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Why Elderly Patients with Ground Level Falls Die Within 30 Days And Beyond?

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Abstract

Background: Together with a growing geriatric population in the United States, ground level falls (GLF) are troubling and quickly becoming a significant cause for geriatric trauma deaths. This study describes the factors associated with GLF fall deaths and examines how these factors changed mortality rate over a 3-year follow-up.

Methods: A retrospective study was conducted based on the ASU Center of Health Information and Research (CHiR) database. The dataset included 52,391 patients with GLF admissions at 4 Level-I trauma centers in Arizona from 2008-2011. Patients were identified using ICD-9 GLF specific E-codes E885.x to E888.x. 49,138 patients <60 years who had non-ground level falls were excluded. Abstracted patient demographics, injury characteristics, cause and post injury time of death were summarized and compared using non-parametric tests, Student's t-test, ANOVA, univariate and multivariate regression methods as appropriate; p≤.05 was considered statistically significant.

Results: There were 3,251 patients with GLF who were followed during the 3-year study period. The majority was white (85.7%), female (57.8%), and 36.1% were in the 8th decade of life. Most patients fell at home (71.5%) and suffered medium severity injuries (median ISS= 9). The Trauma Revised Injury Severity Score (TRISS) was 0.93 and mean Charlson Comorbidity Index (CCI) was 0.63. The mortality rate (31.1%) over the 3-year period was remarkably high despite the fact that GLF is often considered a low-energy mechanism of injury. We identified the following significant, non-modifiable and independent risk factors for 1-30 day post-injury mortality: age ≥80 years, male gender, ISS≥16, AIS head ≥4, AIS extremities >2, TRISS <0.63, CCI ≥0.67, and ICU LOS >2.

Conclusion: GLF although considered a low-energy mechanism of injury, is fast becoming a significant cause of mortality among the elderly, beginning immediately after the injury, through intermediate and longer-term follow-up periods. Mortality outcomes were modified only by the unalterable effects of chronic conditions such as cardiac diseases, stroke, cancer, diabetes or liver diseases in subsequent years. We recommend trauma level 1 activation for all elderly patients who suffer GLF with concerns for head injury and emphasis on aggressive head injury management strategies to mitigate GLF-related deaths.

Keywords: Ground Level Fall (GLF); G-60; CHiR; Head injury; Geriatric trauma; Post-injury mortality

Background

The geriatric population in the United States is rapidly growing. By 2030, more than 20% of the population will be age 65 and over, compared to 9.8% in 1970 [1]. The increase in life expectancy is attributed to decreasing rates of heart diseases, stroke, cancer, and increasing adoption of healthier lifestyles. As the geriatric population increased so has the number of geriatric trauma cases with ground level falls (GLF). GLF has becomes a leading mechanism of injury in the elderly [2]. Although GLF has been traditionally considered a low-energy mechanism of injury it has become a significant risk factor for morbidity and mortality among the elderly with 38-47% of those who fall will eventually have a fatal outcome [3]. Furthermore, one-half of those who fall are likely to fall again [4].

A previous study of GLF in elderly patients focused on the epidemiology and risk factors for in-patient deaths after GLF using the national trauma data bank of the American College of Surgeons [3]. The study reported that patient age >70 years, with GCS score<15 were at significant risk of in-patient mortality after GLF. This study, although important omits deaths that occur after hospital discharge. Very few GLF studies have used data on all Level-1 trauma centers in a

State to measure how GLF death rates change over short (inpatient), intermediate (30-90 days) and longer terms (0.5 years to 3 years).

This study uses a comprehensive data set from Arizona [5] to describe the risk factors associated with GLF in the elderly ≥60 years, (G60) and examine how these factors change death rate over a 3-year follow-up period.

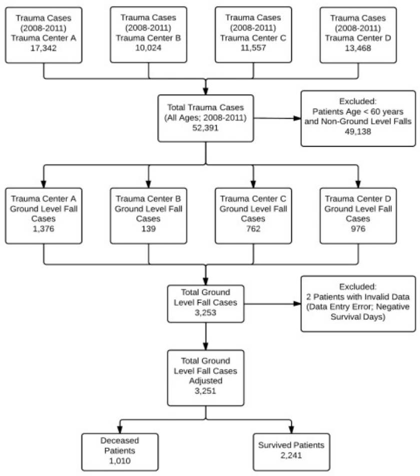

Figure 1: The study includes four Level 1 Trauma Center cases in Maricopa County from 2008-2011.

Methods

Data sources

The Arizona Health Query (AZHQ) Data Repository at CHIR stores health information on millions of Arizona residents from a variety of sources to be used for health care operations and research [5]. The data include patient level information from the eight Level-1 trauma centers. The hospital discharge data and death certificate data contributed to AZHQ by the Arizona Department of Health Services.

Several steps were required to link the data from the different sources. First, demographic data were reviewed and compared to ensure that there were no duplicates.The cleaned record were then merged with claims data for inpatient and emergency department visits from all Arizona acute care hospitals to create the patient level records used for this study. Administrative approval was obtained from each hospital and approved by institutional review board. Four out of eight Level-1 trauma centers including John C. Lincoln North Mountain (now HonorHealth), Dignity St.Joseph's Hospital, Scottsdale Healthcare Osborn (now HonorHealth), and MIHS Trauma Center, participated in this study.

Patients

All the trauma cases from the four participating trauma centers for the time period 2008 to 2011 were selected for the sample. The selection criteria included patient age 60 years and older who had a ground level fall identified by (ICD-9) E- codes E885.x to E888.x. CHiR queried the data sources and, for the selected patients, extracted all inpatient and emergency department visits into an analysis data set with the following variables: categorized age, gender, race/ethnicity, hospital length of stay, diagnosis codes (ICD-9), place of service, discharge status, paid and charged amounts, ISS, AIS scores, pre-medical history, TRISS, date of death, cause of death, waiting time in the emergency department, number of inpatient visits, and Charlson Comorbidity Index.

Statistical analysis

Patients were dichotomized as either "died" or "survived" during specific time intervals. For clarity and comparison, those who died were categorized into groups based on the time interval within which the patient died. The post-injury time periods were: 1-30 days, 31-90 days, 91-180 days, 181-364 days, 1-2 years, and >2-3 years. For simplicity and ease of interpretation, in-hospital deaths were separately categorized and presented regardless of time frame. Patients who were alive at the end of the study period were grouped as "survived" regardless of the differences among patients in time from onset to the end of the study period.

The explanatory variables include demographics, fall location, charged and paid amounts, hospital length of stay (HLOS), ICU length of stay (ICU LOS), hours spent in emergency department (ED), number of inpatient visits (IP), ISS, AIS scores, TRISS, and Charlson Comorbidity Index (CCI). Age was classified by deciles 60-69, 70-79, 80-89 and >90 years. The primary study outcome was death. The cause of death was determined using death certificate data. The immediate cause of death, consequential cause of death A, B, and C according to the Arizona Department of Health Services Certification of Cause of Death were reviewed. The cause of death was grouped into either a "trauma death" or "non-trauma death". Trauma deaths were defined based on the anatomical location of injury and classified further into the following: head and neck, torso, upper extremity and lower extremity, and other trauma injuries such as multiple area injuries, and unspecified blunt and fall injuries. All other deaths were classified as non-trauma deaths consistent with the causal mechanisms.

The data were analyzed using SPSS ver. 22 (IBM) and Microsoft Excel. Continuous variables with normal distributions were compared using Student's t test or Mann-Whitney U test for skewed data. Multiple continuous variables were analyzed using ANOVA or Kruskall-Wallis test. The results were reported as means (95% confidence interval). Proportions were reported as percentages and categorical variables were analyzed using Chi-Square test; p value of ≤0.05 was considered statistically significant.

Results

From 2008 – 2011, 52,391 trauma patients were identified from four level-1 trauma centers in Arizona. After excluding patients less than 60 years of age, and patients who did not have a ground level fall (GLF), a total of 3,251 patients were included in our sample (Figure 1). Demographic characteristics of patients in the study are described in detail (Table 1). In summary age distribution in deciles was 60 – 69 (24.5%), 70 –79 (28.5%), 80 – 89 (36.0%), and 90 above (11.0%). The majority of the patients were female white and fell at home. The average CCI score was 0.6296 ± 0.0125. The average TRISS was 0.9264 ± 0.005, and median ISS was 9 (IQR= 5 – 16). Of the 3,251 patients, males spent significantly more days in hospital (4.8 vs. 5.9, $p<0.0001$) and in ICU (1.6 vs. 2.7, $p<0.0001$) compared to females. Males also had statistically significant higher average ISS scores than females (11.4 ±

0.41 vs. 10.2 ± 0.32, p<0.0001). Differences in TRISS scores between males and females were statistically significant (0.916 vs. 0.934, p<0.0001). A higher proportion of males sustained head injuries, (65.3% vs. 52.3%) and males also had higher median AIS Head scores (4 vs. 3). When ISS and TRISS values for age (decile) groups were compared, there were no significantly differences between them. On the other hand, HLOS, IP, and ED decreased as age increased (p<0.05).

Comparing mortality rates across time periods post injury, more males died during 1-30 days post-injury than females. After 30 days post-injury time, mortality in females was higher than in males (Table 1).

As suspected, the median ISS was highest among patients who died in-hospital compared to patients who died after discharge. Patients who died in-hospital also had longer ICU LOS. HLOS was longest among patients who died during the 31- 90 days interval compared to patients who died in-hospital or later. Patients who died during later time intervals spent more hours waiting in the emergency department (ED), had higher readmission rates (increased number of in-patient visits (IP), and increased TRISS.

	In-hospital(n=154)	**1-30 days (n=394)**	**31-90 days (n=143)**	**91-180 days (n=122)**	**0.5-1 years (n=129)**	**1-2 years (n=145)**	**2-3 years (n=64)**	**Survived (n=2241)**
	n (%)							
Age (years)								
60-69	29 (18.8)	49 (12.4)	18 (12.6)	21 (17.2)	19 (14.7)	23 (18.3)	11 (17.2)	653 (29.1)
70-79	49 (31.8)	97 (24.6)	29 (20.3)	33 (27.0)	28 (21.7)	44 (34.9)	19 (29.2)	671 (29.9)
80-89	60 (39.0)	176 (44.6)	63 (44.1)	47 (38.5)	57 (44.2)	62 (49.2)	25 (38.5)	734 (32.8)
≥90	16 (10.4)	72 (18.3)	33 (23.1)	21 (17.2)	25 (19.4)	16 (12.7)	9 (14.1)	183 (8.2)
Ethnicity								
White	129 (83.8)	343 (87.1)	125 (87.4)	105 (86.1)	111 (86.0)	122 (96.8)	53 (42.1)	1912 (85.5)
Black	2 (1.3)	5 (1.3)	3 (2.1)	5 (4.1)	0 (0.0)	2 (1.6)	0 (0.0)	29 (1.3)
Asian	1 (0.6)	3 (0.7)	1 (0.6)	2 (1.6)	1 (0.8)	2 (1.6)	2 (1.6)	19 (0.9)
Other	22 (14.3)	43 (10.9)	14 (9.8)	10 (8.2)	17 (13.2)	19 (15.1)	9 (7.1)	275 (12.3)
Gender								
Male	84 (54.5)	203 (51.5)	72 (50.3)	57 (46.7)	54 (41.9)	57 (39.3)	26 (40.6)	896 (40.0)
Female	70 (45.5)	191 (48.5)	71 (49.7)	65 (53.3)	75 (58.1)	88 (60.7)	38 (59.4)	1345 (60.0)
Fall Location								
Home	108 (70.1)	262 (66.5)	102 (79.1)	90 (81.1)	96 (81.4)	98 (73.7)	43 (67.2)	1481 (69.5)
Other sites	46 (29.9)	132 (33.5)	27 (20.9)	21 (18.9)	22 (18.6)	35 (26.3)	21 (32.8)	651 (30.5)
Charged Mean (95% CI)	$89,242 ($68,577-$109,907)	$73713 ($65,603-$82,362)	$69,496 ($53,156-$85,835)	$62,226 ($47,777-$76,675)	$50,529 ($40,106-$60,953)	$49,958 ($38,605-$61,265)	$56,885 ($41,929-$71,841)	$53,506 (± $2664)
Collected Mean (95% CI)	$20,570 ($16,135-$25,005)	$17,767 ($15,646-$19,888)	$15,357 ($11,364-$19,351)	$13,755 $(10,647-$16,864)	$12,385 ($9,640-$15,131)	$10,527 ($8,270-$12,784)	$11,902 ($8,497-$15,307)	$12,165 (± $775)
Ratio of mean Collected/Charge	23.00%	24.10%	22.10%	22.10%	24.50%	21.10%	20.90%	22.70%
HLOS Mean (± SD)	5.1 (± 1.5)	5.4 (± 0.5)	7.5 (± 1.6)	6.5 (± 1.0)	5.2 (± 0.9)	5.3 (± 1.0)	4.9 (± 1.1)	5.1 (± 0.2)
ICU LOS Mean (± SD)	3.3 (± 0.6)	3.3 (± 0.4)	2.9 (± 0.7)	2.3 (± 0.7)	2.0 (± 0.7)	1.8 (± 0.7)	1.7 (± 0.6)	1.8 (± 0.2)
ED Mean (± SD)	1.6 (± 0.4)	1.7 (± 0.2)	1.6 (± 0.3)	1.9 (± 0.5)	2.8 (± 0.7)	2.9 (± 0.6)	2.9 (± 0.3)	2.8 (± 0.3)
IP Mean (± SD)	2.3 (± 0.4)	2.7 (± 0.3)	3.6 (± 0.4)	4.1 (± 0.5)	4.4 (± 0.5)	5.0 (± 0.8)	5.9 (± 1.3)	3.2 (± 0.1)

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TRISS Mean (95% CI)	0.63 (± 0.06)	0.77 (± 0.03)	0.92 (± 0.03)	0.94 (± 0.02)	0.95 (± 0.02)	0.95 (± 0.02)	0.95 (± 0.04)	0.95 (± 0.01)
CCI Mean (95% CI)	0.57 (± 0.06)	0.67 (± 0.04)	0.66 (± 0.06)	0.62 (± 0.07)	0.67 (± 0.07)	0.62 (± 0.06)	0.59 (± 0.1)	0.62 (± 0.01)
ISS Median (IQR)	25 (10-26)	16 (9-25)	9 (5-16)	9 (5-16)	9 (4-16)	9 (4-10.5)	9 (4-10.8)	9 (5-16)
AIS Face	1 (1-2)	2 (1-2)	1 (1-2)	2 (1-2)	2 (1-2)	1 (1-2)	2 (1-2)	2 (1-2)
AIS Head	5 (4-5)	4 (3-5)	3 (3-4)	4 (3-4)	3 (3-4)	3 (2-4)	3 (3-4)	3 (3-4)
AIS Extremities	3 (2-3)	3 (2-3)	2 (2-3)	3 (2-3)	2 (2-3)	3 (2-3)	3 (2-3)	2 (2-3)
AIS Chest	3 (2-3)	3 (2-3)	2 (2-3)	2 (1.5-3)	2 (2-2.75)	2 (2-3)	2 (2-3)	2 (2-3)
AIS External	1 (1-1)	1 (1-1)	1 (1-1)	1 (1-1)	1 (1-1)	1 (1-1)	1 (1-1)	1 (1-1)
AIS abdomen	2.5 (2-4)	2 (2-3)	2 (2-2)	2.5 (2-3.25)	2 (2-3)	2 (2-2)	2 (2-2.25)	2 (2-3)
TC								
TC (A)	71 (46.1)	177 (44.9)	73 (51.0)	42 (34.4)	56 (43.4)	61 (42.1)	23 (35.9)	932 (41.6)
TC (B)	5 (3.2)	11 (2.8)	9 (6.3)	7 (5.7)	3 (2.3)	3 (2.1)	3 (4.7)	103 (4.6)
TC (C)	36 (23.4)	98 (24.9)	17 (11.9)	27 (22.1)	27 (20.9)	38 (26.2)	22 (34.4)	530 (23.7)
TC (D)	42 (27.3)	108 (27.4)	44 (30.8)	46 (37.8)	43 (33.3)	43 (29.7)	16 (25.0)	676 (30.2)
HLOS, Hospital Length of Stay; ICU LOS, Intensive Care Unit Length of Stay; ED, Emergency Department (hours); IP, In-patient visit (times); TRISS, Trauma Revised Injury Severity Score; CCI, Charlson Comorbidity Index; ISS, Injury Severity Score; AIS, Abbreviated Injury Score; TC, Trauma Centers.								

Table 1: Demographic characteristics of patients who died after GLF during specified post-injury time periods.

We compared AIS scores across post-injury mortality periods (Table 1). AIS head score was highest in patients who died in-hospital (median=5) compared to deaths in 1-30 days post-injury (median=4) period. The 4 participating level 1 trauma centers showed wide variations in rates of GLF-related deaths at all-time intervals we examined (Table 1). The reasons for this variation in mortality rates among the centers were not entirely clear from our study.

We examined the relationship between trauma-caused deaths and non-trauma-caused deaths as a function of age (decile) groups (Figure 2 A). There was a positive association between the proportion of trauma deaths and age. A similar but stronger association was observed between non-trauma death rate and age group deciles. The proportion of patients who survived remained the same for all age groups except for those aged 90 years and above. We examined the cause of death for each of the post-injury mortality periods. In-patient mortality due to trauma and non-trauma causes was 70.2% and 29.8% respectively. During subsequent post-injury time intervals, the proportion of deaths from trauma causes decreased (Figure 2B).

We also examined injury diagnoses and cause of death secondary to GLF. The majority of patients who died (80%) had suffered head and neck injury from GLF regardless of the post- injury time periods. A significant proportion of patients who died after 30 days post-injury sustained torso and extremities injuries. However, the overall trend showed that a smaller proportion of patients died from their traumatic injury during subsequent years of follow-up.

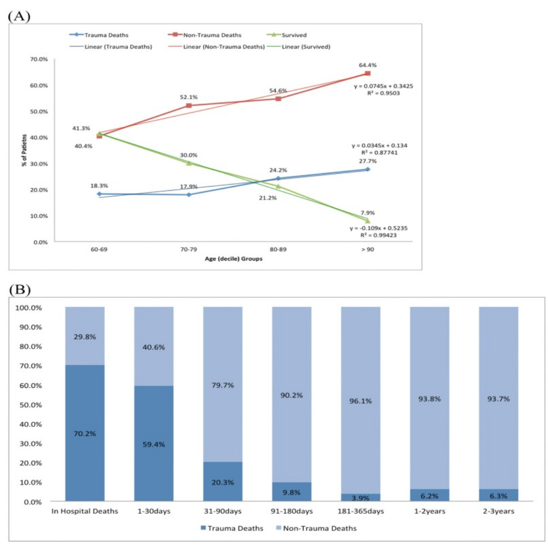

Figure 2: (A) Age distribution of patients who either died from trauma or non-trauma related causes, or survived. (B) Proportion of trauma and non-trauma related deaths by post-injury mortality period.

We assessed the relationship between specific explanatory variables and mortality in a univariate analysis of variance model (Table 2). In this univariate regression model, age ≥80 years, male gender, ISS ≥16, AIS Head ≥4, AIS Extremity >2, TRISS <0.63, and CCI ≥0.67 were significant predictors of post-injury mortality 1-30 days ($p < 0.05$). In a multivariate logistic regression model, age, male gender, HLOS, ICU LOS, AIS head, and TRISS were all significant independent predictors of post-injury 1-30 day mortality (Table 3). The equation derived from this analysis showed that mortality [probability of death (p) due to GLF] in 30 days post-injury can be predicted using ln [p/1-p] = - 0.821 + 0.45 (male) p=0.007 + 0.22 (ICU LOS) p<0.001 - 0.17 (HLOS) p<0.001 + 1.76 (90 and older) p<0.001 + 1.60 (80-89 years old) p<0.001 + 1.04 (70-79 years old) p<0.001 + 0.51 (AIS head) p<0.001- 4.50 (TRISS) p<0.001. The specificity and sensitivity of prediction were 98.5% and 32.8% respectively, and the accuracy of prediction was 88.0%.

Variables	Odds Ratio (95% CI)	P-values
Age (<80* vs. ≥80)	2.09 (1.69 – 2.60)	0.001
Gender (males vs. females*)	1.50 (1.24 – 1.89)	0.001
ISS (<16* vs. ≥16)	3.71 (2.97 – 4.65)	0.001
AIS Head (<4* vs. ≥4)	3.61 (2.73 – 4.77)	0.001
AIS chest (<3* vs. ≥3)	1.73 (0.93 – 3.23)	0.084
AIS face (≤1 vs. >1*)	1.15 (0.69 – 2.27)	0.689
AIS extremities (≤2* vs. >2.0)	1.70 (1.03 – 2.82)	0.037
AIS external (≤1 vs. >1*)	1.04 (0.41 – 2.67)	0.936
AIS abdomen (≤2* vs. >2)	1.44 (0.61 – 3.41)	0.409
TRISS (<0.63* vs. ≥0.63)	0.04 (0.03 – 0.07)	0.001
CCI (<0.67 vs. ≥0.67*)	1.45 (1.17 – 1.81)	0.001
HLOS (≤4 vs. >4*)	0.88 (0.70 – 1.1)	0.260
ICULOS (≤2 vs. >2*)	0.38 (0.30 – 0.47)	0.001
*Denotes reference value: ISS, Injury Severity Score; AIS, Abbreviated Injury Score; TRISS, Trauma Revised Injury Severity Score; CCI, Charlson Comorbidity Index.		

Table 2: Univariate Logistic Regression (1-30 days post-injury mortality).

Variables	Odds Ratio (95% CI)	P-values
Age Group		
60 – 69*		
70 – 79	2.82 (1.64 – 4.84)	0.001
80 – 89	4.93 (2.94 – 8.25)	0.001
90 and above	5.82 (3.08 – 10.99)	0.001
Male gender	1.56 (1.13 – 2.16)	0.007
HLOS	0.84 (0.79 – 0.90)	0.001
ICU LOS	1.24 (1.14 – 1.35)	0.001
AIS Head	1.67 (1.37 – 2.04)	0.001
TRISS	0.01 (0.00 – 0.03)	0.001
*Denotes reference value: HLOS, Hospital Length of Stay; ICU LOS, Intensive Care Unit Length of Stay; AIS, Abbreviated Injury Score; TRISS, Trauma Revised Injury Severity Score. Hosmer-Lemeshow Chi- square = 10.497; p = 0.232		

Table 3: Multivariate Logistic Regression (1-30 days post-injury mortality).

Discussion

In this study, we observed that majority of patients who had GLF were female, white and elderly. In-patient mortality secondary to GLF was significant. This observation is consistent with previous studies [3]. Specifically in a study done using National Trauma Data Bank, the results showed that ISS >16, GCS <15, age >70 years, male gender, and hepatic, splenic, or renal injury were significant predictors of in hospital mortality for patients 65 years and older [3]. Other studies also showed significant associations between high ISS and mortality secondary to GLF [6-8]. Our report confirms these previous results as they relate to in-patient mortality and the corresponding predictors. A major new finding in this study is our description of the temporal variation of mortality after GLF. We found that patients aged >60 years (G-60 patients) with GLFs can be divided into two distinct groups: patients who died in-hospital or within 1-30 days post-injury, and those who died after 30 days post-injury. Thirty days after injury became a critical pivoting time point in many of the variables that we assessed. For example, median ISS of those who died 1-30 days after injury was 16 compared to 9 for patients who died greater than 30 days post injury. The patients who died 0-30 days after injury also spent more days in the ICU and had higher AIS head scores. There is a general consensus that trauma death is multifactorial with contributions from injury, acute physiology, co-morbidity, functional status and advanced age. We observed in our study that GLF deaths within the first 30 days were strongly associated with traumatic brain injury, including spine injury. Our observation is consistent with a previous study which reported that 46% of the GLF patients had head injuries, and 28% incurred injuries to the vertebral column, including 35 vertebral fractures [8]. In our study, the majority of the GLF patients sustained head injuries. Most importantly, one half of the people who died 0-30 days post-injury died from the head injury secondary to GLF (Table 3). In this setting it appeared pre-injury conditions such as chronic diseases played a less significant causal role in the demise of the patient. After 30 days however, pre-injury health status played a larger role than initial trauma. In our multiple regression model, we found that increasing age, male gender, and ISS>16 were significant independent predictors of mortality during the 1-30 days post-injury time interval. Our study also identified high AIS head score and low TRISS as significant risk factors for post-injury mortality within the 1-30 day time interval.

The study results permitted us to draw the important inference that death secondary to GLF has a temporal dimension. We defined these temporal dimensions as short (in-patient), intermediate (1-30 days) and longer term (greater 30 days to 3 years) mortality. These temporal dimensions are characterized by specific modifiable and non-modifiable risk factors. For example, the most vulnerable population for short-term mortality was older males who sustained a traumatic injury to the head or neck with AIS head score of 4 or greater. In general, ISS was an independent risk factor for early mortality such as death as an in-patient or death within 1-30 days. We also observed increase in age as the strongest predictor (Table 3) for increase in mortality an observation that is consistent with reports in the current medical literature [3,9]. It is also of interest that ISS was a significant predictor variable in a univariate regression model. However, ISS was not significant in a multivariate logistic regression model. A possible explanation for this observation was that ISS associated with GLF mechanism is a relatively minor injury and not strongly associated with age per se. In other words variations in ISS values associated with GLF were too narrow to support statistically sound association between ISS and mortality especially during longer follow-up. Our results also showed that CCI was significant in the univariate model but failed to achieve significance in the multivariate model. Among other AIS body regions, AIS head showed statistically significant relationship with 1-30 days mortality in a multivariate logistic regression model. This was further support for our conclusion that head injury secondary to GLF is inimical and predicts early death in the elderly after GLF.

The cause of death is important in determining the primary and secondary causal mechanisms of death. Our results were intriguing because a higher proportion of patients who died during 0-30 days post-injury died from trauma causes even though GLF is commonly considered as a low-energy mechanism of injury (Figure 2B). Those who died after 30 days post-injury died mostly from non-traumatic causes. Because death among these patients occurred during time intervals which were remote from the GLF event, it was difficult to assess any direct effect of GLF on long term deaths with any degree of confidence. We speculate however that long-term GLF-related death may be inevitable and exacerbated by unalterable consequences of pre-existing comorbidities including repeated falls. In general, older patients in the cohort had higher mortality rates which also occurred during the shorter post-injury periods. Increasing age was also associated with shorter hospital LOS, ICU LOS, and ED time.

We have identified several limitations of this study. A major limitation of previous studies, as well as, the present study is patient selection biases that are intrinsic to all retrospective studies. We have addressed these biases in our study by controlling for confounding variables using multivariate logistic analysis. Several studies on ground level falls are either single institution reports or national trauma registry studies. Our study presented findings using data from 4 level I trauma centers in a single state and reflects trauma management practice in a defined area and within a specified time interval. The data from our trauma centers were managed in accordance with existing Business Associate Agreements between the hospitals, including human subject and HIPAA regulations. The data elements in our study were from Arizona Department of Health Services Required Data Set, including 97 raw trauma data tables. Special care was taken to address missing data and analysis was performed on complete datasets only. Thus the details of our study ensure data quality at the patient level. These efforts addressed some of the limitations inherent in some registry-based studies. Our study focused on fall-related deaths in a population aged ≥ 60 years; this differs from previous studies on the elderly using age ≥ 65 years as their threshold for defining the geriatric population [10-12]. Future research directions should focus on longer term patient outcomes secondary to ground level falls. Geriatric fall studies could benefit from the wider use of radiographic assessment (PAN-SCAN) of ground-level falls in patients ≥ 60 years [12].

Conclusions

GLF although considered a low-energy mechanism of injury is fast becoming a significant cause of mortality among the elderly, beginning immediately after the injury, through intermediate and longer-term follow-up periods. Mortality outcomes were modified only by the unalterable effects of chronic conditions such as cardiac diseases, stroke, cancer, diabetes or liver diseases in subsequent years. We recommend trauma level activation for all elderly patients who suffer GLF with concerns for head injury and emphasize an aggressive head injury management strategy to mitigate GLF-related deaths.

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