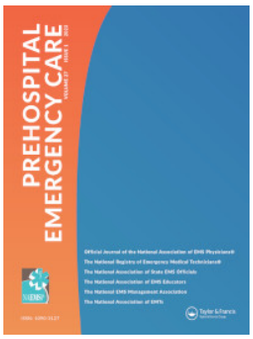

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Under-Triage and Over-Triage Using the Field Triage Guidelines for Injured Patients: A Systematic Review

Joshua R. Lupton[a], Cynthia Davis-O'Reilly[b], Rebecca M. Jungbauer[b], Craig D. Newgard[a], Mary E. Fallat[c], Joshua B. Brown[d], N. Clay Mann[e], Gregory J. Jurkovich[f], Eileen Bulger[g], Mark L. Gestring[h], E. Brooke Lerner[i], Roger Chou[b], and Annette M. Totten[b]

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ABSTRACT

Objectives: The Field Triage Guidelines (FTG) are used across North America to identify seriously injured patients for transport to appropriate level trauma centers, with a goal of under-triaging no more than 5% and over-triaging between 25% and 35%. Our objective was to systematically review the literature on under-triage and over-triage rates of the FTG.

Methods: We conducted a systematic review of the FTG performance. Ovid Medline, EMBASE, and the Cochrane databases were searched for studies published between January 2011 and February 2021. Two investigators dual-reviewed eligibility of abstracts and full-text. We included studies evaluating under- or over-triage of patients using the FTG in the prehospital setting. We excluded studies not reporting an outcome of under- or over-triage, studies evaluating other triage tools, or studies of triage not in the prehospital setting. Two investigators independently assessed the risk of bias for each included article. The primary accuracy measures to assess the FTG were under-triage, defined as seriously injured patients transported to non-trauma hospitals (1-sensitivity), and over-triage, defined as non-injured patients transported to trauma hospitals (1-specificity). Due to heterogeneity, results were synthesized qualitatively.

Results: We screened 2,418 abstracts, reviewed 315 full-text publications, and identified 17 studies that evaluated the accuracy of the FTG. Among eight studies evaluating the entire FTG (steps 1–4), under-triage rates ranged from 1.6% to 72.0% and were higher for older (≥55 or ≥65 years) adults (20.1–72.0%) and pediatric (<15 years) patients (15.9–34.8%) compared to all ages (1.6–33.8%). Over-triage rates ranged from 9.9% to 87.4% and were higher for all ages (12.2–87.4%) compared to older (≥55 or ≥65 years) adults (9.9–48.2%) and pediatric (<15 years) patients (28.0–33.6%). Under-triage was lower in studies strictly applying the FTG retrospectively (1.6–34.8%) compared to as-practiced (10.5–72.0%), while over-triage was higher retrospectively (64.2–87.4%) compared to as-practiced (9.9–48.2%).

Conclusions: Evidence suggests that under-triage, while improved if the FTG is strictly applied, remains above targets, with higher rates of under-triage in both children and older adults.

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Introduction

Injured patients in the prehospital setting require field triage by emergency medical services (EMS) professionals to identify patients with serious injuries and ensure they are transported to appropriate destinations with the resources to care for their injuries. To assist in the accurate triage of injured patients, multiple national organizations have supported development of the Field Triage Guidelines for Injured Patients (FTG) using the best available evidence and expert consensus. These FTG, which are widely used in North America, have undergone periodic evidence-based updates since 1976, most recently updated in 2011 (1, 2).

Similar to the prior 2006 FTG, the 2011 FTG contains four sequential steps structured in descending specificity for severe injury to assist EMS professionals in making triage decisions about the appropriate level of trauma center care. Step one and two contain physiologic and anatomic factors, respectively, that, if present, would indicate transport to the highest-level trauma center in a system. Steps three (mechanism of injury) and four (special considerations) contain variables that suggest transfer to a trauma center, though not necessarily the

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highest-level trauma center in a system. The primary goal of the algorithm is to identify seriously injured patients and concentrate them in trauma centers, which has been shown to improve in-hospital and 1-year survival (3). The performance of the field triage guidelines in a system is measured through under-triage and over-triage, where a patient is taken to a non-trauma or low-level center when he or she has serious injuries, or to a high-level center when he or she has minor injuries, respectively. Because the tools available in the prehospital setting for identifying severe injury are limited, it is acknowledged that identifying those with serious injury is not always possible; the commonly accepted goal is to under-triage less than 5% of seriously injured patients (4). To achieve this goal, it is likely that some who do not need trauma center resources will be falsely identified as needing them. To minimize over-utilization of this valuable resource, a secondary goal is to reduce over-triage to between 25 and 35% (4). The FTG favor minimizing under-triage at the expense of over-triage, as taking a severely injured patient to a non-trauma center (under-triage) carries a greater risk of harm than unnecessary resource utilization for a patient without serious injuries at a trauma center (over-triage).

Given the widespread use of the FTG, it is critical to understand the performance of the FTG in accurately triaging injured patients. Our objective was to conduct a systematic literature review of the evidence of the accuracy (under- and over-triage) of the FTG at appropriately triaging potentially injured patients, evaluating all studies that were published after the 2011 FTG update.

Methods

Study Design

This systematic review followed published methods (5), and was conducted at the direction of the American College of Surgeon National Expert Panel on Field Triage and is intended to establish a baseline performance of the FTG for comparing to future updates to the FTG. The key question for this systematic review was: to what extent do the FTG result in under-triage or over-triage (Supplemental Table 1)? We defined under-triage as the FTG not identifying a patient with severe injuries as needing a higher-level trauma center (false negative rate, 1-sensitivity), and over-triage as the FTG identifying a patient without severe injuries as needing a higher-level trauma center (false positive rate, 1-specificity) (6). Due to variations in how studies defined serious injury so as to determine under- and over-triage rates, we considered the following definitions: injury severity scores, mortality (limited to in-hospital mortality or sooner), resource use (non-orthopedic operative intervention, intensive care unit admission, advanced airway management, early administration of blood products, or similar resource-based interventions), and composite outcomes combining these measures.

Literature Search Strategy

A research librarian conducted searches of literature published from January 1, 2011 through February 28, 2021 in the online Ovid MEDLINE®, EMBASE, and Cochrane Databases. We restricted search start dates to January 2011 as our objective was to identify and include only publications not included in reviews informing the 2011 guidelines, as these were most likely to be relevant to this revision of the guidelines. Study authors reviewed reference lists of included articles and excluded reviews to identify additional potentially relevant studies. A detailed search strategy and terms are included in Supplemental Table 2.

Study Selection

The review of abstracts and full texts was conducted in accordance with the AHRQ Methods Guide (5). Criteria for review and inclusion were developed based on the key question above and PICOTS (populations, interventions, comparators, outcomes, timing, and setting; see Supplemental Table 1). Briefly, we included studies evaluating under- or over-triage, regardless of outcome used to assess this, of patients using the FTG in the prehospital setting. We excluded studies not reporting an outcome of under- or over-triage, studies evaluating other triage tools that were not the US FTG, studies of triage not in the prehospital setting, and studies of military or mass casualty triage. All excluded abstracts were independently reviewed by a second team member to confirm exclusion decisions. A full-text article was retrieved for review for any article recommended for inclusion by at least one reviewer. Two team members independently reviewed each full-text article for inclusion, and disagreements were resolved by consensus with the research team. Team members did not review their own publications, at any stage including consensus discussions of a study by the research team, to avoid any conflict of interest. The same reviewer could evaluate a study at two different stages (abstract review, full text review, risk of bias) provided they did not have any conflicts of interest and were not an author on the study.

We included any studies reporting on the under- and over-triage using the FTG, regardless of whether they were conducted in the United States or internationally. Given that EMS and trauma systems vary considerably by country, for qualitative synthesis we reported results of international studies separately. We excluded descriptive studies, commentaries, letters, and non-English language articles.

Data Extraction and Risk of Bias Assessment

Abstracted data included study design, year, setting, country, sample size, eligibility criteria, population, outcomes, and intervention characteristics. We abstracted adjusted odds ratios, the under-triage rate (1-sensitivity), and over-triage rate (1-specificity) to allow for comparisons between studies.

We assessed the risk of bias for individual studies using predefined criteria adapted from the Quality in Prognosis Studies (QUIPS) tool (7), including domains of study participation, study attrition, prognostic factor measurement, outcomes measurement, study confounding, and statistical analysis and reporting. Two team members independently reviewed each included study for risk of bias and any

disagreements were resolved by consensus. Team members who were authors on an included study did not review their own studies for risk of bias. We rated studies on individual criteria and an overall assessment of their risk of bias as being low, moderate, or high (Supplemental Table 3).

Synthesis Approach

There were insufficient numbers of studies with the same outcomes and population; thus, we did not conduct meta-analyses to generate pooled outcome estimates due to this heterogeneity. We performed qualitative synthesis of studies based on the results from each individual study. We included results from studies that used strict adherence to the FTG including all steps, but did not exclude studies that only evaluated part of the FTG, such as steps 1-3. All studies evaluated appropriate initial transport destination from the field in determining accuracy of the FTG. We additionally included studies that reported adjusted odds ratios for appropriate triage using the FTG, although they did not report data that permitted calculation of under-triage or over-triage rates.

Results

Our search strategy yielded a total of 2,418 abstracts. After dual-review of these abstracts, 315 full text publications were reviewed, with a total of 17 relevant studies evaluating the accuracy of the FTG in the triage of injured patients meeting all eligibility criteria (Figure 1) (8–24). Of the 17 studies, seven evaluated the most recent (2011) FTG and 10 used earlier versions of the FTG (Table 1). Any assessment of triage effectiveness requires a clear endpoint of definition of appropriate trauma triage. In the papers reviewed, there was considerable variability in what constitutes appropriate triage. The most widely used definition was based on the presence of serious injury, defined as a patient with a final Injury Severity Score (ISS) of 16 or greater. However, more recent papers instead used composite measures of trauma center need (non-orthopedic operations, blood transfusions, emergent angiography or embolization, emergent intubation, or intensive care unit admission) as part of the definition of appropriate triage.

Among the seven studies evaluating the 2011 FTG, six reported data allowing calculation of under- and over-triage, with two examining outcomes of ISS $\geq$16 (11, 21), three

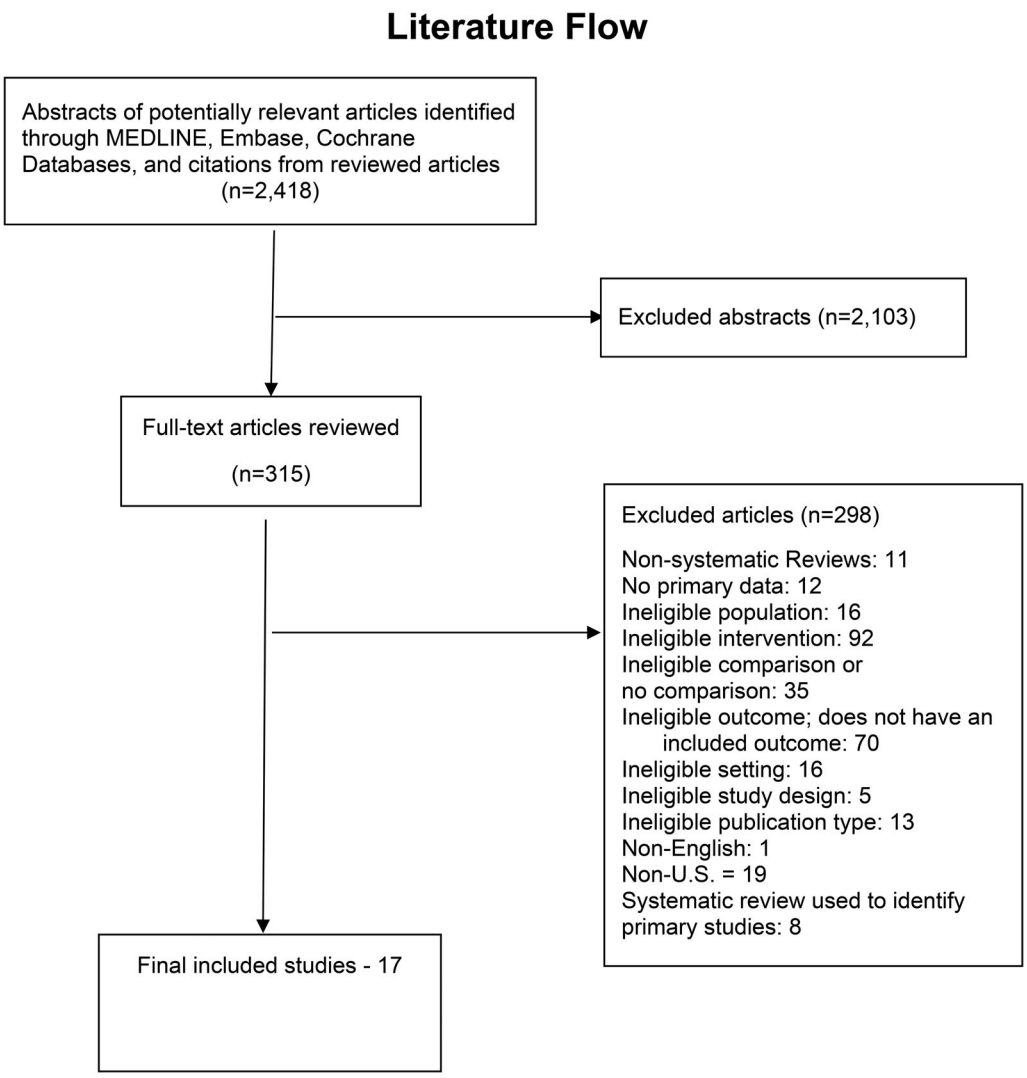

Figure 1. Literature flow diagram of the systematic review.

Table 1. Characteristics of included studies.

Category	Characteristics	Number of studies
Year of Publication	2011–2015	7
	2016–2021	10
Field Triage Guidelines	2011	7
	Earlier Field Triage Guidelines (1999–2006)	10
Study Design	Prospective cohort	4
	Retrospective cohort	12
	Before/after	1
Data Source	US National Trauma Data Bank	1
	National Automotive Sampling System Crashworthiness Data System	2
	State or regional data	9
	Other	4
	Other national data base	1
Type of Receiving Hospitals	Trauma centers only (Level 1 or 2)	2
	Mixed	15
	Not reported	0
Number of Agencies/ Institutions	Single	0
	Multiple	17
	Not reported	0
Separately Reported Patient Age Group	Pediatric	4
	Geriatric	13
Risk of Bias Rating	High	0
	Moderate	4
	Low	13

Table 2. Under- and over-triage with strict application of the 2011 field triage guidelines.

Article	FTG Steps	Outcome	Under-triage % (95% CI)	Over-triage % (95% CI)	n	Age Range
Newgard, 2017[11]	All**	ISS $\geq$ 16	8.9 (7.6–10.4)	64.2 (63.8–64.6)	17,633	All
	All**	Composite[a]	4.2 (3.0–5.8)	64.6 (64.1–65.0)	17,633	All
	All**	In-hospital mortality	1.6 (0.7–3.4)	64.8 (64.4–65.2)	17,633	All
Parikh, 2017[21]	All**	ISS $\geq$ 16	9.1 (NR)	87.4 (NR)	4,757	All
Lerner, 2017[20]	All**	Composite[b]	34.8 (29.2–40.7)	28.0 (26.8–29.3)	5,594	<15
Hon, 2020[19]	1-3**	Intracranial hemorrhage	73.7 (62.8–82.3)	11.7 (9.4-14.6)	673	≥55
Nishijima, 2017[18]	1-3**	Intracranial hemorrhage	80.2 (48.8–94.5)	6.9 (5.3–8.8)	2,110	≥55
	1-3**	Composite[c]	65.8 (49.4–79.9)	7.7 (6.1–8.3)	2,110	≥55
Nishijima, 2018[17]	1-3**	Intracranial hemorrhage	73.2 (64.0–81.1)	9.1 (8.0–11.6)	1,304	≥55
	1-3**	Composite[c]	40.9 (NR)	NR	1,304	≥55

**Applying strict FTG retrospectively. Abbreviations: NR = Not Reported, ISS = Injury Severity Score; FTG = Field Triage Guidelines. Composite definitions included: [a]Early critical resource use defined as emergent intubation in the emergency department, major non-orthopedic surgery, interventional radiology procedures, at least six units of red blood cells transfused, or death within 24 hours. [b]Composite defined as non-orthopedic surgery within 24 hours, intensive care unit admission, or death. [c]Composite defined as death or neurosurgical intervention during hospitalization.

intracranial hemorrhage (17–19), four composite outcomes such as surgery, intensive care unit admission, emergent intubation, or death (11, 17, 18, 20) and one in-hospital mortality (Table 2) (11). The ages evaluated ranged from pediatric patients (age <15 years) to older adults (age ≥55 years) and all patients regardless of age. Three studies evaluated all steps (1–4) of the 2011 FTG (11, 20, 21), whereas three evaluated only steps 1-3 in patients with possible head injuries (17–19). All six studies retrospectively applied the components of the FTG to already collected data and did not assess actual (as-practiced) performance of the FTG.

Across all outcomes in these six studies (Table 2), under-triage rates were frequently greater than the national benchmark of ≤ 5%, ranging from 1.6% to 80.2%, with higher rates for children (34.8%) and older adults (40.9% to 80.2%) versus populations not restricted to these age groups (1.6% to 9.1%). Over-triage rates ranged from 6.9% to 87.4%, with higher rates for all ages combined (64.2% to 87.4%), and lower rates for children (28.0%) or older adults (6.9% to 11.7%). Over-triage was generally highest in studies with lower rates of under-triage (Figure 2). Two studies used ISS ≥ 16 as the primary outcome among all patients regardless of age and found rates of under-triage less than 10% (8.9% (11) and 9.1% (21)), with high rates of over-triage (64.2% (11) vs. 87.4% (21)). One of these studies also evaluated early critical resource use as a composite outcome and in-hospital mortality, finding improved rates of under-triage (4.2% and 1.6%) with similar over-triage (64.6% and 64.8%) compared to using ISS ≥ 16, respectively (11). The remaining studies evaluated head injury outcomes in older adults (age ≥55 years), finding high under-triage rates (40.9-80.2%) and low over-triage rates (6.9-11.7%). All but one of the six studies had low risk of bias, with the other having moderate risk due to missing data (Supplemental Table 3) (20).

Ten studies evaluated the 2006 version of the FTG (8–10, 12–16, 22, 24), with all but one (8) using the as-practiced performance of the 2006 FTG in contrast to the above studies of the 2011 FTG. Of these ten studies, seven included data the allowing calculation of under- and over-triage rates (Table 3). Across all outcomes, under-triage ranged from 10.5% to 72.0%, with highest levels for older adults

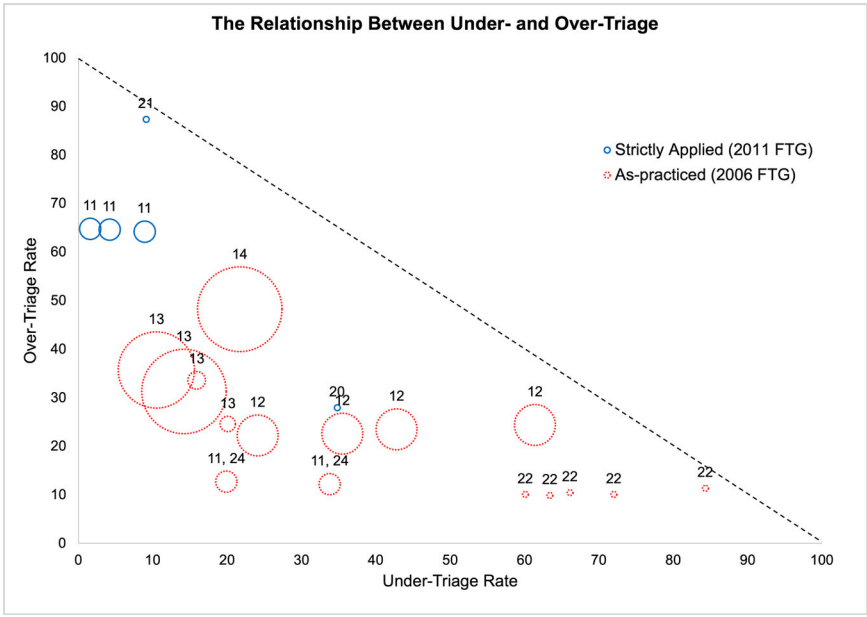

Figure 2. The relationship between under- and over-triage in studies evaluated all steps in the field triage guidelines. Numbers above the data points (circles) correspond to the manuscript citations also present in Tables 2 and 3 for the nine studies evaluating all steps of the 2011 or 2006 FTG. The sizes of the corresponding data points (circles) are proportional to the study sample size (Tables 2 and 3). Values used from under- and over-triage are reported for each study in Tables 2 and 3. A color version of this figure is available online.

Table 3. Under- and over-triage of the 2006 field triage guidelines, as-practiced.

Article	FTG Steps	Outcome	Under-triage % (95% CI)	Over-triage % (95% CI)	n	Age Range
Newgard, 2011[13]	All*	ISS ≥ 16	14.2 (13.4–15.0)	31.3 (31.1–31.6)	122,345	All
	All*	ISS ≥ 16	15.9 (13.2–18.7)	33.6 (32.9–34.4)	14,874	0-17
	All*	ISS ≥ 16	10.5 (9.6–11.4)	35.7 (35.3–36.1)	62,442	18-54
	All*	ISS ≥ 16	20.1 (18.5–21.7)	24.6 (24.2–25.0)	12,372	≥55
Newgard, 2016 & 2017[11,24]	All*	ISS ≥ 16	33.8 (28.3–39.2)	12.2 (12.0–12.3)	17,633	All
	All*	Composite[a]	19.9 (10.6–34.2)	12.7 (12.6–12.9)	17,633	All
Newgard, 2016[12]	All*	ISS ≥ 16	24.1 (20.7–27.5)	22.2 (21.5–22.9)	33,298	≥65
	All*	Serious TBI[b]	35.5 (31.8–39.2)	22.6 (21.9–23.4	33,298	≥65
	All*	Serious Chest Injury[c]	42.8 (38.3–47.4)	23.5 (22.7–24.2)	33,298	≥65
	All*	Serious abdominal injury[d]	61.4 (55.1–67.6)	24.4 (23.6–25.1)	33,298	≥65
Newgard, 2019[22]	All*	ISS ≥ 16	60.1 (54.0–66.3)	10.1 (9.3–11.0)	5,021	≥65
	All*	Composite[e]	63.4 (58.0–68.8)	9.9 (9.0–10.8)	5,021	≥65
	All*	Head, chest, or abdominal-pelvic AIS ≥3	72.0 (65.9–78.1)	10.1 (9.3–11.0)	5,021	≥65
	All*	Head AIS ≥3	66.1 (57.0–75.2)	10.5 (9.6–11.4)	5,021	≥65
	All*	30-day mortality	84.3 (79.6–89.0)	11.4 (10.5–12.2)	5,021	≥65
Scheetz, 2011 [14]	All*	mAIS3-5	21.7 (21.2–22.3)	48.2 (48.0–48.5)	154,608	≥55
Brown, 2011[8]	1-2**	Composite	68.0 (NR)	9.0 (NR)	1,086,764	≥18

*As-practiced FTG performance. **Applying strict FTG retrospectively. [a]Composite defined as emergency airway intervention in the emergency department, major non-orthopedic surgical intervention, interventional radiology procedure, six or more units of blood transfused, or death within 24 hours. [b]Serious TBI defined as maximum head AIS ≥ 3 or intracranial procedure. [c]Serious chest injury defined as maximum thoracic AIS ≥ 3 or thoracic surgery. [d]Serious abdominal injury defined as maximum abdominal-pelvic AIS ≥ 3 or therapeutic laparotomy or pelvic surgery. [e]Composite defined as ISS ≥ 16, non-orthopedic surgery, or early mortality. Abbreviations: mAIS = maximum abbreviated injury scale; NR = Not Reported; ISS = Injury Severity Score; FTG = Field Triage Guidelines; TBI = traumatic brain injury.

(20.1–72.0%). Over-triage ranged from 9.9% to 48.2%, without clear overall trends by age. Over-triage was generally highest in studies with lower rates of under-triage (Figure 2). Four studies used ISS ≥ 16 as an outcome, with a rate of under-triage ranging from 14.3% to 33.8% (all ages) (12, 13), and 20.1% to 60.1% (age ≥55 or ≥65) (13, 22, 24). Composite outcomes indicative of trauma center need or resources use were assessed in two studies (12, 22), with under-triage rates of 19.9% (all ages) and 63.4% (age ≥65) and over-triage rates of 12.7% (all ages) and 9.9% (age ≥65).

One study examined the adjusted odds of adult patients with a serious head injury being transported appropriately to a trauma center using the 2011 FTG compared to earlier versions of the FTG (23). In this study, the authors found the 2011 FTG resulted in higher adjusted odds for appropriate field triage across all ages when compared to earlier versions of the FTG, with the highest increase among those ≥85 years old (adjusted odds ratio 1.37). Despite these improvements, older adults were consistently less likely to be transferred to trauma centers compared to adults aged 18–44 years regardless of FTG revision used. This study did not report the sensitivity, specificity, under-triage, or over-triage for serious head injury for either version of the FTG.

Several of the above studies used overlapping datasets, including two using a 2011 Northwest United States cohort (11, 24), two a 2006–2008 Western United States cohort (13,

16), and two a sample of the NAS CDS database (14, 15). Additionally, a study published in 2015 did not clarify what version of the triage guidelines was being used, whether the 2011 FTG, an earlier version of the FTG, or a local or state FTG, and thus was not included in the qualitative synthesis above (9). This study evaluated adults (ages 18–65) using an outcome of high-risk of death, based on an International Classification Injury Severity Score less than 0.85, and reported under-triage (43%) and over-triage (11%) rates that were within the range of reported studies above using the 2006 or 2011 FTG. One study evaluating the 2006 FTG found older adults had lower adjusted odds of being appropriately transferred to trauma centers versus patients aged 18–45 years (10). Another study using 2004–2008 data found that nearly 26% of older adults (age ≥65) with significant injury were initially transported to non-trauma centers, and this under-triaged group had nearly twice as many deaths within 48–72 hours of injury than patients properly triaged (15). However, this study did not report the overall sensitivity, specificity, under-triage rate, or over-triage rate or specify the version of the FTG used.

A study evaluating real world as-practiced application of the 2006 FTG found under-triage and over-triage rates of 33.8% and 12.2%, respectively, using ISS ≥ 16 as the outcome. After strict adherence was retroactively applied using the 2011 FTG criteria, including age, the under-triage rate in this same sample dropped to 8.9%, whereas the over-triage rate increased to 64.2% (11). Similarly, a study that evaluated as-practiced compared to retrospective strict application of the 2006 FTG found that 34.3% of patients meeting no FTG criteria on retrospective review were transported to trauma centers (16). Overall, three studies evaluating the 2006 FTG were rated moderate risk of bias due to unclear outcome measures (16), unclear selection methods (14), or no accounting for confounders or adjustment when reporting odds ratios (15). The remaining 2006 FTG studies were low risk of bias (Supplemental Table 3).

One international study with high risk of bias evaluated the 2011 FTG in comparison to national guidelines in Poland among 159 seriously injured patients admitted to a single center (25). The under-triage rate using the 2011 FTG in this patient population was 12.6%. Unfortunately, given this was a single center retrospective study of patients already at a trauma center, under-triage or over-triage could not be reliably estimated, resulting in high risk of bias.

Discussion

We report the results of a systematic review of the accuracy of the FTG reported in the literature published since the revised 2011 FTG for injured patients were released. There were only three studies considering all four steps that reported on the under-triage and over-triage rates of the 2011 FTG, and all used retrospective strict application of the FTG rather than as-practiced performance. Nevertheless, all three studies reported under-triage rates greater than the goal of 5% in their primary outcome, with the highest (34.8%) in a pediatric population (age <15 years). The rate of under-triage was also notably higher (≥40%) in the three studies assessing only steps one to three of the 2011 FTG among older adults (≥55 years) with possible head trauma. Over-triage rates were above 60% in both studies evaluating all patients regardless of age using the 2011 FTG. Pediatric (<15 years) and older adult (≥55 years) patients had lower rates of over-triage (<30%) in all studies using all or part of the 2011 FTG. Taking together, these findings suggest that under-triage remains above the national benchmark, particularly for pediatric and older patients, while over-triage is generally lower than the benchmark for pediatric and older patients yet exceeds goals when all patients are evaluated together. These results represent a baseline of performance of the FTG, if strictly followed, that can be used to measure efficacy of future revisions of the FTG.

Notably, there were minimal changes from the 2011 FTG and 2006 FTG, mostly related to wording and with age-specific blood pressure cutoffs for older adults added in step 4 (2). As a result, we included studies evaluating the 2006 FTG. Notably, these studies found consistently higher rates of under-triage (all >10%) with overall lower over-triage (all <50%) compared to the 2011 FTG. Part of these discrepancies could be due to most studies evaluating the 2006 FTG (Table 3) and reporting data on under- or over-triage using as-practiced performance evaluation, whereas the 2011 FTG studies (Table 2) used retrospectively strictly applied performance, the latter more indicative of a best-case scenario. This may be why when comparing the consistent outcome of ISS ≥ 16, measured in four studies of all ages, this showed the 2006 FTG having higher under-triage rates (14.2–33.8%) (13, 24) than the 2011 FTG (8.9–9.1%) (11, 21). Furthermore, there was an inverse relationship between under- and over-triage such than studies reporting reduced under-triage generally had higher over-triage rates (Figure 2).

There are a multitude of possible reasons for the observed differences in under-triage and over-triage rates. The reported studies evaluated a variety of different populations, such as a single county (17–19), single state (21), or multiple states (12, 20, 22), which may have affected the generalizability of the results given local protocols may affect adherence to the trauma guidelines. The smaller sample sizes in the 2011 FTG studies may have resulted in greater ranges of under-triage and over-triage rates compared to evaluations of the 2006 FTG. Of the four studies evaluating the complete 2011 FTG, the largest outlier in over-triage (87.4% for all ages) was from a single state and had the smallest sample size (21). Finally, not all studies evaluated all steps of the FTG or used as-practiced application of the FTG when evaluating its performance, which may suggest more research is needed on the implementation and ease of use of the FTG.

In addition to variations in populations, the outcomes used in studies varied significantly from ISS ≥ 16, to composite outcomes, specific injuries, and mortality. Certain serious injury definitions, such as an intracranial hemorrhage that requires no intervention and only observation, may not be the ideal outcome to measure trauma center need or FTG performance. In studies evaluating composite outcomes

indicative of resource need in addition to separately measuring injury severity (11, 17, 18, 22, 24), the composite outcome in all but one study had lower rates of under-triage, with similar rates of over-triage (Tables 2–3). This suggests overestimation of under-triage based on injury severity alone.

The difference in ages used in evaluation of the FTG (<15, all ages, ≥55, and ≥65) make it difficult to make comparisons between studies. However, there remain differences in FTG performance that likely reveal true age-related differences in the accuracy of the FTG, which appears to result in higher rates of under-triage for both pediatric patients and older adults. This is consistent with other work evaluating the 2011 FTG, finding higher odds of under-triage for older adults (23), similar to findings from evaluations of the 2006 FTG (10).

Limitations

The overall risk of bias was low for the majority of studies. However, the significant variation in age cutoffs, outcomes used, and the method in which the triage criteria were assessed (as-practiced or retrospectively applied) precluded a meta-analysis to pool under- and over-triage estimates across studies, which is a limitation of this systematic review. We excluded studies published prior to January 1st, 2011 as our goal was to capture studies published since the most recent (2011) FTG revision, as this is most relevant for guiding changes to the current FTG. We did include studies of the 2006 FTG if they were published after the date of the 2011 FTG revision and thus not available at the time the last FTG were revised. Our selection criteria, which may have excluded single trauma center studies evaluating appropriate triage in their population but without looking at prehospital FTG, may have limited the inclusiveness of our qualitative synthesis of data. Finally, under- and over-triage rates do not necessarily correlate to health outcomes, as not all under-triage patients will have adverse health outcomes, although appropriate triage has been correlated to higher in-hospital and one-year survival (3). Similarly, our review focused on under- and over-triage without focusing on studies evaluating the specific costs and potential downsides associated with over-triage.

Conclusion

Among studies evaluating the performance of the Field Triage Guidelines at appropriately triaging potentially injured patients in the prehospital setting, under-triage rates are frequently above established goals (<5%) and under-triage was higher in pediatric and elderly populations. In the two studies where under-triage was below 10%, the over-triage rate exceeded 60%. The major limitation of this systematic review is the heterogeneity of the populations, methods, and outcomes of included studies. This emphasizes the need for future large, multisite studies to evaluate the accuracy of the FTG using consistent application of the FTG and standardized outcomes indicative of trauma center need.

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