7% (94 pts) of all trauma patients were elderly. Most injuries were intentional (56.4%), with most assault victims being female (64.6%). Extremity (72.3%) and head injuries (66.0%) were the most common locations with soft tissue injuries the overwhelming injury type (89.4%). Mortality was 14.9% with advancing age and severe head injury as factors associated with increased mortality.
Epidemiology of Ocular Trauma Among the Elderly in a Developing Country Onakpoya, et al, 2010[17]	To study the epidemiology of ocular trauma among the elderly in a developing country	Retrospective case review	Nigeria	All elderly (≥ 65 years) patients managed for ocular trauma over 7 years (2001-2007) at four tertiary eye centers in southwestern Nigeria.	78 elderly patients had complete records. 78.2% of patients presented 3 or more days after injury (78.2%). Farming-related activity was the most commonly associated mechanism (35.9%). 44.9% were blinded in their injured eye and 35.9% had visual impairment.
Fall incidence in a population of elderly persons in Nigeria Bekibele, et al 2010[18]	To study the prevalence of falls and associated factors among the elderly	Prospective cross-sectional survey study	Nigeria	Stratified sampling of households with persons ≥ 65 years old in southwestern and north central areas of Nigeria. 2,096 participants surveyed.	482 (23%) participants reported a fall in the previous year. Female gender was associated with falls compared to males (OR 1.4, 95% CI 1.1-1.8). No other demographic or chronic physical conditions were associated with falls. No outcome data was reported.

Table 1. Characteristics of studies included in this systematic review.

Study	Selection Bias	Measurement Bias	Confounding	Internal Validity	External Validity	Overall Score
Neurotrauma burden in a tropical urban conurbation level I trauma centre Idowu, et al, 2014[15]	+++ All pts admitted through an ED at one center included. Excludes pts who died before reaching the hospital, transfers, non-admissions.	+ Characteristics and outcomes standardized	*N/A.* No comparisons between groups were made.	*Poor* Measurement consistent for all pts. Study is only descriptive. Significant selection bias.	*Poor* Study conducted at urban tertiary hospital in Western Africa. Definition of neuro trauma was sufficiently broad to be applicable broadly. However, no comparisons were made.	*Poor* This is a purely descriptive study with no cohort comparisons, significant selection bias.
Trauma-Related Mortality among Adults in Rural Western Kenya: Characterising Deaths Using Data from a Health and Demographic Surveillance System Odihiambo, et al, 2013[16]	++ All adult deaths recorded from a region reviewed. Unclear how many potential deaths were not recorded and thus not reviewed. Large pt population.	+ Standardized verbal autopsy WHO form used. Researchers used standard cause of death categories for comparison.	+++ No control for confounding. Risk ratios were unadjusted.	*Fair* Standardized, measurement tool used. Large patient population but unclear who is excluded from registry and possible bias. No control for confounding.	*Fair* Good comparison for east Africa. Study covered large region and reviewed several thousand verbal autopsies. Used WHO standardized autopsy form which improves possible comparisons.	*Fair* Large study population over a large region but with unknown selection bias for who is recorded in the verbal autopsy registry.
Injury Outcomes in Elderly Patients Admitted at an Urban African Hospital Saidi, et al, 2013[19]	+++ Did not review pts not admitted or who died in the emergency dept. at a large tertiary trauma center. Limited acuity.	+ Reviewed simple clinical outcomes that appear to be uniform between younger and elderly patients.	+++ No control for confounding. Simple bivariate analysis or unadjusted ratios reported.	*Poor* Appears to include all admitted pts but any exclusions not described. Very small study size. No control for confounding.	*Fair* Conducted at large urban area that is likely similar to other cities in east Africa but with small sample size and possibly limited acuity.	*Poor* Very small study with very basic analysis. Concern for significant selection bias. No control for confounding.
Geriatric injuries among patients attending a regional hospital in Shinyanga Tanzania Chalya, et al, 2012[20]	++ Included all pts evaluated in ED. Unconscious pts without family to consent excluded.	+ Standardized questionnaire used. All pts followed until discharge or death.	*N/A* No comparisons between groups were made.	*Fair* All pts evaluated in ED were included but sicker pts without family were excluded.	*Poor* Very small study population from a small regional area with an unusually high intentional injury rate.	*Poor* Very small study with no comparisons to younger cohorts. Sicker patients excluded.
Epidemiology of Ocular Trauma Among the Elderly in a Developing Country Onakpoya, et al, 2010[17]	++ All elderly pts presenting with ocular trauma studied. 6% had incomplete records and were excluded.	++ Standardized eye injury classification. Unclear if vision outcome testing was standardized.	+++ Retrospective study with no control for confounding. Simple bivariate analysis reported.	*Poor* Significant # of pts with incomplete records, unclear measurement standardization, no control for confounding.	*Fair* Pts taken from four different centers but sample is small. Unclear how representative of general population.	*Poor* Very small study, limited analysis, and unclear applicability to general population.
Fall incidence in a population of elderly persons in Nigeria Bekibele, et al 2010[18]	+ Random sampling of a large region in Nigeria. Weighting was used to account for regional bias.	+ Trained interviewers with standardized questionnaires and assessment tools.	+++ No control for confounding. Simple bivariate analysis or unadjusted odds ratios reported.	*Fair* Random sampling improved selection bias with standardized measurement. No control for confounding.	*Fair* Sampling techniques improve generalizability in region but lack of significant results make comparisons difficult.	*Fair* Well designed survey study but without control for confounding with fair applicability to other populations.

Table 2. Quality assessment of studies included in this systematic review. Definitions: +++ poor, ++ fair, + good. ED=emergency department. Pts=patients.

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Injury Characteristics and Outcomes in Elderly Trauma Patients in Sub-Saharan Africa

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Abstract

Importance: Traumatic injury in the elderly is an emerging global problem with an associated increase in morbidity and mortality.

Objective: To describe the epidemiology of elderly injury and outcomes to help inform trauma care in this growing population in low-resource settings.

Design: We conducted a retrospective analysis of adult patients (≥ 18 years) with traumatic injuries presenting to Kamuzu Central Hospital (KCH) in Lilongwe, Malawi over five years (2009-2013). Elderly patients were defined as adults aged ≥ 65 years and compared to adults aged 18-44 years and adults aged 45-64 years. We used bivariate analysis to compare groups and propensity score matching and logistic regression to compare the odds of mortality between age groups using the youngest age group as the reference.

Setting: Public, tertiary hospital.

Participants: 42,816 adult patients with traumatic injuries presented to KCH during the study period. 1,253 patients (2.9%) were aged ≥ 65 years. 77.4% of patients were male.

Main Outcome Measure: Mortality in the elderly population versus those aged 18-44 years.

Results: Injuries occurred far more often at home as age group increased (25.3, 29.5, 41.1%, $p<0.001$) and the injury mechanism was more likely to be a fall (14.1, 23.8, 36.3%, $p<0.001$) or as a pedestrian in a road-traffic injuries (8.2, 9.9, 13.2%, $p<0.001$) for elderly patients. Fractures were more common in elderly patients (10.6, 21.3, 35.2%, $p<0.001$). Elderly age group was associated with a significantly higher proportion of hospital admissions (10.6, 21.3, 35.2%, $p<0.001$) and a higher overall mortality prevalence (1.7, 2.5, 5.6%, $p<0.001$). Upon propensity score matching and logistic regression analysis, the odds ratio of mortality for patients aged ≥ 65 was 3.15 (95% CI 1.39, 2.60, $p=0.0037$) compared to the youngest age group (18-44 years).

Conclusions and Relevance: Elderly trauma in a resource-poor area in sub-Saharan Africa is associated with a significant increase in hospital admissions and mortality. The setting, mechanism, and pattern of injury differ between elderly and other adult patients and trauma centers in low-resource settings must be prepared to manage these differences. Significant improvements in trauma systems, pre-hospital care, and hospital capacity for older, critically ill patients are imperative.

Introduction

The world is aging rapidly. From 2000 until 2050, the world's population aged 60 and over will more than triple from 600 million to 2 billion. Most of this increase is occurring in less developed countries where the number of older people will rise from 400 million in 2000 to 1.7 billion by 2050.[1,2] In fact, low and middle-income countries (LMIC) will account for 80% of people older than 60 globally by 2050.[3] The lack of health care and public health infrastructure that currently exists in LMIC, especially countries in sub-Saharan Africa, portends an ominous sign for care of the elderly in the years to come.

Traumatic injury and its associated treatment is a global challenge and it is endemic at all ages accounting for 16% of all adult morbidity and premature death worldwide.[4] The burden is disproportionately high in LMIC, which bear 90% of global mortality from traumatic injury, particularly from road traffic injuries (RTI).[5,6] Trauma mostly affects the younger segment of society (<45 years) and more emphasis and resources have understandably been extended to this group of trauma patients.[7] With an increasing life expectancy, traumatic injury in the elderly is emerging as a serious public heath concern, particularly in the developed world with an associated increase in morbidity and mortality compared to younger patients.[8-10]

While traumatic injury in the elderly has been well described in high-income countries, very little data on elderly trauma have been published from sub-Saharan Africa.[11-15] To address this gap, we evaluated the common mechanisms, patterns of injury, and outcomes associated with elderly trauma patients compared to other adult trauma patients presenting to our tertiary trauma center in Lilongwe, Malawi.

Methods

This study is a retrospective analysis of secondary data from the Kamuzu Central Hospital (KCH) Trauma Registry. KCH is a public 600-bed tertiary care hospital in the capital city of Lilongwe, which serves as a referral center for approximately 5 million people in the central region of Malawi. KCH is equipped with four ICU beds and four ventilators and a surgical step-down unit. Trauma and orthopedic surgical services are available seven days a week. Surgical consultants and Malawian general surgery registrars staff the trauma service.

The KCH Trauma Registry was established to collect patient demographic information, clinical characteristics, and outcome data of all patients presenting to the emergency department with traumatic injuries. Specifically, data points utilized in this study for comparison include age, sex, date of injury, setting of injury, mechanism of injury, type and location of injury, time to presentation to hospital, date of admission, clinical scoring systems such as the Alert, Voice, Pain, Unresponsive (AVPU) Scale, date and type of operative procedures, length of hospital stay, and outcome (discharge or death). The AVPU scale records a patient's level of consciousness as either alert, responding to verbal stimuli, responding to pain stimuli, or unresponsive. It correlates with GCS and the United States ATLS protocol uses it in its primary survey.[16,17] All adult patients (≥ 18 years old) who presented to the emergency department with traumatic injuries over five years between January 2009 and December 2013 were included in this study. Patients less than 18 years old or patients missing a recorded age or birthdate were excluded from analysis.

Elderly age was defined as age ≥ 65 years based on the accepted definition in high-income countries.[9,18] Admittedly, there is debate on the appropriate definition of the elderly in LMIC due to a lower life expectancy. Some studies use 50, 55, or 60 years as their definition.[10,19,20] To account for these differing definitions, we created an additional age category, 45-64 years that encompasses these varying and competing definitions of the elderly, while also allowing a comparison between elderly, middle-aged, and younger patients. This resulted in three age cohorts for comparison: 18-44 years, 45-64 years, and ≥ 65 years. We performed bivariate analysis using Chi^2 tests for categorical variables and one-way analysis of variance tests for continuous to compare characteristics between our three age groups. When comparing categorical variables with more than two categories, the aggregate of the remaining categories was used as the referent for comparison. For time to presentation, we used a Kruskal-Wallis test to compare medians across the three age groups due to a nonparametric distribution. Overall crude mortality was calculated using any deaths declared in the emergency department and any deaths in the hospital against all patients recorded in the trauma registry. In-hospital mortality excluded any deaths from the emergency department using only deaths recorded for admitted patients.

Additionally, propensity score matching analysis was performed to determine the relative odds of mortality due to age in the 18-44 year old group versus both the 45-64 and ≥ 65 year old age groups. All propensity score analysis was done using the R programming language and the R MatchIt package was used to match entries based off of this propensity score.[21,22] Patients were matched using the covariates of gender, initial AVPU score, and their three primary traumatic injury types. Initially, the 3 different age categories were randomly sorted. Then the first "treatment" group (patients not in the 18-44 age groups) was matched with the "control group" (18-44 age group) based on the absolute value of the difference between the propensity score of the treatment and control groups under consideration. The closest control unit is selected as a match. The procedure was performed twice. First the dataset was paired down to just patients ages 18-64. Then, patients ages 45-64 were marked as the treatment group. Next, logistic regression was repeatedly performed on the new matched dataset with factors eliminated or added until the maximum number of factors were found such that all were deemed to have a statistically significant effect in patient mortality by the Wald z-statistic and the associated p-value. Odds ratios with 95% confidence intervals are reported for the elderly trauma group versus the control group as well as for the middle aged group versus the control group.

All other statistical analysis was performed using Stata/SE 13.1 (Stata- Corp LP, College Station, TX). The University of North Carolina Institutional Review Board and the Malawi National Health Services Review Committee approved this study.

Results

68,162 patients with traumatic injuries presented to KCH during the study period with 42,816 adult patients (age $\geq$ 18 years). 931 patients (2.1%) were missing a recorded age and were not included in the analysis. 36,826 (86.0%) patients were aged 18-44 years, 4,737 (11.1%) were aged 45-64 years, and 1,253 (2.9%) were aged $\geq$ 65 years with a male preponderance of 77.4%, 71.1% and 64.9% for each age category, respectively ($p<0.001$). Mean age ($\pm$ SD) in the 18-44, 45-64, and $\geq$ 65 years category was 28.5 $\pm$ 6.5, 52.1 $\pm$ 5.3, and 72.5 $\pm$ 6.4 years, respectively (Table 1).

Traumatic injuries occurred more often at home as patients increased in age (25.3, 29.5, 41.1%, $p<0.001$) with road traffic associated trauma decreasing as age increased (44.1, 43.6, 35.3%, $p<0.001$). There were also significant differences in mechanism of injury between groups. Falls increased dramatically as patients aged (14.1, 23.8, 36.3%, $p<0.001$) while assaults decreased (36.9, 20.7, 13.6%, $p<0.001$). Within motor vehicle related trauma, there were variations between groups. The incidence of driver or passenger related injury decreased with each age cohort (23.0, 27.1, 19.4%, $p<0.001$) while the incidence of vehicular related injury to pedestrians increased (8.2, 9.9, 13.2%, $p<0.001$). Elderly patients presented to our trauma center later compared to other age groups with a median time from injury to presentation of 8 hours (IQR 2-37 hours) compared to 3 hours (IQR 1-13 hours) and 4 hours (IQR 1-18 hours) in the 18-44 years old and 45-64 years old age groups, respectively ($p<0.001$). Elderly patients were also more likely to arrive by ambulance (8.3, 16.1, 27.1%, $p<0.001$) and less likely by private vehicle (43.1, 39.5, 33.0%, $p<0.001$). There were also some significant differences in initial AVPU Score with slightly more geriatric patients presenting with an "Alert" AVPU score (49.8, 50.8, 51.2%, $p<0.001$).

The Glasgow Coma Scale (GCS) score and the Revised Trauma Score (RTS) were not reliably recorded in the registry until 2011 with approximately 50% of GCS scores missing in each age category (49.4, 49.3, 49.2%, $p=0.99$) and slightly more RTS scores missing (56.5, 56.2, 57.5%, $p=0.73$). For those patients with recorded scores, GCS mean scores (± SD) were 14.9 ± 1.0, 14.9 ± 1.1, and 14.7 ± 1.7 while RTS mean scores (± SD) were 11.2 ± 2.2, 11.1 ± 2.2, and 11.0 ± 2.6 for each age category respectively. These differences were small and not clinically significant.

Injury patterns between age groups were very different. In the elderly population, fractures were three times more common than in the youngest age group (10.6, 21.3, 35.2%, $p<0.001$). Notably, penetrating wounds were not common in any group but were especially rare in elderly patients (2.4, 1.1, 0.6%, $p<0.001$). (Figure 1) In terms of injury location, the most significant differences were in head/face and lower extremity injuries. Head and face injuries were much more common in younger patients (35.7, 27.4, 20.8%, $p<0.001$) while lower extremity injuries (21.1, 27.9, 33.8%, $p<0.001$) and pelvic injuries (2.1, 2.9, 7.3%, $p<0.001$) were more common in elderly patients. (Figure 2)

Most patients were evaluated, treated, and discharged home from the emergency department (80.3, 71.1, 52.0%, $p<0.001$) but proportionally far more elderly patients were admitted to the hospital compared to the other age groups (10.6, 21.3, 35.2%, p<0.001). Additionally, there were more deaths declared in the emergency room for elderly patients (1.1, 1.0, 2.5%, p<0.001). Once hospitalized, mean hospital length of stay (± SD) was significantly longer for elderly patients (10.8 ± 17.1, 13.2 ± 17.9, 18.1 ± 19.3 days, p<0.001). For all patients, only fractures were associated with an increased length of stay (mean 9.3 ± 16.4 vs. 16.7 ± 18.8 days, p<0.001). There were differences in surgical intervention for admitted patients between the age groups with a slightly greater proportion of younger patients receiving an operation (15.5, 14.0, 11.9%, p=0.032). Elderly patients underwent a much greater proportion of orthopedic procedures and fewer wound repairs. The three most common procedures performed by age group were wound debridement/repair (55.1, 46.4, 23.6%, p<0.001), orthopedic procedures (21.1, 29.4, 51.4%, p<0.001), and exploratory laparotomy (8.4, 4.1, 2.8%, p=0.034).

The overall mortality prevalence for elderly patients was over three times the prevalence for the younger age group and two times the prevalence of the middle age group (1.7, 2.5, 5.6%, p<0.001). (Table 1) After excluding deaths in the emergency department, the inpatient mortality prevalence was also higher for elderly patients (4.9, 7.6, 9.3%, p<0.001). Upon propensity score matching, logistic regression analysis revealed an odds ratio of death for elderly patients to be 3.15 (95% CI 1.39, 2.60, p=0.0037) compared to the youngest age group (18-44 years) when adjusting for severe injury types and initial AVPU score. Middle-aged patients (45-64 years) also had an increased risk of death compared to the youngest age group with an odds ratio of 1.82 (95% CI 0.94, 2.22, p=0.0109) adjusting for severe injury types and initial AVPU score that was not statistically significant.

Within injury types, head injury had the highest mortality rate at 22.6% for all patients. All other injury types had a mortality rate lower than 8%. When examining injury specific mortality by age, mortality was much higher with head injury for elderly patients compared to younger patients (21.1, 25.2, 45.7, $p<0.001$). However, for patients who had a recorded a GCS, the mean initial GCS (± SD) was lower for older patients (13.5 ± 3.4, 13.0 ± 3.7, 9.7 ± 5.7, $p<0.001$). Logistic regression modeling controlling for initial GCS, gender, and hours to presentation revealed an increased adjusted odds ratio of death of 3.12 (95% CI 1.05, 9.25, $p=0.040$) for elderly patients compared to the youngest age group in the presence of a head injury.

We performed a sensitivity analysis comparing patients missing an outcome with those who had an outcome recorded to assess if these data variables were missing at random. 2,931 (6.7%) were missing a recorded outcome with more elderly patients missing this variable than other age groups (5.8, 8.4, 12.8%, $p<0.001$). For those missing a recorded outcome, there were no significant differences between admission disposition ($p=0.66$), length of stay ($p=0.29$), GCS score ($p=0.67$), or RTS score ($p=0.20$) across age groups. Injury mechanism and injury type had similar breakdowns to those patients not missing a recorded outcome.

Discussion

The elderly population in sub-Saharan Africa is increasing and will rise exponentially over the next four decades.[1] There is an urgent imperative to understand the impact of this segment of the population on the health care system, particularly in resource-constrained environments.

This study shows a significant increase in mortality in the elderly trauma cohort compared to other adult trauma patients. This observed difference in mortality is primarily attributable to traumatic brain injury (TBI). Furthermore, in the elderly trauma cohort, admission rates were double that of the younger cohort as was hospital length of stay. Lastly, our study demonstrates that middle-aged patients (45-64 years) carry a similar, but slightly lower, increased risk of hospital admission and mortality compared to the youngest age group (18-44 years). Our findings are consistent with several studies, which demonstrate that older age is an independent predictor of trauma-associated mortality, with some studies showing mortality rates in the elderly to be more than double younger patients.[7-10, 23-26] Described mortality rates are widely variant but a 2014 meta-analysis reported a rate of 14.8%, a finding comparable to ours.[9]

With regards to TBI, there is clear evidence that mortality is strongly associated with increasing age, even with less severe injuries, and that the risk may start increasing as early as age 30 years.[27-30] Overall mortality rates for TBI have been reported as high as 30%, double the rate of younger patients in one cohort.[31] While our mortality rates are higher than those reported in the literature, the trend is the same with exceptionally high mortality rates for elderly patients compared to younger adults, even when controlling for GCS. This demonstrates there is much room for improvement with regards to TBI management in this environment. At our institution, we only have four working ventilators available and our data shows that despite a high mortality, only 0.6% of geriatric patients were admitted to the ICU. In addition to a lack of ICU facilities, subspecialists such as neurosurgeons are also often not available and geriatricians are virtually non-existent in sub-Saharan Africa.[32]

In contrast to our findings, the evidence is conflicting on whether elderly age is associated with an increase in hospital admissions in developed countries with some data suggesting that the elderly may have disparate access to care resulting in lower admission and transfer rates to tertiary trauma centers.[25,33] However, it does appear that longer a length of stay can lead to exceptionally high costs, even for simple falls.[34] While our study did not include a cost analysis, the combination of a significantly higher admission rate with a longer length of stay suggests that elderly trauma patients are likely accounting for a higher proportion of trauma-associated healthcare costs in an environment already constrained by limited resources.

There is a paucity of data on the characteristics and outcomes of the elderly trauma patient in sub-Saharan Africa. A few studies have been published, mostly with very small cohorts of elderly patients and most without comparison to younger patients.[11-15] The most relevant studies were from neighboring Tanzania and Kenya. Saidi et al showed similar patterns of injury to our study with a comparable percent of elderly patients in their trauma population (4.5% vs. our 2.9%).[11] Chalya et al had different findings in neighboring Tanzania where nearly 25% of all patients were 60 years or older.[12] They also had a very high rate of assault (52.1% vs our 13.6%) with an associated increase in upper extremity injuries. Their high assault rate compared to our study and Saidi's report is likely explained by local socioeconomic factors. Despite their small cohort, like our study, Saidi also found that older patients were more likely to have a head injury, unintentional injury, and a non-traffic related mechanism. Both studies had similar in-hospital mortality to our proportion of 9.3% with Chalya's study at 14.9% and Saidi's study reporting 13.9% and an unadjusted odds ratio of death of 2.1 compared to younger patients. Odihiambo's verbal autopsy study suggested that trauma is a significant problem for the elderly and may be contributing to death more often in older patients than in younger patients.[15]

Improvement to the care of the elderly trauma patient will require significant systematic changes in pre-hospital care including improvement in public health education on prevention, better ambulance services equipped for older patients, and an increase in the number of trauma centers. Data from the United States demonstrates that large-scale trauma systems can improve outcomes in severely injured elderly patients, but these are difficult to implement. [35] In addition, in-hospital care suffers from a general lack of resources and specialized geriatric care. Recent management guidelines from the United States for elderly trauma patients focused on aggressive triage, correction of coagulopathy, and limitation of care in patients with a very poor prognosis.[36] These recommendations highlight the deficiencies in this environment where emergency departments are understaffed slowing triage, blood banking is often unavailable, and hospice care and counseling is non-existent. Substantial resources will be required to make meaningful improvements in these areas.

Our study presents data from the largest published cohort of elderly patients suffering traumatic injury in sub-Saharan Africa. The size of the patient population and the length of the study allowed us to describe several patterns of injury and their associated outcome data. Additionally, by including two large cohorts of younger patients, we are able to make meaningful comparisons between older and younger patients. By using propensity score matching, we are able to make more valid comparisons between otherwise heterogeneous groups.

The limitations of our study are consistent with the limitations of retrospective data analysis methodology. There is likely some selection bias because we do not have data on trauma-associated pre-hospital mortality for our patients limiting analysis to only those patients that survived long enough to reach the hospital. There is evidence that elderly patients suffer a greater pre-hospital mortality than younger patients and thus we may be underrepresenting the number of elderly patients suffering traumatic injuries and their associated mortality.[19] We have addressed the observational nature of this study and possible selection bias between age groups with propensity score matching in order to provide a more accurate estimate of the odds ratio of death for older patients.

Also, we acknowledge the issues of missing data, especially some variables that were only recorded in the last three years of the study period such as GCS. We are also missing more outcome data for geriatric patients compared to younger patients, which may mean we are underreporting the mortality rate for this population. However, our analysis suggests data were missing at random and patients with missing data are not significantly different in terms of available clinical indicators. Lastly, we do not have comorbidity data in our database. Admittedly this limits comparison between older patients with younger ones given that older patients are more likely to have medical comorbidities that may complicate their traumatic injuries. However, in this setting most patients do not have access to primary healthcare services and would not have any known medical conditions. There is conflicting evidence in developed countries on the importance of medical comorbidities on mortality from traumatic injury with some data suggesting there is not a significant impact.[37]

Conclusion

Trauma in elderly patients in sub-Saharan Africa is associated with a significant increase in hospital admission rate and mortality. The setting, mechanism, and pattern of injury differ between elderly and other adult patients and trauma centers in low-resource settings must be prepared to meet the growing needs of aging trauma patients. Significant improvements in trauma systems, pre-hospital care, and hospital capacity for older, critically ill patients are imperative.

Tables

Table 1. Bivariate analysis of background information on adults presenting with traumatic injuries by age group. *p* values calculated with Chi[2] analysis.

	18 - 44 years (n = 36,826)	45 - 64 years (n = 4,737)	≥ 65 years (n = 1,253)	*p* Value
Patient Age (years)				
Mean ± SD	28.5 ± 6.5	52.1 ± 5.3	72.5 ± 6.4	
Gender: N (%)				
Female	8,727 (22.5)	1,364 (28.8)	439 (35.0)	< 0.001
Male	28,523 (77.4)	3,370 (71.1)	813 (64.9)	
Missing	31 (0.1)	3 (0.1)	1 (0.1)	
Setting of Injury: N (%)				
Home	9,311 (25.3)	1,395 (29.5)	515 (41.1)	< 0.001
Work	4,635 (12.6)	568 (12.0)	79 (6.3)	< 0.001
Road/Street	16,255 (44.1)	2,063 (43.6)	442 (35.3)	< 0.001
Public Space	2,600 (7.1)	175 (3.6)	31 (2.5)	< 0.001
Other	2,060 (5.6)	168 (3.6)	57 (4.6)	< 0.001
Missing	1,965 (5.3)	368 (7.8)	129 (10.3)	< 0.001
Mechanism of injury: N (%)				
Pedestrian hit by vehicle	3,034 (8.2)	467 (9.9)	165 (13.2)	< 0.001
Driver/passenger in vehicle accident	8.458 (23.0)	1,285 (27.1)	243 (19.4)	< 0.001
Fall	5,185 (14.1)	1,128 (23.8)	455 (36.3)	< 0.001
Assault	13,599 (36.9)	982 (20.7)	170 (13.6)	< 0.001
Collapsed Structure	2,019 (5.5)	291 (6.2)	80 (6.4)	0.055
Other	3,887 (10.6)	460 (9.7)	108 (8.6)	0.036
Missing	644 (1.7)	124 (2.6)	32 (2.5)	< 0.001
Hours to Presentation from Injury				
Median (IQR)	3 (1-13)	4 (1-18)	8 (2-37)	< 0.001
Missing (%)	1,578 (4.3)	291 (6.1)	109 (8.7)	
Transport to Hospital				
Minibus	10,584 (28.7)	1,219 (25.7)	280 (22.4)	< 0.001
Private Vehicle	15,885 (43.1)	1,872 (39.5)	414 (33.0)	< 0.001
Ambulance	3,073 (8.3)	763 (16.1)	339 (27.1)	< 0.001
Walked	1,621 (4.4)	159 (3.4)	37 (3.0)	0.001
Police	2,345 (6.4)	180 (3.8)	47 (3.8)	< 0.001
Other	2,250 (6.1)	309 (6.5)	39 (3.1)	< 0.001
Missing	1,068 (2.9)	235 (5.0)	97 (7.8)	< 0.001
Initial AVPU Score: N (%)				
Unresponsive	351 (0.9)	41 (0.9)	23 (1.9)	0.002
Responds to Pain	104 (0.3)	14 (0.3)	3 (0.2)	0.953
Responds to Voice	16,609 (45.1)	1,995 (42.1)	472 (37.7)	< 0.001
Alert	18,325 (49.8)	2,407 (50.8)	642 (51.2)	< 0.001
Missing	1,437 (3.9)	280 (5.9)	113 (9.0)	< 0.001
Disposition from Casualty: N (%)				
Treated and discharged	29,541 (80.2)	3,362 (71.0)	650 (52.0)	< 0.001
Admitted to Ward	6,484 (17.6)	1,258 (26.5)	552 (44.0)	< 0.001
Admitted to ICU	149 (0.4)	36 (0.8)	8 (0.6)	0.002

Death Declared in Casualty	413 (1.1)	48 (1.0)	32 (2.5)	< 0.001
Missing	239 (0.7)	33 (0.7)	11 (0.9)	0.586
Mortality: N (%)				
Combined Casualty & Inpatient	642 (1.7)	119 (2.5)	70 (5.6)	< 0.001
Inpatient Mortality	231 (4.9)	70 (7.6)	38 (9.3)	< 0.001
Missing	2,130 (5.8)	400 (8.4)	160 (12.8)	< 0.001

Figures

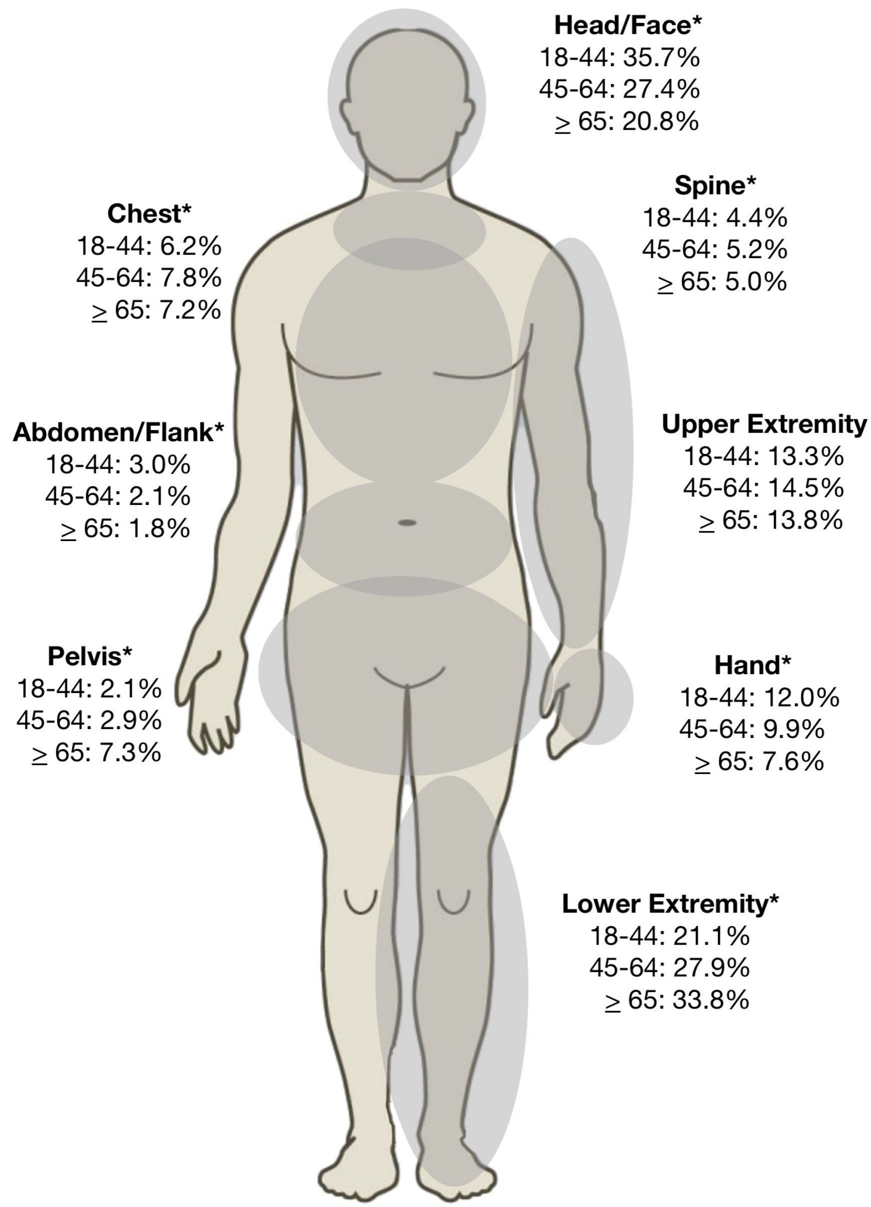

Figure 1. Most severe traumatic injury location by age group (*$p>0.05$). Missing values comprise 2.2%, 2.4%, and 2.7% for each age category respectively.

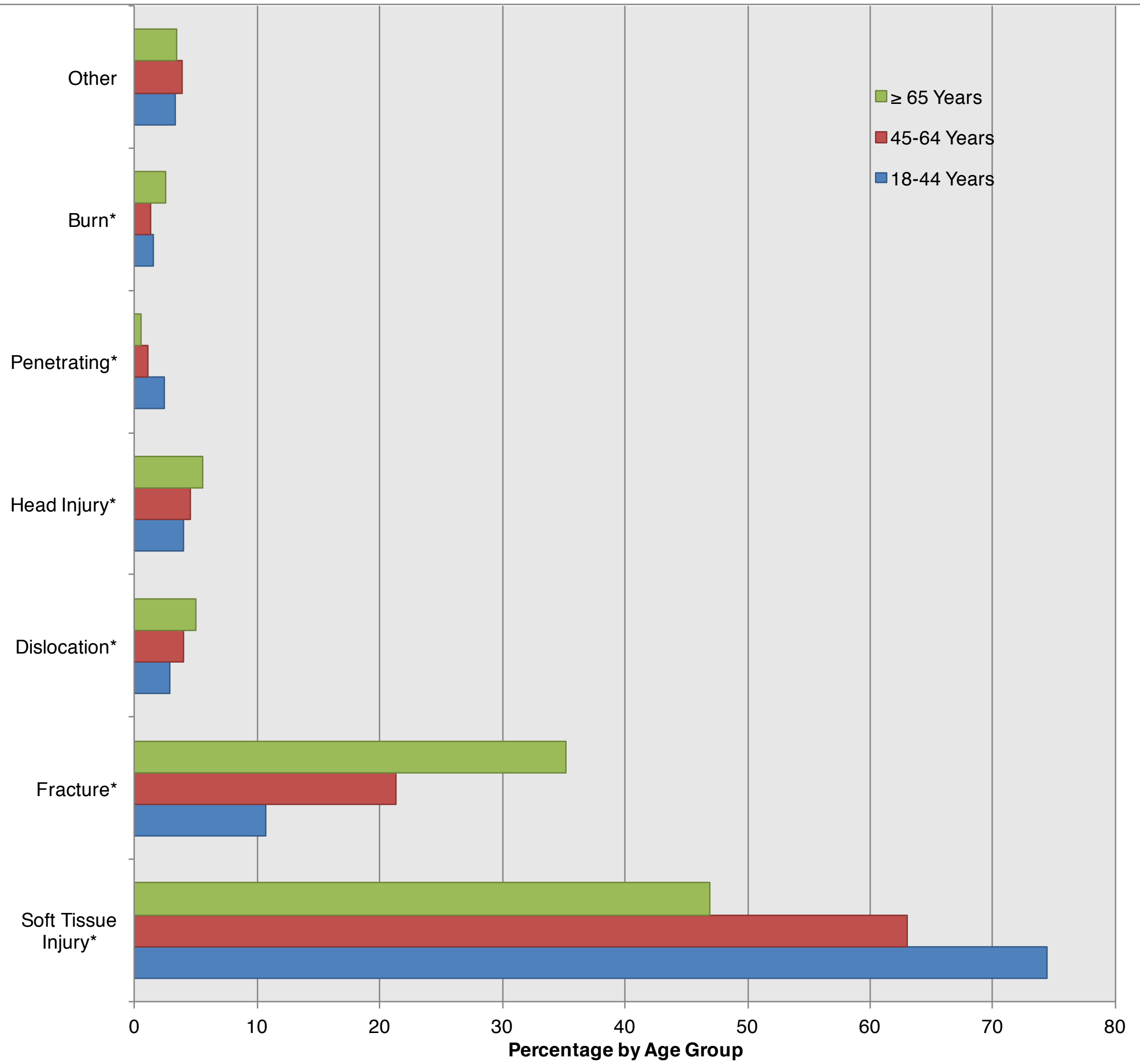

Figure 2. Most severe traumatic injury type by age group (*p<0.05). Missing values comprise 0.80%, 0.9%, and 0.8% for each age category respectively.

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