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The Triage of Injured Patients: Mechanism of Injury, Regardless of Injury Severity, Determines Hospital Destination

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Abstract

The target rate for trauma undertriage is <5 per cent, but rates are as high as 30 to 40 per cent in many trauma systems. We hypothesized that high undertriage rates were due to the tendency to undertriage injured elderly patients and a growing elderly population. We conducted a retrospective analysis of all hospital visits in California using the Office of Statewide Health Planning and Development Database over a 5-year period. All hospital admissions and emergency department visits associated with injury were longitudinally linked. The primary outcome was triage pattern. Triage patterns were stratified across three dimensions: age, mechanism of injury, and access to care. A total of 60,182 severely injured patients were included in the analysis. Fall-related injuries were frequently undertriaged compared with injuries from motor vehicle collisions (MVCs) and penetrating trauma (52% *vs* 12% and 10%, respectively). This pattern was true for all age groups. Conversely, MVCs and penetrating traumas were associated with high rates of overtriage (>70% for both). In conclusion, in contrast to our hypothesis, we found that triage is largely determined by mechanism of injury re- gardless of injury severity. High rates of undertriage are largely due to the undertriage of fall-related injuries, which occurs in both younger and older adults. Patients injured after MVCs and penetrating trauma victims are brought to trauma centers regardless of injury severity, resulting in high rates of overtriage. These findings suggest an opportunity to improve trauma system performance.

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Author contributions: KS and RYH were expanded the study concept and design of the data. The data were acquired by RYH. The data were analyzed and interpreted by KS, Lin, RCM, DAS, TGW, and RYH. The manuscript was drafted by KS and RYH. Critical revision of the manuscript for important intellectual content developed by KS, RCM, DAS, RYH, NEW, PMM, and TGW. KS, Lin, and RYH were statistically analyzed. Funding was obtained by RYH. Administrative, technical, or material support is by KS. This study supervised by RYH.

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INTRODUCTION

Regionalization of trauma center care has been shown to improve outcomes among seriously injured adults.[1–3] The process of accurately triaging severely injured patients to trauma centers is important to ensure patients receive the specialized care they need. The American College of Surgeons Committee on Trauma presently recommends that trauma systems maintain undertriage rates lower than 5 per cent.[4] Unfortunately, there is evidence that many states do not achieve this target.[5, 6] We have recently shown that the undertriage rate in California to be as high as 35 per cent.[7]

One explanation for high undertriage rates may be that current triage guidelines, such as the American College of Surgeons Committee on Trauma–derived Field Triage Decision Scheme, may not be sensitive enough. Newgard et al.[8] has shown that the sensitivity of the Field Triage Decision Scheme for severely injured patients to be only 86 per cent. However, this is unlikely to completely account for the observed high rates of undertriage.

Previous work has demonstrated high rates of undertriage in the elderly.[9–11] We have similarly shown that advanced age and falls were associated with undertriage rates in California.[10] This suggested that the undertriage of the elderly patients was driving high statewide undertriage rates. However, since fall-related injuries were common in the elderly, it was also possible that there existed a tendency to undertriage falls and as a result, the elderly. Separating out the drivers for undertriage would serve to inform efforts aimed at improving trauma systems.

We hypothesized that high statewide undertriage rates were due to a tendency to undertriage all severely injured older adults, regardless of mechanism and that this would be more pronounced when there was limited access to care. Conversely, we hypothesized that undertriage in younger adults would be low. If true, this would suggest that trauma systems are responding appropriately to the needs of severely injured younger adults and that systems behave differently for older adults.

To test this hypothesis, we used a longitudinal database of all hospital and emergency room visits for patients who were severely injured in the state of California. We then stratified trauma system performance across three dimensions: age, mechanism of injury, and access to care.

METHODS

Data Source and Linkage

Nonpublic data for all hospital discharges and emergency department (ED) visits in the state of California were obtained from the California's Office of Statewide Health Planning and Development Database (OSHPD)[12] for the period between January 1, 2005 and December 31, 2009. Mortality was determined using the linked ED and PDD/Vital Statistics data provided by OSHPD. Detailed information on hospital characteristics was derived from the OSHPD state utilization data file of hospitals. Trauma center status was confirmed manually for each hospital for each year by comparing to California Emergency Medical Information System data and evaluation of hospitals' Web sites.

Hospitalizations associated with a primary diagnosis of injury were identified. These admissions were linked to ED visits and other hospitalizations using patient-specific record linkage numbers. The operating assumption was that any ED visit or hospitalization that preceded or followed the index admission date by two days was likely associated with the same injury event. The time span of two days was selected as there are some transfer processes from rural areas that may take longer than 24 hours.

Injury severity measures including Injury Severity Scores (ISS) were derived using a publicly available Stata program for injury classification that uses ICD-9-CM diagnosis codes.[13] Mechanisms of injury were determined using principal E-codes (present in 97% of patients). Finally, the rural–urban designation of the index hospital was also included and was derived from rural- urban commuting area codes classification system.[14, 15]

Inclusion/Exclusion Criteria

We included all patients 18 years of age with a hospital admission listing a primary diagnosis consistent with trauma (ICD-9-CM 800–959, excluding 905–909, 910–924, and 930–939), as described in previous literature.[7] Patients were excluded if the primary diagnosis was listed as a burn injury, if the index ad- mission was listed as "elective," or if admission was not to a general acute care hospital (*e.g.*, psychiatric health facility). Patients who had an ED disposition indicating death were excluded, as it would have not been possible to distinguish between dead on arrival *versus* those who died in the ED. We also excluded cases where it would have been impossible to link or determine the order of subsequent hospital visits (*e.g.*, patient records without record linkage numbers or dates of service).

Outcome Variables

The primary outcome was triage patterns. "Primary triage" was defined as a patient with an ISS > 15 who was directly transported from the field to a Level I or II trauma center." Secondary triage" was defined as a patient with an ISS > 15 who first visited a non-Level I/II trauma center, but was subsequently transferred to a Level I/II trauma center. "Undertriage" was defined as any patient with an ISS > 15 who was never taken to a Level I/II trauma center. "Overtriage" was defined as a person with an ISS < 15 who was brought directly from the field to a trauma center (regardless of if the patient was subsequently transferred).

The California Trauma System

California is the third largest state in area and the largest state in terms of population. There is no centrally managed trauma system, rather county-based local emergency medical system agencies (LEMSAs) coordinate trauma response under the auspices of the California Statewide EMS agency. California has 72 trauma centers located unevenly throughout the state, pre- dominantly in urban areas. Some LEMSAs have multiple trauma centers, whereas others have none.

Analysis

Patients were analyzed along three strata: 1) access to care, 2) younger *versus* older adults, and 3) mechanism of injury. Access to care was divided into LEMSA regions that had a trauma center *versus* LEMSA regions that did not have a trauma center. Younger adults were defined as those aged 18 to 54, whereas older adults were $55 years of age. Only the most common mechanisms of injury were included. These were motor vehicle collisions (MVCs), penetrating trauma, and fall- related injuries.

Categorical data were compared using x^2 analysis. Continuous data were compared using Student's *t* test for data satisfying normality assumptions and Wilcoxon rank sum was used for nonparametric data. All statistical analysis was performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC).

RESULTS

As previously reported, a total of 550,683 patients were admitted for injury during the study period.[10] Of these patients, 60,182 (11%) had an ISS > 15 and were considered severely injured (Table 1). Patients who were $55 years of age comprised 52 per cent of this severely injured population (n 4 31,162). Most of the severely injured patients (82%, n 4 49,640) resided in a LEMSA that had a trauma center. A total of 45,498 patients (76%) sustained one of the three most common mechanisms of injury of MVC, penetrating trauma, and falls. Overall, primary triage occurred for 59 per cent of patients, whereas 6 per cent underwent secondary triage, and 35 per cent were undertriaged. However, triage patterns differed for younger *versus* older adults. Patients $55 years of age were severely injured experienced higher rates of undertriage com- pared with those aged 18 to 54 (49% *vs* 20%, P <0.001).

We first evaluated triage by mechanism of injury and access to a trauma center (Fig. 1). Overall, undertriage was low for severely injured patients due to an MVC or penetrating trauma (statewide undertriage rate of 12% *vs* 10%, respectively). In contrast, fall-related injuries were frequently undertriaged, even in LEMSAs with access to a trauma center (52% statewide, and 48% in LEMSAs with trauma centers).

To determine the relationship between age, mechanism of injury, and access to care, we stratified across these three variables (Figs. 2 and 3). In LEMSAs with trauma centers, undertriage was relatively low for MVCs and penetrating trauma, with slightly higher rates in patients older than 55 years (8% *vs* 13% for MVCs for patients <55 *vs* those $55 years, respectively; and 6% *vs* 10% for MVCs for <55 *vs* those $55 years, respectively). Undertriage rates were high for falls, in both younger and older adults (27% and 53 % for <55 *vs* those $55 years). In LEMSAs without trauma centers, the lowest undertriage rates were for patients who sustained MVCs (33% and 36% for <55 *vs* those $55 years) and were highest for falls (57% and 78% <55 *vs* those $55 years).

Because triage patterns adhered closely to mechanism of injury, we sought to determine if mechanism of injury was the primary driver of where a patient was taken. If so, then even minor injuries sustained in an MVC or penetrating trauma would be transported to a trauma center. We calculated rates of field transport directly to a trauma center *versus* a non-trauma center for all patients (*i.e.*, regardless of injury severity; Fig. 4). To remove the effects of trauma center access, we focused only LEMSAs with trauma centers.

Overall, MVCs and penetrating trauma were associated with high primary triage rates (*i.e.*, patients with ISS > 15 who were brought to trauma centers) as well as high overtriage rates (*i.e.*, patients with ISS < 15 who were brought to trauma centers). The rates of overtriage for MVCs and penetrating trauma were 74 and 70 per cent, respectively. In contrast, fall-related injuries were brought to a trauma center 28 to 45 per cent of the time depending on injury severity.

Finally, we determined the proportion of under- triaged patients that were due the different mechanisms of injury (Fig. 5). The largest proportion of undertriaged patients sustained a fall mechanism in LEMSAs with access to trauma centers (66%), with the next most common being falls in LEMSAs without trauma centers (16%). The undertriage of MVCs and penetrating trauma together only accounted for 18 per cent of the undertriage population. Access to care played a smaller role as only 23 per cent of under- triaged patients were injured in LEMSAs without trauma centers.

DISCUSSION

In contrast to our hypothesis, we have found mechanism of injury, rather than age, to be associated with undertriage in this statewide analysis of injured adults. The statewide undertriage rate for fall-related injuries is 52 per cent. The undertriage of patients injured by fall mechanisms of injury was true not only for elderly fall victims, but also for younger adults. Undertriage rates for younger adults were 27 to 57 per cent (depending on access to trauma center care). In contrast, the statewide undertriage rates for MVCs and penetrating trauma were low (12% and 10%). Furthermore, disproving our hypothesis, undertriage rates for older adults were only 3 to 7 per cent higher when compared to younger adults in the case of MVCs and penetrating trauma. These findings argue against a global bias to undertriage the elderly, as has been previously described.9 Instead, a tendency to undertriage the most common mechanism of injury in older adults likely explains the association between undertriage and age.

An important implication to these findings is that mechanism of injury may supersede field triage guidelines. Due to the limitations of the current study, we are not able to determine field triage guideline compliance to definitively conclude that mechanism-driven triage is occurring. However, given the observed triage patterns, an association between mechanism and triage is clear. It is possible to imagine how a mechanism-driven decision to transport to a trauma center would occur. Prehospital personnel who observe a badly damaged automobile or a gunshot wound may have a sense of urgency that would seem to mandate trauma center care, even in the absence of severe injury. In contrast, a person who fell may have no external cues to indicate the force of impact, or may shows minimal external signs of injury. Fall-related injuries, therefore, rep- resent a more “silent” threat to life. Given these findings, there is an opportunity to re-evaluate cur- rent field triage criteria in the context of these existing biases.

An alternate explanation for mechanism-driven triage may be that in the case of MVCs and penetrating trauma, the trauma center was the closest and most logical destination. However, even in LEMSAs with- out trauma centers, undertriage rates remain higher in fall-related injuries. Furthermore, it would be difficult to conceive that fall-related injuries regularly occur at distances to trauma centers in a way different from MVCs or penetrating trauma.

Access to a trauma center care does remain an important contributor to undertriage. A total of 23 per cent of undertriaged patients are injured in LEMSAs without trauma centers, even though only 14 per cent of the severely injured population resides in these re- gions. On average, undertriage rates are 25 to 43 per cent higher for severely injured patients in LEMSAs that do not have trauma centers compared with LEMSAs with trauma centers, depending on mechanism. And similar to LEMSAs that do have trauma centers, the largest proportion of undertriaged injuries is for fall victims. This suggests that while improving access to regions without trauma centers, particular attention should be again focused on the fall victims.

In the United States, fall-related mortality is rising and may soon exceed motor vehicle traffic–related deaths.[16] Improving the triage of severely injured patients of all ages represents an opportunity for improvement. For the younger fall victims, this may simply involve educa- tional opportunities for first responders. For the oldest of fall victims, this could be more complex. With in- creasing age, even low-energy ground falls resulting in minor injuries can be associated with poor outcomes.[17] Furthermore, it may be that treatment at a trauma center does not necessarily improve outcomes for injured elderly patients.[11] What is needed in future research is to determine which elderly patients would benefit from the specialized resources available at trauma centers and work to ensure the triage of this group.

Another opportunity to improve trauma systems would come from reducing high rates of overtriage associated with non-fall mechanisms of injury. Over- triage risks taxing limited trauma center resources. With decreasing rates of MVC-related mortality and severity of injury due in large part to improvements in automobile safety, we will need to re-evaluate predictors of severe injuries based on the limited in- formation available to prehospital providers.[16]

The current study has several limitations. The first is that this represents a retrospective study based on administrative data. Because these are administrative data, we were limited in the amount of clinical data available. Another limitation is that we did not have data on the zip code of injury, so we assumed the zip code of residence to be the same as injury. This was supported by the fact that 84 per cent of injured patients lived in the same LEMSA as the hospital they visited. However, it is likely that patients were injured while far from home and may have been counted in the incorrect LEMSA. Last, because we excluded those who did not have record linkage numbers, our sample is likely to be less representative of the entire population of California, with missing records that are likely to be from populations that are marginally housed or undocumented. However, only way to do a population based study and the number is small.

CONCLUSIONS

In conclusion, triage appears to be strongly associated with mechanism of injury, and the high rates of undertriage seen in California are largely due to the undertriage of fall-related injuries in both younger and older adults. In contrast, there is a tendency to bring almost all MVC and penetrating trauma victims to a trauma center, regardless of injury severity and at the expense of overtriage. These findings suggest an opportunity to address undertriage and improve trauma system performance.

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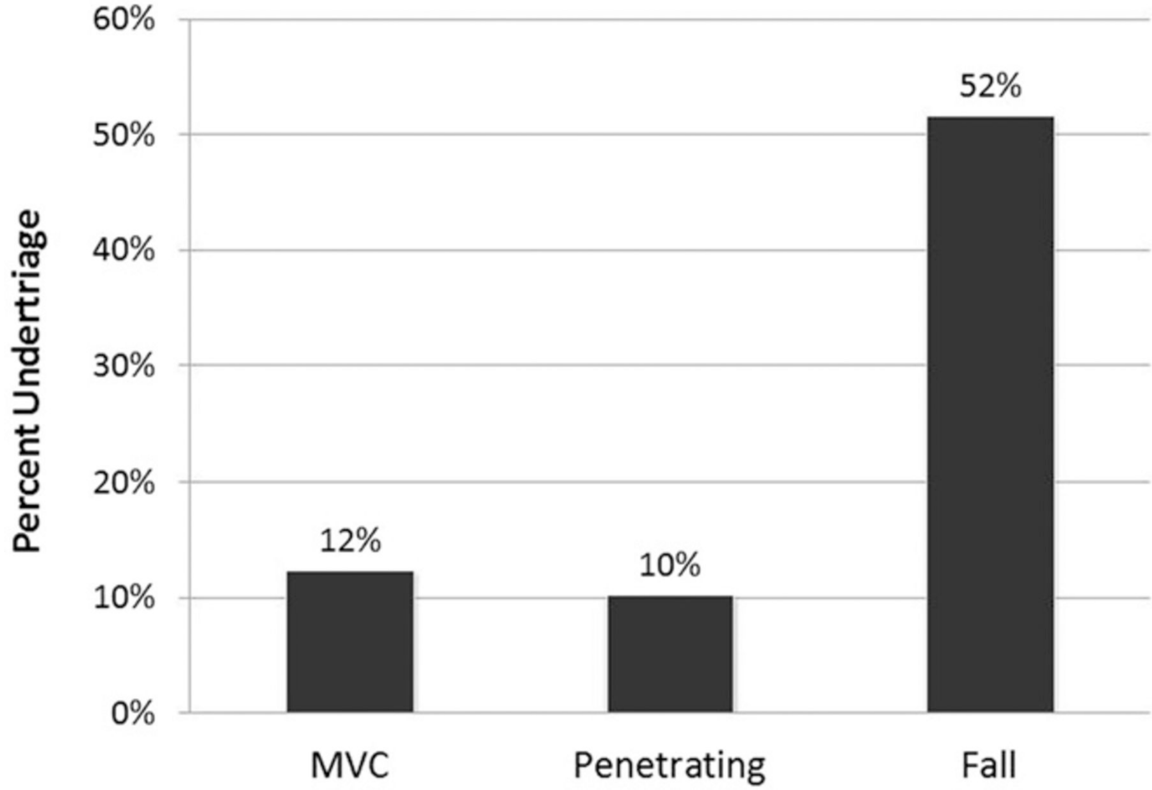

Figure 1.
Undertriage by mechanism and access to trauma center. Undertriage rates for MVCs, penetrating injuries, and falls for all LEMSAs, LEMSAs with trauma centers, and LEMSAs without trauma centers.

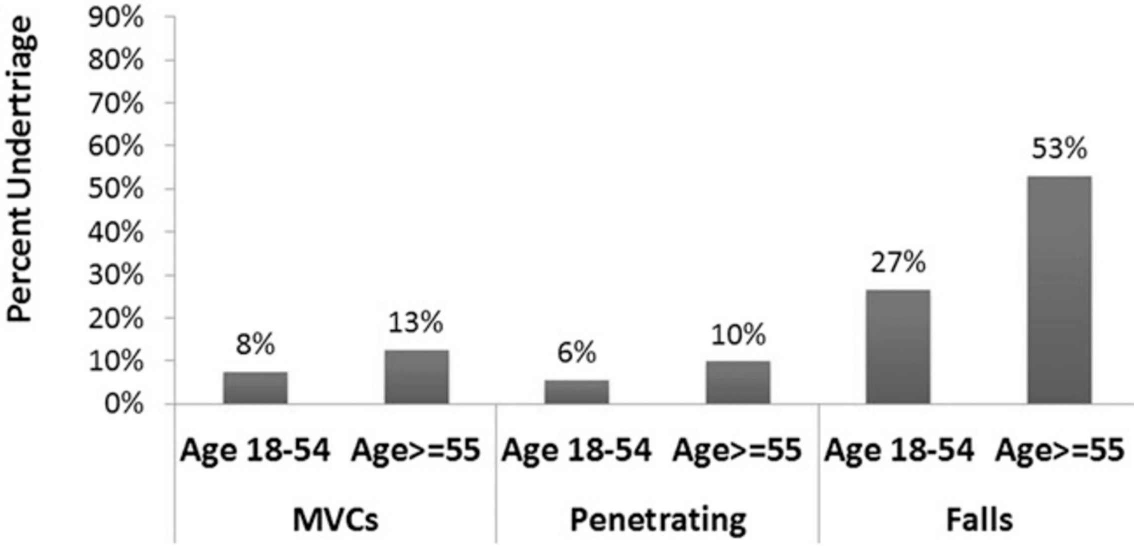

Figure. 2.
Undertriage by mechanism and age in LEMSAs with trauma centers. Shown are undertriage rates for MVCs, penetrating injuries, and falls by age 18 to 54 and age $55.

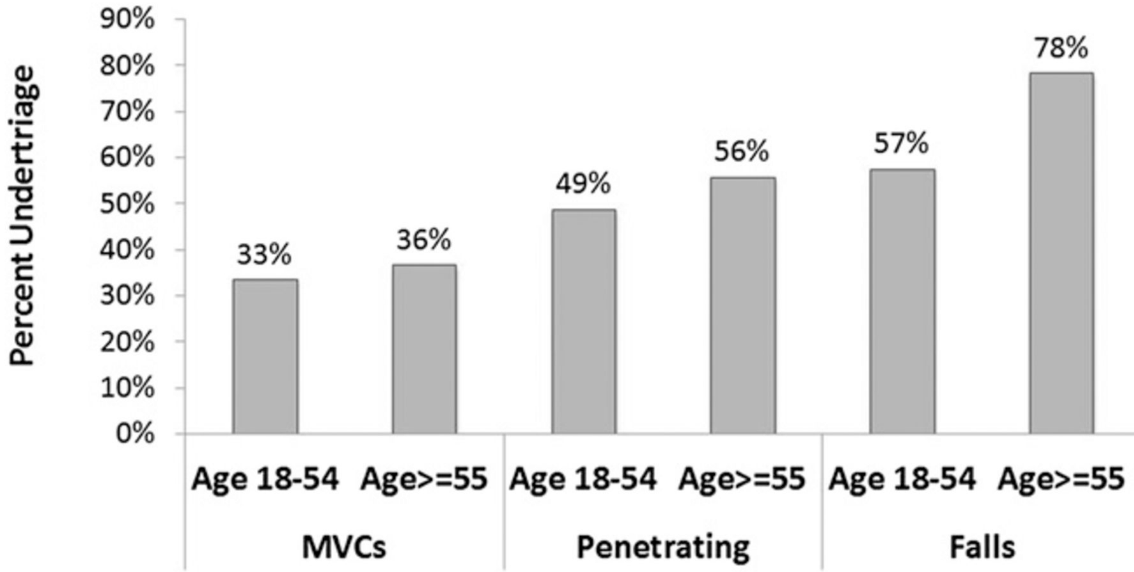

Figure 3.

Undertriage by mechanism and age in LEMSAs without trauma centers. Shown are undertriage rates for MVCs, penetrating injuries, and falls by age 18 to 54 and age $55

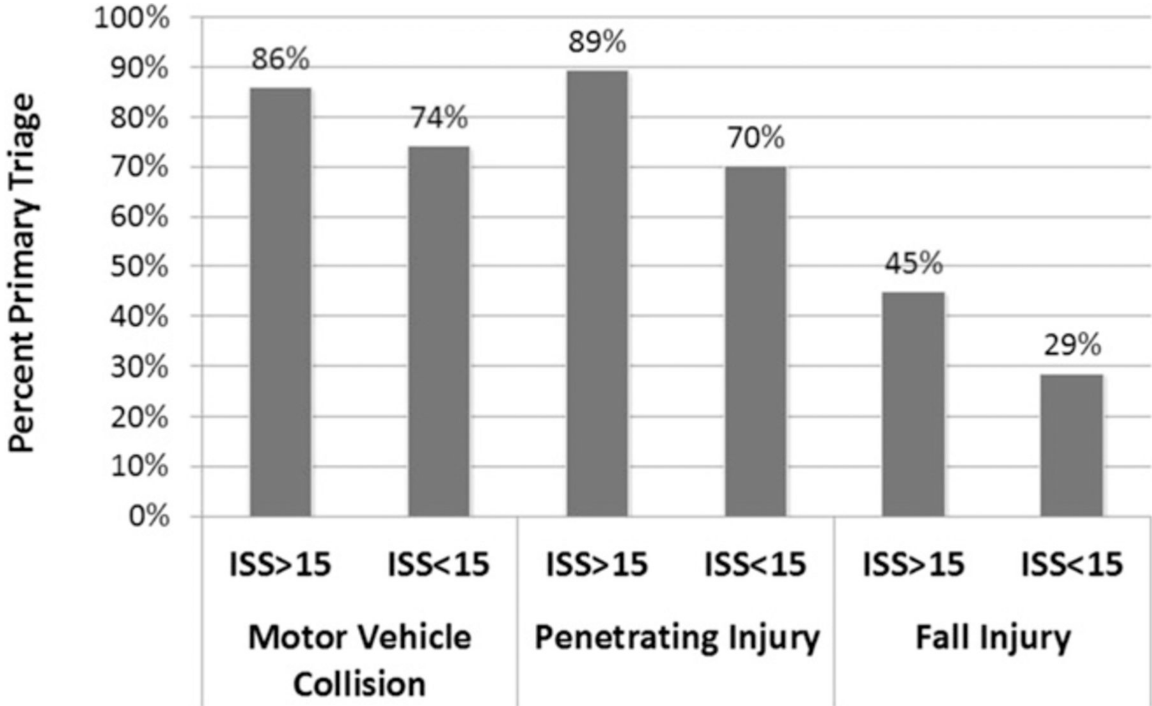

Figure 4.

Percent of patients with minor injuries (ISS < 15) triaged to trauma centers in LEMSAs with trauma centers. Rates of primary triage from the field are shown for motor vehicle collisions, penetrating injuries, and fall injuries by ISS < 15 *versus* ISS > 15.

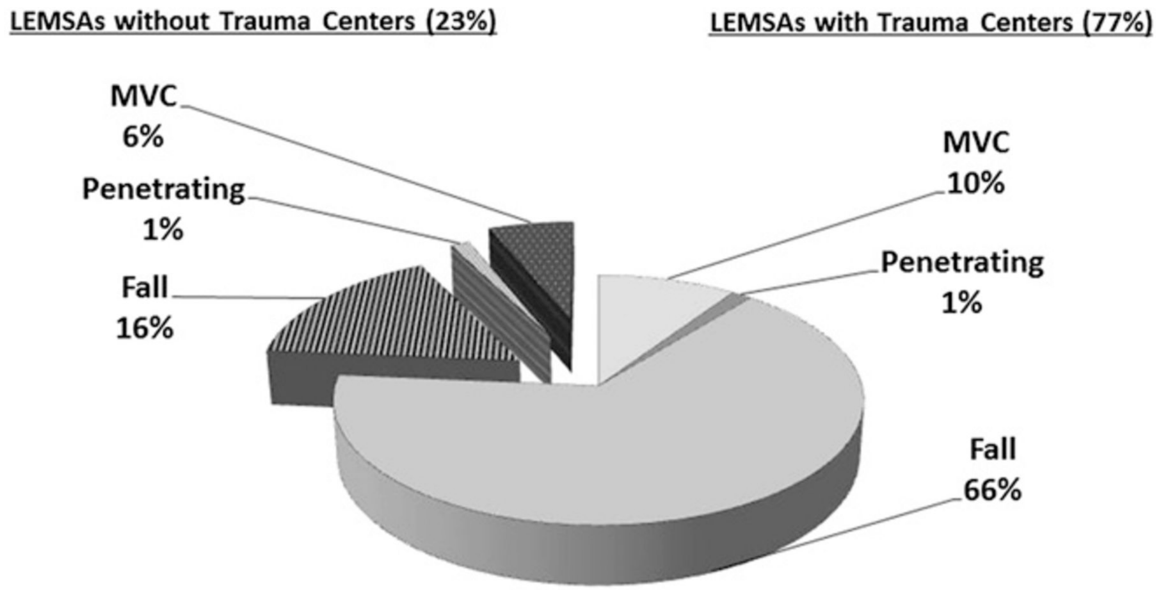

Figure 5.

Distribution of undertriaged patients by mechanism and LEMSAs. Percentages represent the percentage of the undertriaged population

TABLE 1.

Patient Characteristics: Characteristics of all Patients, Young Adults (Age < 55 Years), and Older Adults (Age $ 55 Years). The P Value Represents the Comparison of Age < 55 versus Age > 55 Years

		All Patients	**Age < 55**	**Age $ 55**	***P* Value**
		Number (%) or Mean ± SD	**Number (%) or Mean ± SD**	**Number (%) or Mean ±SD**	
Demographics		60,182 (100.0)	29,020 (48.2)	31,162 (51.8)	
Age	18–24	7,787 (12.9)	7,787 (26.8)	–	NA
	25–34	6,446 (10.7)	6,446 (22.2)	–	
	35–44	6,300 (10.5)	6,300 (21.7)	–	
	45–54	8,487 (14.1)	8,487 (29.3)	–	
	55–65	7,092 (11.8)	–	7,092 (22.8)	
	65–74	6684 (11.1)	–	6,684 (21.5)	
	75–84	9882 (16.4)	–	9,882 (31.7)	
	>84	7504 (12.5)	–	7,504 (24.1)	
Gender	Male	40,100 (66.6)	22,565 (77.8)	17,535 (56.3)	<0.001
	Female	20,082 (33.4)	6,455 (22.2)	13,627 (43.7)	
Race	White	35,745 (59.4)	15,101 (52.0)	20,644 (66.3)	<0.001
	Black	4,410 (7.3)	3,082 (10.6)	1,328 (04.3)	
	Hispanic	12,292 (20.4)	7,764 (26.8)	4,528 (14.5)	
	Asian	4,742 (7.9)	1,415 (4.9)	3,327 (10.7)	
	Other	2,036 (3.4)	1,139 (3.9)	897 (2.9)	
	Unknown	957 (1.6)	519 (1.8)	438 (1.4)	
Payer status	Self-pay	5,340 (8.9)	4,541 (15.7)	799 (2.6)	<0.001
	Medicare	22,941 (38.1)	1,173 (4.0)	21,768 (69.9)	
	Medicaid	7,667 (12.7)	5,973 (20.6)	1,694 (5.4)	
	Comm. insurance/HMO	17,017 (28.3)	11,368 (39.2)	5,649 (18.1)	
Injury characteristics	Other	7,207 (12.0)	5,961 (20.5)	1,246 (4.0)	
	ISS (mean)	20.41 ± 7.67	22.05 ± 8.87	18.88 ± 5.96	<0.001
Injury severity	ISS categories				<0.001
	15–24	49,031 (81.5)	21,584 (74.4)	27,447 (88.1)	
	>25	11,151 (18.5)	7,436 (25.6)	3,715 (11.9)	
Mechanism of injury	Penetrating injury	3,879 (6.5)	3,612 (12.5)	267 (0.9)	<0.001
	Falls	23,125 (38.4)	4190 (14.4)	18,935 (60.8)	
	Any MVC	18,459 (30.7)	13,032 (44.9)	5,427 (17.4)	
	Other	7,077 (11.8)	4,794 (16.5)	2,283 (7.3)	
	Missing	7,642 (12.7)	3,392 (11.7)	4,250 (13.6)	
Outcomes					
Triage pattern	Primary	35,299 (58.7)	21,293 (73.4)	14,006 (45.0)	<0.001
	Secondary	3,342 (5.6)	1,606 (5.5)	1,736 (5.6)	
	No triage to TC	20,988 (34.9)	5,830 (20.1)	15,158 (48.6)	
Mortality	In-hospital death	5,733 (9.5)	1,895 (6.5)	3,838 (12.3)	<0.001

	All Patients	Age < 55	Age $ 55	*P* Value
	Number (%) or Mean ± SD	Number (%) or Mean ± SD	Number (%) or Mean ±SD	
1-year mortality	9125 (19.3)	2,071 (8.8)	7,054 (29.7)	<0.001

Abbreviations: SD, standard deviation; NA, not applicable; Comm. insurance, Commercial insurance; HMO, Health Maintenance Organization; TC, trauma center.