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Patient Choice in the Selection of Hospitals by 9-1-1 Emergency Medical Services Providers in Trauma Systems

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Abstract

Objectives—Reasons for under-triage (transporting seriously injured patients to non-trauma centers) and the apparent lack of benefit of trauma centers among older adults remain unclear; understanding emergency medical services (EMS) provider reasons for selecting certain hospitals in trauma systems may provide insight to these issues. In this study, the authors evaluated reasons cited by EMS providers for selecting specific hospital destinations for injured patients, stratified by age, injury severity, field triage status, and prognosis.

Methods—This was a retrospective cohort study of injured children and adults transported by 61 EMS agencies to 93 hospitals (trauma and non-trauma centers) in five regions of the western United States from 2006 through 2008. Hospital records were probabilistically linked to EMS records using trauma registries, state discharge data, and emergency department (ED) data. The seven standardized reasons cited by EMS providers for selecting hospital destinations included: closest facility, ambulance diversion, physician choice, law enforcement choice, patient or family choice, specialty resource center, and other. “Serious injury” was defined as an Injury Severity Score (ISS) ≥ 16, and unadjusted in-hospital mortality was considered as a marker of prognosis. All analyses were stratified by age in 10-year increments, and descriptive statistics were used to characterize the findings.

Results—A total of 176,981 injured patients were evaluated and transported by EMS over the three-year period, of whom 5,752 (3.3%) had ISS ≥ 16, and 2,773 (1.6%) died. Patient or family choice (50.6%), closest facility (20.7%), and specialty resource center (15.2%) were the most common reasons indicated by EMS providers for selecting destination hospitals; these frequencies

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varied substantially by patient age. The frequency of patient or family choice increased with increasing age, from 36.4% among 21 to 30 year olds to 75.8% among those older than 90 years. This trend paralleled under-triage rates, and persisted when restricted to patients with serious injuries. Older patients with the worst prognoses were preferentially transported to major trauma centers, a finding that was not explained by field triage protocols.

Conclusions—Emergency medical services transport patterns among injured patients are not random, even after accounting for field triage protocols. The selection of hospitals appears to be heavily influenced by patient or family choice, which increases with patient age, and involves inherent differences in patient prognosis.

INTRODUCTION

A key aspect of regionalized trauma care is concentrating seriously injured patients in major trauma centers to maximize health outcomes. Because most seriously injured patients access acute trauma care through 9-1-1 emergency medical services (EMS), optimizing field triage has been a crucial aspect of concentrating high-need patients in the hospitals most capable of caring for them. Since 1987, the process of field triage has been guided by the Field Triage Decision Scheme, an algorithmic national guideline for identifying seriously injured patients in the prehospital setting.[1-3] Patients not meeting the triage guidelines for transport to major trauma centers are assumed to be transported to non-trauma hospitals. However, factors affecting the actual distribution of injured patients among hospitals in trauma systems remain poorly understood. Because trauma systems serve as the model for regionalized health care, understanding factors driving the distribution of injured patients transported by EMS has important implications for improving the efficiency of other regionalized care systems.

Two key issues in trauma systems related to the distribution of injured patients remain poorly understood: 1) the high rate of under-triage (seriously injured patients transported to non-trauma hospitals) among older adults,[4-9] and 2) the lack of demonstrated outcome benefit of care in major trauma centers among seriously injured older adults.[10] Whether these issues are inter-related remains unknown, although it is plausible they are tied to other out-of-hospital factors affecting the selection of hospitals. With an aging U.S. population, understanding these issues and determining the ideal location of care for injured older adults are critically important. If factors other than field triage protocols are important in directing the regional distribution of injured patients in trauma systems (especially older adults), such findings may help explain under-triage and the role of trauma centers in caring for an ageing population.

We hypothesized that older patients have strong preferences in directing EMS transport to specific hospitals following injury, even in the setting of prehospital field triage protocols. To test this hypothesis and further assess EMS transport patterns, we evaluated reasons cited by EMS providers for selecting specific hospital destinations among injured patients transported by 61 EMS agencies to 93 hospitals. We stratified the analysis by age, injury severity, field triage status, and prognosis. This study expands on a previous single-site study that evaluated EMS provider cognitive processing during field triage, and the selection of hospital destinations for injured patients.[11]

METHODS

Study Design

This was a multi-region, population-based, retrospective cohort study. Eleven institutional review boards at five sites approved this protocol and waived the requirement for informed consent.

Study Setting and Population

The study included injured children and adults evaluated and transported by 61 EMS agencies to 93 hospitals, including 10 Level I, 6 Level II, and 77 community/private/federal hospitals in five regions across the western United States between January 1, 2006 and December 31, 2008. The regions included: 1) Portland, OR/Vancouver, WA (four counties); 2) Sacramento, CA (two counties); 3) San Francisco, CA; 4) Santa Clara, CA (two counties); 5) and Salt Lake City, UT (four counties). These sites are part of the Western Emergency Services Translational Research Network (WESTRN), a consortium of geographic regions, EMS agencies, and hospitals linked through Clinical and Translational Science Award centers. Regions were selected for this study based on standardized EMS documentation of reasons for hospital selection in their patient care reports. Each site represents a pre-defined geographic "footprint" consisting of a central metropolitan area and surrounding region (urban, suburban, and some rural areas), defined by EMS agency service areas. All sites have mature trauma systems and use a variety of EMS system structures and response types (e.g., dual advanced life support response, tiered basic-advanced life support response). For injured patients evaluated by EMS providers at these sites, there is an initial decision of whether an injured patient meets field trauma triage criteria (a field "trauma activation") using standardized triage protocols based on the Field Triage Decision Scheme.[2,3] A field trauma activation generally triggers transport to a major trauma center (Level I or II hospital).

The study sample included all injured patients for whom the 9-1-1 EMS system was activated within the five predefined geographic regions with transport to an acute care hospital (trauma centers and non-trauma centers). Injured patients were identified based on an EMS provider primary impression of "injury" or "trauma" recorded in the prehospital patient report. Specifying the sample in this manner allowed for a broad, population-based, out-of-hospital injury cohort served by EMS providers in multiple trauma systems. We excluded patients transferred between hospitals without initial presentations involving EMS, EMS runs without patient contact (e.g., "cancelled," "no patient found," "stand-by"), and patients who were not transported (e.g., deaths in the field, refusals of transport).

Study Protocol

The primary variables of interest were EMS provider-cited reasons for selecting specific hospital destinations, and patient age. Reasons for selecting hospital destinations were systematically captured in the participating sites using categories specified in the National EMS Information System.[12] Reasons included closest facility, ambulance diversion, physician choice (e.g., patient's physician choice, direct medical oversight), law enforcement choice, patient or family choice, specialty resource center, and other (e.g., health maintenance organization, protocol). While some EMS agencies separated "patient choice" and "family choice," other agencies did not, so they were combined for purposes of this analysis. Similarly, the categories for direct medical oversight and patient's physician choice were combined because many agencies considered these reasons a single "physician choice" category.

We also captured field trauma activation status, a dichotomous measure of patients meeting field trauma triage criteria as determined by EMS providers. Because relying exclusively on EMS charts to ascertain field triage status can underestimate the proportion of field trauma activations (e.g., due to missing data and differing terminology between systems), we triangulated multiple data sources to minimize misclassification bias. We identified field trauma activations by the presence of any of the following: field trauma triage criteria specified in the EMS chart: EMS provider documented "trauma activation" (or similar charting, depending on local terminology), EMS-recorded trauma identification number

(used at some sites as a mechanism for tracking injured patients entered into the trauma system), a matched record from the local trauma registry specifying "scene" origin (i.e., EMS-identified trauma patient), and matched trauma communication telephone records from local base hospitals (a requirement in some sites specifying that EMS providers call ahead to the Level I hospital before transporting a trauma activation patient). All other patients were considered trauma triage-negative. The presence of triage criteria was considered independent of transport destination. We also captured hospital destinations, with categorization of acute care hospitals as tertiary trauma centers (Level I or II trauma hospitals) based on their American College of Surgeons accreditation status and state-level designations.

We tracked transport mode (air vs. ground), Injury Severity Score (ISS), and in-hospital mortality. We defined "serious injury" as an ISS ≥ 16 based on the American College of Surgeons Committee on Trauma (ACS-COT) definition for trauma systems[2] and the definition most consistently used to demonstrate the benefit of trauma center care.[10,13-17] We defined under-triage using the ACS-COT definition of patients with ISS ≥ 16 transported to non-trauma centers.[2] We considered unadjusted in-hospital mortality as a measure of prognosis, rather than a primary patient outcome. While adjusted mortality is commonly used as an outcome measure in observational trauma research, unadjusted mortality reflects a combination of prognostic factors (e.g., injury severity, comorbidities, age, physiologic compromise, and overall clinical acuity). In this study, we used crude mortality as a global measure of acuity and prognosis for patients transported to different types of hospitals.

We matched hospital records (required for calculating injury severity, and mortality) to EMS records using probabilistic linkage (LinkSolv v8.2, Strategic Matching, Inc., Morrisonville, NY). Record linkage methodology has been used to link EMS data to hospital records in previous studies,[18] has been validated for matching ambulance records to trauma registry data,[19] and was rigorously evaluated in this database.[20] Sources of electronic hospital records included local trauma registries, state hospital discharge databases, and state emergency department databases. To calculate ISS, we used a mapping function (ICDPIC, Stata v. 11, StataCorp, College Station, TX) that converts ICD9-CM diagnosis codes to ISS values.[21] The use of mapping software to convert administrative diagnosis codes to anatomic injury scores has been validated in previous studies[22,23] and we have validated ICDPIC-generated ISS against chart-abstracted ISS in this database.[24]

Data Analysis

We used descriptive statistics to characterize the sample and evaluate EMS reasons for selecting different hospitals. We stratified all analyses by patient age in 10-year increments. Additional strata included field trauma activation status and serious injury (ISS ≥ 16). To preserve the population-based sampling design and minimize bias in the analysis, we used multiple imputation[25] to handle missing values. We have demonstrated the validity of multiple imputation for imputing missing out-of-hospital values and trauma data under a variety of conditions,[26,27] and have thoroughly evaluated the use and benefit of multiple imputation in this sample.[20] We used flexible chains regression models for multiple imputation (IVEware, Survey Methodology Program, Survey Research Center, Institute for Social Research, University of Michigan, MI)[28] with generation of 10 multiply imputed datasets, each analyzed independently and combined using Rubin's rules to appropriately account for variance within and between datasets.[25] In the context of multiple imputation, flexible chains regression refers to the sequenced use of varying multivariable regression models (e.g., logistic, linear, mixed) to impute missing values for each variable,[28] rather than building a large framework of observed values to impute missing data (e.g., Markov

chain, Monte Carlo simulations). We managed the database and conducted descriptive analyses using SAS (v 9.2, SAS Institute, Cary, NC).

RESULTS

There were 176,981 injured patients evaluated and transported by EMS to acute care hospitals over the three-year period, of whom 38,924 (22.0%) were field trauma activations, 5,752 (3.3%) were seriously injured, and 2,773 (1.6%) died during their hospital stays. One thousand six hundred thirteen (28.0%) patients with ISS ≥ 16 were under-triaged to non-trauma centers. The most common reasons cited by EMS providers for selecting specific hospitals were: patient or family choice (50.6%), closest facility (20.7%), and specialty resource center (15.2%). Characteristics of the study sample and reasons for selecting transport destinations are described in Table 1.

The reasons cited by EMS providers for selecting different hospitals varied substantially by patient age (Figure 1). The proportion of transports cited as patient or family choice by EMS providers increased steadily with increasing patient age older than 30 years, reaching 75.8% for injured patients older than 90 years (Figure 1A). The percentage of under-triaged patients closely paralleled the proportion of transports citing patient or family choice as the reason for selecting a hospital destination. Findings were similar when the sample was restricted to seriously injured patients (ISS ≥ 16) (Figure 1B). Among seriously injured patients under-triaged to non-trauma centers (n = 1,613), patient or family choice was commonly cited, increasing from a low of 31% among 21 to 30 year olds, to 73% among patients over 90 years (Figure 1B).

Figure 2 details age-specific mortality rates by transport destination (major trauma center vs. non-trauma center). Mortality rates rose with increasing age, especially among patients older than 60 years (Figure 2A). Mortality rates were consistently higher among patients transported to major trauma centers. This finding was more pronounced when the sample was restricted to seriously injured patients, and was most evident among persons older than 70 years (Figure 2B). The proportion of patients transported to major trauma centers steadily decreased after 60 years; this was evident both for the full sample and among seriously injured patients. Age-specific mortality rates calculated based on field trauma activation status (rather than by transport destination) closely followed the curves based on destination hospital and were omitted for clarity (data not shown).

Finally, we compared the characteristics of seriously injured older adults (patients over 60 years with ISS ≥ 16) transported to a hospital destination based on patient or family choice vs. other reasons (Table 2). Seriously injured older adults choosing a specific hospital were older, predominantly female, commonly injured from falls (78.6% vs. 52.2%), and with little physiologic compromise in the field. The patient or family choice group also tended to be transported to non-trauma centers (63.0% vs. 24.2%), have less severe injuries (ISS ≥ 25: 19.4% vs. 30.4%), and lower unadjusted mortality (6.9% vs. 18.6%). Hospital interventions also differed between these groups, with the patient/family choice group having a higher proportion of orthopedic surgeries (46.4% vs. 24.6%), and lower proportion of other major surgeries (13.2% vs. 24.5%).

DISCUSSION

In this study, we demonstrate that the process of selecting hospitals by EMS providers in trauma systems is affected by several factors other than field triage protocols. In particular, we found patient/family choice to be a leading reason cited by EMS providers for selecting certain hospitals, especially among older patients. When restricted to patients ultimately

found to have serious injuries who were transported to non-trauma centers (under-triage), patient/family choice was commonly cited as the reason for hospital selection (60.3%). These findings demonstrate the importance of patient choice in directing EMS transport decisions in trauma systems, and illustrate how such non-clinical factors can affect the distribution of injured patients among hospitals. Our results also offer insight into understanding two perplexing issues affecting trauma systems: under-triage, and the lack of demonstrated benefit of trauma centers among older adults.

Previous research has detailed the importance of patient choice in selecting hospitals for their care,[29-32] although little research has focused on the role of patient choice in emergency care settings. For elective admissions, patient experience with a hospital was shown to be a primary factor in selecting a subsequent hospital for care,[29,30] with patients trusting their own experience more than other factors in this selection process.[29] Other research has demonstrated that older patients and those with “good or very good” health were more likely to choose the hospitals where they were last treated.[31] A single-site EMS study of injured patients found that field providers initially focus on field trauma triage status, then typically ask patients where they would like to be transported for those not meeting triage criteria, with patient choice being a common reason for selecting hospital destinations.[11] The current study expands on previous research by further exploring the role of patient choice in selecting hospitals by EMS in multiple trauma systems. Our findings suggest that patients with high-acuity clinical conditions still value choice in selecting locations for care, particularly among older adults.

Although our data do not explain why patient choice increases with increasing age, there are potential reasons for this finding. With increasing age comes an increased burden of ill health and a generally unavoidable increase in experience with health care services. This increased experience likely informs opinions about different health care facilities regarding the perceived quality of care, insurance and costs of care, travel distance, familiarity, and ease of access. The increased use of and experience with health care resources may ultimately drive the establishment of a default single hospital “medical home” among older patients. If true, selecting the same hospital for future medical care (including EMS transports) would be sensible. If our findings are replicated among patients with other high-acuity clinical conditions (e.g. stroke, ST-elevation myocardial infarction), patient choice may represent a factor preventing fully regionalized care systems, and be an important consideration in optimizing the efficiency of health care delivery systems.

The finding that more severely injured patients with inherently worse prognoses are transported to major trauma centers seems intuitive. The use of field triage protocols is a deliberate feature of trauma systems designed to concentrate the most seriously injured patients in major trauma centers. However, because under-triage is greatest among older adults, one would expect the prognostic gap between trauma and non-trauma hospitals to narrow in this age group (i.e., less concentration of older patients with the worst prognoses in trauma centers). Rather, our results show that this gap actually widens with increasing age, even after accounting for injury severity. This finding suggests that factors other than field triage (e.g., patient choice) are related to both underlying prognosis and hospital selection, thus representing key confounders when comparing hospital-level outcomes. Because seriously injured (ISS ≥ 16) older patients listed as “patient/family choice” for destination reason tended to have less physiologic compromise, less severe injuries, and less transport to major trauma centers, the net result was non-trauma hospitals receiving seriously injured patients with inherently better prognosis. Ringard et al. demonstrated similar findings, with older, healthier patients tending to select specific hospitals for their care.[31] Such age-based selection bias combined with the inability of commonly measured variables to fully account for these prognostic differences may help explain the lack of

measureable benefit of major trauma centers for older adults that exists for younger patients.[10]

There are several policy implications from this study. First, patient choice and established hospital preferences should be considered in the development of regionalized care systems. Second, the lack of demonstrable outcome benefit among seriously injured older adults treated in major trauma centers should not be interpreted as evidence that care is equivalent for all such patients in non-trauma hospitals. Teasing out the most appropriate hospitals to care for older adults may depend on many factors, including comorbidity burden, medical fragility, and clinical complexity. Complicated patients with life-threatening injuries will continue to require the highest level of care available. However, there may be a portion of injured older adults who have equivalent outcomes at non-trauma hospitals. Furthermore, the traditional definition of "seriously injured" (ISS ≥ 16) used to evaluate trauma systems may be less appropriate for older adults; some older adults with lower ISS values may require the resources of major trauma centers, while others with higher ISS may do well in non-trauma hospitals. National field triage guidelines and related trauma system policy would benefit from research defining which older patients are most likely to benefit from care in major trauma centers.

LIMITATIONS

With the retrospective study design, it is possible there were other reasons that EMS providers selected certain hospitals beyond what was recorded in the "reason for destination selection" term. Also, because the reason for selecting a hospital is completed by EMS providers, it is unclear whether cited reasons would be the same if completed by patients. It is also possible that different EMS providers selected these reasons differently. Furthermore, our data do not allow assessment of misclassification bias (e.g., patient requests a certain tertiary care hospital, but is charted by the EMS provider as "specialty resource center"). The robustness of our findings would be enhanced if replicated in studies with other EMS systems and including patients with non-injury conditions.

For some patients, data were missing regarding EMS provider reason for selecting a particular hospital and hospital measures (injury severity and mortality). Rather than excluding such patients, we used multiple imputation to handle missing values. Multiple imputation has been shown to reduce bias compared to complete-case analysis,[26,27,33-36] and has been validated in studies using EMS and trauma data.[20,26,27] However, it is possible that the results would have been different if there were no missing data.

This study was not designed to analyze the benefit of trauma center care among older adults. Rather, our results provide insight into some of the difficulties of demonstrating the potential benefit of trauma center care across all age groups. Future studies seeking to measure the hospital-level effect on outcomes among older adults should consider accounting for patient choice in selecting specific hospitals. Finally, while our findings provide additional insight into under-triage and the apparent lack of trauma center benefit among older adults, both of these topics are complex and are likely affected by many factors. Our results are hypothesis-generating and will require additional research to further understand.

CONCLUSIONS

Emergency medical service transport patterns for injured patients are heavily influenced by patient choice, especially among older adults, a finding that persists even after accounting for injury severity. Also, patient prognosis differed based on the type of hospital to which they were transported and the reason for selecting a hospital, again most notable among

older adults. These findings offer insight into the factors affecting the distribution of patients in trauma systems, challenges in demonstrating the potential benefit of trauma centers among older adults, and the increased rate of under-triage in this population.

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References

1. Mackersie RC. History of trauma field triage development and the American College of Surgeons criteria. Prehosp Emerg Care. 2006; 10:287–94. [PubMed: 16801263]
2. American College of Surgeons. Resources for the Optimal Care of the Injured Patient. Chicago, IL: American College of Surgeons; 2006.
3. Centers for Disease Control and Prevention. Guidelines for field triage of injured patients: recommendations of the national expert panel on field triage. MMWR Morbid Mortal Wkly Rep. 2009; 58:1–35.
4. Hsia RY, Wang E, Torres H, Saynina O, Wise PH. Disparities in trauma center access despite increasing utilization: data from California, 1999 to 2006. J Trauma. 2010; 68:217–24. [PubMed: 19901854]
5. Vassar MJ, Holcroft JJ, Knudson MM, Kizer KW. Fractures in access to and assessment of trauma systems. J Am Coll Surg. 2003; 197:717–25. [PubMed: 14585404]
6. Newgard CD, Zive D, Holmes JF, et al. A multi-site assessment of the ACSCOT field triage decision scheme for identifying seriously injured children and adults. J Am Coll Surg. 2011; 213:709–21. [PubMed: 22107917]
7. Nakamura Y, Daya M, Bulger EM, et al. Evaluating age in the field triage of injured persons. Ann Emerg Med. 2012; 60:335–45. [PubMed: 22633339]
8. Chang DC, Bass RR, Cornwell EE, Mackenzie EJ. Undertriage of elderly trauma patients to state-designated trauma centers. Arch Surg. 2008; 143(8):776–81. [PubMed: 18711038]
9. Baez AA, Lane PL, Sorondo B. System compliance with out-of-hospital trauma triage criteria. J Trauma. 2003; 54:344–51. [PubMed: 12579063]
10. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of traumacenter care on mortality. New Engl J Med. 2006; 354:366–78. [PubMed: 16436768]
11. Newgard CD, Nelson MJ, Kampp M, et al. Out-of-hospital decision-making and factors influencing the regional distribution of injured patients in a trauma system. J Trauma. 2011; 70:1345–53. [PubMed: 21817971]
12. National Emergency Medical Services Information System Data Dictionary. NHTSA Version 3.30, Build 121121. EMS Data Standard. Office of Emergency Medical Services, National Highway Traffic Safety Administration; Available at: http://www.nemsis.org/v3/downloads/datasetDictionaries.html [Jul 9, 2013]
13. Mullins RJ, Veum-Stone J, Helfand M, et al. Outcome of hospitalized injured patients after institution of a trauma system in an urban area. JAMA. 1994; 271:1919–24. [PubMed: 8201736]
14. Mullins RJ, Veum-Stone J, Hedges JR, et al. Influence of a statewide trauma system on location of hospitalization and outcome of injured patients. J Trauma. 1996; 40:536–45. [PubMed: 8614030]
15. Mullins RJ, Mann NC. Population-based research assessing the effectiveness of trauma systems. J Trauma. 1999; 47(3 Suppl):S59–66. [PubMed: 10496613]

16. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. J Trauma. 1999; 47(3 Suppl):S46–55. [PubMed: 10496611]

17. Hulka F, Mullins RJ, Mann NC, et al. Influence of a statewide trauma system on pediatric hospitalization and outcome. J Trauma. 1997; 42:514–9. [PubMed: 9095120]

18. Dean JM, Vernon DD, Cook L, Nechodom P, Reading J, Suruda A. Probabilistic linkage of computerized ambulance and inpatient hospital discharge records: a potential tool for evaluation of emergency medical services. Ann Emerg Med. 2001; 37:616–26. [PubMed: 11385330]

19. Newgard CD. Validation of probabilistic linkage to match de-identified ambulance records to a state trauma registry. Acad Emerg Med. 2006; 13:69–75. [PubMed: 16365326]

20. Newgard CD, Malveau S, Staudenmayer K, et al. Evaluating the use of existing data sources, probabilistic linkage and multiple imputation to build population-based injury databases across phases of trauma care. Acad Emerg Med. 2012; 19:469–80. [PubMed: 22506952]

21. Clark, DE.; Osler, TM.; Hahn, DR. ICDPIC: Stata Module to Provide Methods for Translating International Classification of Diseases (Ninth Revision) Diagnosis Codes into Standard Injury Categories and/or Scores. Boston, MA: Boston College, Department of Economics; 2009.

22. MacKenzie EJ, Steinwachs DM, Shankar BS, Turney SZ. An ICD-9CM to AIS conversion table: development and application. Proc AAAM. 1986; 30:135–51.

23. MacKenzie EJ, Steinwachs DM, Shankar B. Classifying trauma severity based on hospital discharge diagnoses. Validation of an ICD-9CM to AIS-85 conversion table. Med Care. 1989; 27:412–22. [PubMed: 2649755]

24. Fleischman RJ, Mann NC, Wang NE, et al. Validating the use of ICD9 codes to generate injury severity score: the ICDPIC mapping procedure. Acad Emerg Med. 2012; 19(Suppl 1):S596. abstract.

25. Rubin, DB. Multiple Imputation for Nonresponse in Surveys. New York, NY: John Wiley & Sons, Inc; 1987.

26. Newgard CD. The validity of using multiple imputation for missing prehospital data in a state trauma registry. Acad Emerg Med. 2006; 13:314–24. [PubMed: 16495420]

27. Newgard CD, Haukoos J. Missing data in clinical research – part 2: multiple imputation. Acad Emerg Med. 2007; 14:669–78. [PubMed: 17595237]

28. Raghunathan T, Lepkowski, Van Hoewyk J, Solenberger P. A multivariate technique for multiply imputing missing values using a sequence of regression models. Survey Method. 2001; 27:85–95.

29. Leister J, Stausberg J. Why do patients select a hospital? A conjoint analysis in two German hospitals. J Hosp Market Public Relations. 2007; 17:13–31.

30. Jun K, Feldman R, Scanlon D. Where would you go for your next hospitalization? J Health Econ. 2011; 30:832–41. [PubMed: 21665300]

31. Ringard Á. Equitable access to elective hospital services: the introduction of patient choice in a decentralized healthcare system. Scand J Public Health. 2012; 40:10–17. [PubMed: 21948995]

32. De Groot IB, Otten W, Dijs-Elsinga J, Smeets HJ, Kievit J, Marang-van de Mheen PJ. Choosing between hospitals: the influence of the experiences of other patients. Med Decis Making. 2012; 32(6):764–78. [PubMed: 22546750]

33. Van Der Heijden GJMG, Donders ART, Stijnen T, Moons KGM. Imputation of missing values is superior to complete case analysis and the missing-indicator method in multivariable diagnostic research: a clinical example. J Clin Epid. 2006; 59:1102–9.

34. Crawford SL, Tennstedt SL, McKinlay JB. A comparison of analytic methods for non-random missingness of outcome data. J Clin Epidemiol. 1995; 48:209–19. [PubMed: 7869067]

35. Joseph L, Belisle P, Tamim H, Sampalis JS. Selection bias found in interpreting analyses with missing data for the prehospital index for trauma. J Clin Epidemiol. 2004; 57:147–53. [PubMed: 15125624]

36. Greenland S, Finkle WD. A critical look at methods for handling missing covariates in epidemiologic regression analyses. Am J Epidemiol. 1995; 142:1255–64. [PubMed: 7503045]

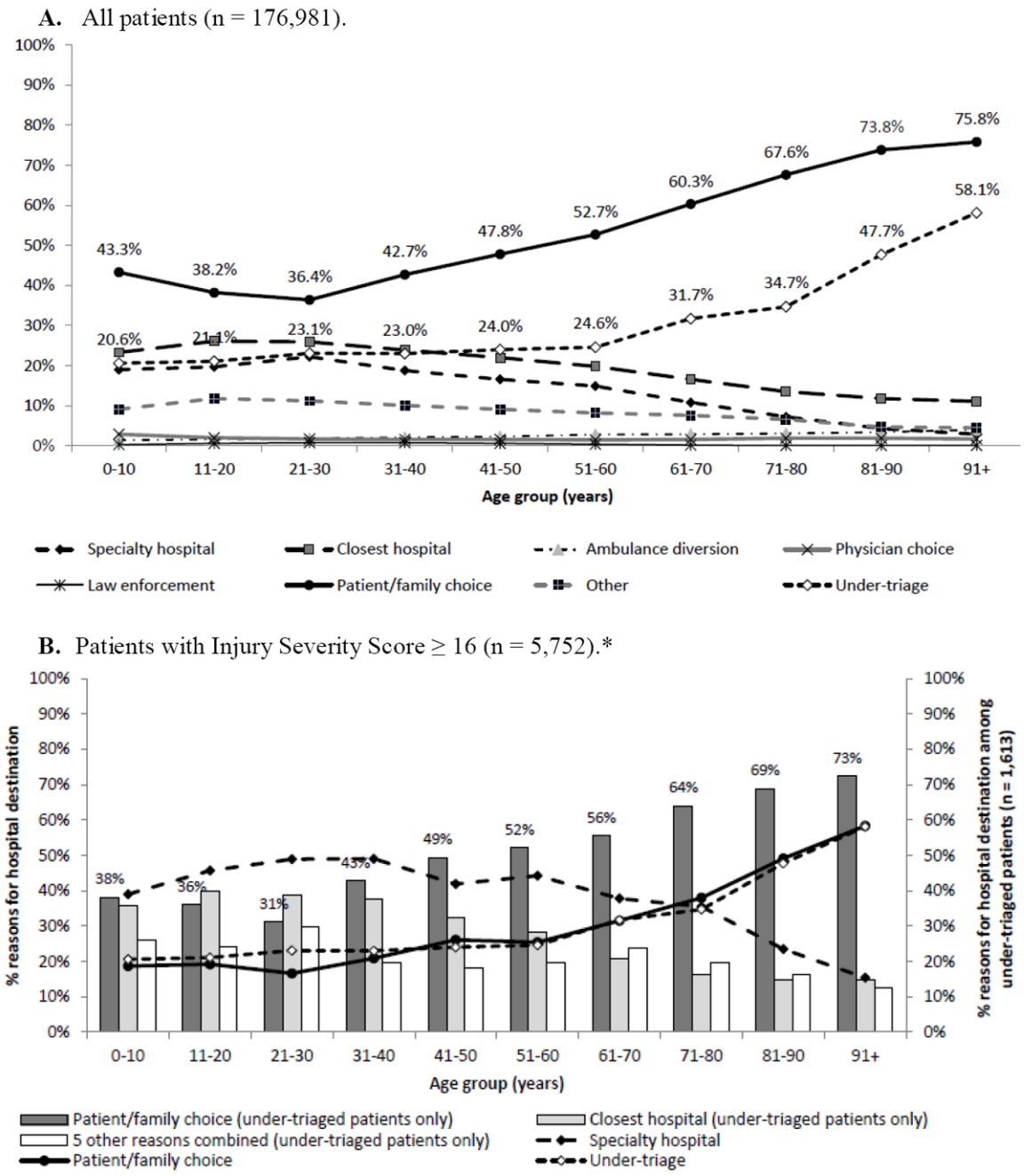

Figure 1.

Reasons for hospital selection by EMS providers and under-triage, by age group.

*For Figure 1B, trend lines are plotted on the primary y-axis for patient/family choice, specialty hospital and under-triage (proportion of seriously injured patients transported to non-Level I/II hospitals) for all patients with ISS ≥ 16 (n = 5,752). The secondary y-axis represents the primary reasons for hospital destination selection when restricted to under-triaged patients (n = 1,613).

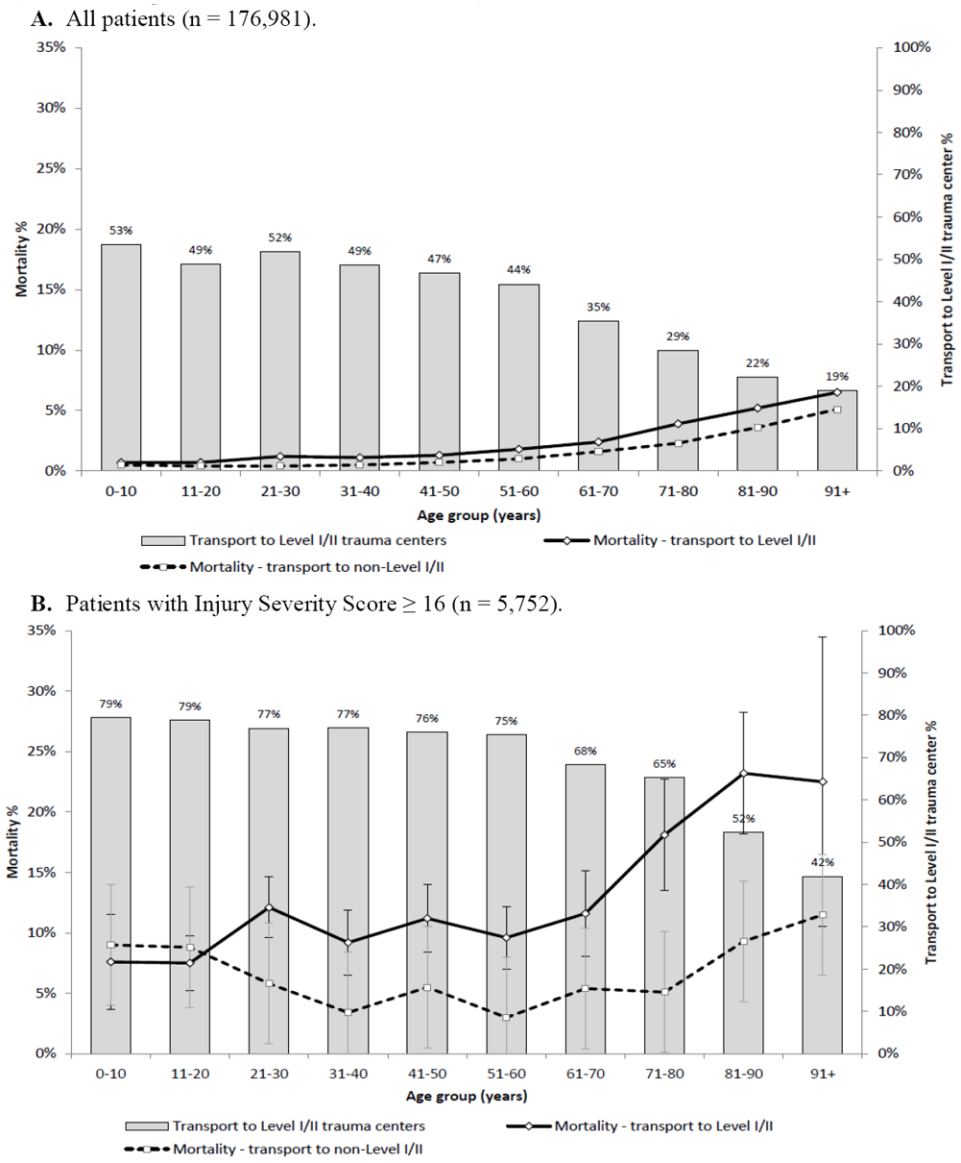

Figure 2.

In-hospital mortality and EMS transport patterns.

*There are 95% confidence limits around each mortality estimate for each age group, separated by transport destination (Level I/II vs. non-Level I/II hospital).

Table 1

Characteristics of injured patients transported by EMS, including EMS provider reasons for selecting hospital destinations.*

Characteristic	All patients	Patients transported to Level I/II trauma centers	Patients transported to non-trauma hospitals	Seriously injured (ISS ≥ 16)
	n = 176,981	n = 74,796	n = 102,185	n = 5,752
Reasons for selecting hospital destinations:				
Patient/family choice	89,464 (50.6)	27,827 (37.2)	61,636 (60.3)	1,563 (27.2)
Closest facility	36,660 (20.7)	13,155 (17.6)	23,506 (23.0)	1,013 (17.6)
Specialty center	26,837 (15.2)	26,446 (35.4)	392 (0.4)	2,368 (41.2)
Ambulance diversion	4,240 (2.4)	1,378 (1.8)	2,862 (2.8)	111 (1.9)
Physician choice	3,153 (1.8)	1,324 (1.8)	1,830 (1.8)	202 (3.5)
Law enforcement	857 (0.5)	330 (0.4)	528 (0.5)	36 (0.6)
Other	15,769 (8.9)	4,337 (5.8)	11,432 (11.2)	460 (8.0)
Demographics:				
< 18 years	22,468 (12.7)	11,086 (14.8)	11,382 (11.1)	622 (10.8)
18 – 54 years	91,870 (51.9)	45,208 (60.4)	46,662 (45.7)	3,041 (52.9)
≥ 55 years	62,643 (35.4)	18,502 (24.7)	44,141 (43.2)	2,090 (36.3)
Women	87,276 (49.3)	30,651 (41.0)	56,625 (55.4)	2,067 (35.9)
Out-of-hospital physiology, procedures and transport:				
sBP < 90 mmHg	4,227 (2.4)	2,249 (3.0)	1,979 (1.9)	420 (7.3)
GCS – mean	14.4	14.2	14.5	12.7
GCS ≤ 8 (%)	3,576 (2.0)	2,101 (2.8)	1,475 (1.4)	806 (14.0)
Intubation attempt	910 (0.5)	709 (1.0)	202 (0.2)	385 (6.7)
Intravenous line placement	69,223 (39.1)	38,870 (52.0)	30,353 (29.7)	3,638 (63.2)
Helicopter transport	904 (0.5)	904 (1.2)	0 (0)	127 (2.2)
Mechanism of injury:				
Gunshot wound	1,960 (1.1)	1,341 (1.8)	619 (0.6)	131 (2.3)
Stabbing	2,567 (1.5)	2,049 (2.7)	518 (0.5)	86 (1.5)
Assault	8,950 (5.1)	4,941 (6.6)	4,010 (3.9)	140 (2.4)
Fall	69,031 (39.0)	21,564 (28.8)	47,466 (46.5)	2,088 (36.3)
Motor vehicle crash	59,320 (33.5)	28,667 (38.3)	30,653 (30.0)	2,361 (41.0)
Pedestrian or bicycle	5,954 (3.4)	3,841 (5.1)	2,113 (2.1)	266 (4.6)
Other (%)	29,199 (16.5)	12,393 (16.6)	16,807 (16.5)	681 (11.8)
Hospital measures:				
Level I/II	74,796 (42.3)	74,796 (100.0)	0 (0)	4,140 (72.0)
ISS 0 – 8	156,031 (88.2)	63,149 (84.4)	92,882 (90.9)	0 (0)
ISS 9 – 15	15,197 (8.6)	7,508 (10.0)	7,690 (7.5)	0 (0)
ISS >= 16	5,752 (3.3)	4,140 (5.5)	1,613 (1.6)	5,752 (100)
Major non-orthopedic surgery	6,963 (3.9)	4,144 (5.5)	2,819 (2.8)	1,450 (25.2)
Orthopedic surgery	33,884 (19.2)	11,333 (15.2)	22,551 (22.1)	1,978 (34.4)
In-hospital mortality	2,773 (1.6)	1,253 (1.7)	1,520 (1.5)	590 (10.3)

[*] ISS = Injury Severity Score; AIS = Abbreviated Injury Scale; sBP = systolic blood pressure; GCS = Glasgow Coma Scale; resource use = in-hospital mortality or major non-orthopedic surgical intervention.

Data are reported as n (%) unless otherwise noted

Table 2

Characteristics of seriously injured (ISS ≥ 16) adults over 60 years, by EMS reason for selecting hospital destinations (n = 1,661).

Characteristic	EMS reason for hospital selection	
	Patient/family choice n = 694 (41.8)	Other reason n = 967 (58.2)
Demographics		
61- 70 years	153 (22.1)	334 (34.5)
71 - 80 years	172 (24.8)	280 (29.0)
81 - 90 years	279 (40.2)	289 (29.9)
> 90 years	90 (12.9)	64 (6.6)
Women	424 (61.1)	421 (43.5)
Out-of-hospital physiology and procedures:		
SBP < 90 mmHg	8 (1.1)	44 (4.6)
GCS ≤ 8	12 (1.8)	128 (13.2)
Intubation attempt	5 (1.0)	49 (5.0)
Intravenous line placement	358 (51.7)	653 (67.5)
Mechanism of Injury:		
Gunshot wound	1 (0.1)	12 (1.2)
Stabbing	1 (0.1)	3 (0.3)
Assault	2 (0.3)	7 (0.7)
Fall	545 (78.6)	505 (52.2)
Motor vehicle crash	96 (13.9)	297 (30.7)
Pedestrian or bicycle	5 (0.8)	48 (5.0)
Other	44 (6.3)	95 (9.8)
Hospital measures:		
Non-Level I/II	437 (63.0)	234 (24.2)
ISS ≥ 25	135 (19.4)	294 (30.4)
Major non-orthopedic surgery	92 (13.2)	237 (24.5)
Orthopedic surgery	322 (46.4)	238 (24.6)
In-hospital mortality	48 (6.9)	180 (18.6)

sBP = systolic blood pressure; GCS = Glasgow Coma Scale score; ISS = Injury Severity Score.

Data are reported as n (%)