



ORIGINAL RESEARCH

Need for Trauma Intervention and Improving Under-Triaging in Geriatric Trauma Patients: Under-Triaged or Misclassified

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Abstract

Background: Combining the Need for Trauma Intervention (NFTI) calculation with the Cribari Matrix Method (CMM) more accurately determines appropriate triage, particularly of geriatric trauma patients. These patients (\geq age 65 years) have comorbidities, increased frailty, and decreased overall functional capacity. The CMM alone does not address their increased risk of mortality secondary to inappropriate or suboptimal care; performance improvement efforts to decrease the risk of under-triage have prompted the use of NFTI in this institution.

Methods: Geriatric patients presenting to a level 1 trauma center and requiring full or limited trauma team activation or consultation from January 1, 2018 to January 31, 2020 were selected for this retrospective review; 79 under-triaged geriatric patients were included. Those categorized as under-triaged by CMM + Injury Severity Score (ISS) were then analyzed using the NFTI criteria. The hypothesis was that the percent of patients classified as under-triaged would be significantly less following the application of NFTI.

Results: Application of NFTI criteria to patients classified as under-triaged by CMM + ISS reduced the study time period under-triage rate from 7.6% to 0.8% for 1,041 trauma activations ($P < 0.0003$) and 2.5% to 0.3% for 3,123 trauma admissions ($P < 0.0003$).

Conclusion: This study provides evidence of the utility of NFTI-adjusted triage determination in more accurately identifying under-triaged geriatric trauma patients. Further, these results imply the benefit of applying NFTI earlier in the continuum of care, perhaps even requiring the initiation of formal process improvement.

Background

It is estimated that the geriatric population in the United States will grow from 14.5% to 23.5% by the year 2060, resulting in approximately 90 million people over the age of 65 [1]. Consequently, the proportion of geriatric trauma patients will continue to rise, which will present trauma service departments a unique challenge. Geriatric trauma patients frequently circumvent the standard protocols as their traumatic injuries often follow seemingly insignificant mechanisms or mechanisms that do not typically meet Trauma Team Activation (TTA) or triage criteria, and this is further complicated by the coexistence of multiple confounding comorbidities such as polypharmacy, anticoagulation, as well as an underlying diminished functional capacity related to frailty [2,3]. While some facilities have responded to this issue by initiating a TTA for all individuals 65 years of age or older following any traumatic event, this invariably will result in an effective over-triage rate resulting in resource overutilization.

One of the primary goals of trauma centers is to quickly and efficiently perform a systematic evaluation to identify potential and actual life-threatening injuries in patients following traumatic events, thereby matching appropriate resources with the known or suspected injuries. This appropriateness of resource utilization and the measurement of over-and under-triage are currently based on injury severity score (ISS) at the time of admission. However, this score can only be accurately assessed after all the injuries are known,

which is an inherent deficiency of this current process. Trauma centers in the state of Pennsylvania are verified through a state-sponsored agency as opposed to the American College of Surgeons (ACS). However, at a minimum, these trauma centers use the ACS standards. During the periodic survey process, over-and under-triage rates are assessed using the Cribari matrix method (CMM) with the expectation of an under-triage rate of 5% or less and an over-triage rate of 35% or less [4,5].

In our institution, geriatric patients constitute between 50 to 60% of trauma patients, and many of these patients present to the emergency department on their own following seemingly trivial injuries. Many of these patients are prescribed antiplatelets or anticoagulation and are subsequently found to have a traumatic brain injury with completely normal physiologic parameters. Therefore, geriatric trauma patients often circumvent even the strictest triage criteria resulting in an increase in under-triage. In our case, despite quickly identifying the injuries followed by an appropriate evaluation by the trauma team as well as the institution of therapies, the under-triage rate approached 8% resulting in a citation during the verification process despite concurrent review of all these patients, which resulted in no patients with adverse outcomes due to the lack of the full trauma team activation.

To the best of the authors' knowledge, the literature does not contain any studies that investigated under-triage in the geriatric population, as calculated by the Need for Trauma Intervention (NFTI) tool. The NFTI tool is a novel metric that performs a secondary review of trauma patients to determine the presence of major trauma [6,7]. This tool accounts for resource utilization and patient outcomes in combination with objectively measuring injuries. Adoption of this validated tool allows trauma services to conduct quality improvement processes by enhancing the review of appropriate triage in geriatric patients.

NFTI criteria have been evaluated against ISS for metric superiority regarding the accuracy of triage determination. Studies have demonstrated NFTI to reduce under-triage rates, from 9.1% to 3.3%, and over-triage rates 50.1% to 30.8% [7]. NFTI also has a strong correlation with clinical variables, when compared to ISS [6]. Prior evidence measured several variables, such as number of risk factors, presence of complications, number of procedures in the first three days, total length of stay (LOS), overall mortality, and mortality after 60 hours between CMM and NFTI [7]. In comparison to CMM, the NFTI adjusted model in over-triaged and under-triaged patients was found to have a better correlation with all the variables mentioned above except complications of mortality after 60 hours [7]. Overall, implementing NFTI enhances measuring of triage rates because of the ability to improve monitoring of resources use and patient outcomes. However, these studies did not reflect geriatric populations.

The purpose of this study is to evaluate the use of NFTI versus CMM + ISS in retrospectively calculating triage scores. It is hypothesized NFTI provides a more accurate assessment of true under-triage rates; and therefore, will decrease the calculated under-triage rates in the geriatric population. Although NFTI is not specific to geriatric patients, we hypothesize that in this population who is at a higher risk of under-triage, the use of the specific outcomes associated with NFTI would provide a reliable determination of true under-triage rates in this specific population. Over- and under-triage are integrally linked, over-triage is not explicitly addressed as we evaluate geriatric trauma patients already captured in our institutional data and categorized as under triaged. This group was further evaluated with NFTI criteria to determine if resource allocation was appropriate and, therefore not a true under-triage. If with NFTI the patient had appropriate resource allocation, then patients were reclassified as appropriately triaged and only affecting the under-triage percentage. Over triage rates were unchanged.

Methods

Institutional review board (IRB) review determined this study to be exempt. Following IRB review and adhering to a retrospective cohort design, data from patients meeting inclusion criteria were re-evaluated using NFTI criteria to obtain NFTI-adjusted triage scores. Performance improvement measures are ongoing in every trauma activation or consult, and therefore the NFTI tool was adopted at this institution. NFTI captures the occurrence of major trauma via measuring acute phase resource utilization and survival. Specifically, a six-part criteria is applied to determine if a patient required a TTA. Components of the checklist include:

- Receiving packed red blood cells (PRBC) within the first four hours of arrival.
- Discharged from the Emergency department (ED) to the operating room (OR) within 90 minutes of arrival.
- Discharged from ED to interventional radiology (IR).
- Discharged from the ED to the intensive care unit (ICU) and having a total ICU length of stay (LOS) of three or more calendar days.
- Receiving mechanical ventilation for reasons other than procedural anesthesia within the first three days.
- Death within 60 hours of hospital arrival [6,7].

Occurrence of any component or combination of NFTI criteria results in a NFTI positive (NFTI +) status. Designation of NFTI + is conclusive of a patient having sustained major trauma and requiring TTA. NFTI-adjusted triage score provides reliable context which supports improvement in patient outcomes and

Table 1: Participation criteria.

Inclusion	Exclusion
Adult, age \geq 65 years	< 65 years of age
Trauma activation (second level, consult)	Prisoners
Observation or Admission	Cribari Matrix Method over-triaged classifications
Cribari Matrix Method under-triaged classifications	

Table 2: Trauma team activation levels and criteria.

Full Trauma Team Activation (1 st Level)	Limited Trauma Team Activation (2 nd Level or ACT/Transfer Alert)	Trauma Consult	Absent from Trauma Services
<p>Age 65 and any clinical finding:</p> <ul style="list-style-type: none"> • SBP < 110 • Penetrating injury • GCS deteriorating \geq 2 points • Transfer pt receiving blood to maintain hemodynamic stability • Intubated pt transferred from scene • Intubated pt with resp. compromise from outside facility • Resp. compromise/emergent airway • Acute paralysis • GCS < 14; Verbal \leq 3; Motor \leq 5 • GCS < 15 with suspected TBI • Chest wall instability/deformity • Abdominal tenderness • Femur fracture, \geq 2 proximal long-bone fractures • Crushed/degloved/mangled/pulseless extremity. • Amputation proximal to wrist/ankle • Suspected pelvic fx • Open or depressed skull fx • Falls (> 20 feet) • High-risk auto crash <ul style="list-style-type: none"> o Passenger compartment intrusion o Ejection from automobile o Death in passenger compartment • Auto versus pedestrian/bicyclist thrown, run over, or with significant (> 20 mph) impact. • Pedestrian struck by MVA • Multiple injured body regions • Motorcycle crash > 20 mph • 20% BSA burn • Hypothermia with core temperature of \leq 32 °C 	<ul style="list-style-type: none"> • GCS \geq 13 on anticoagulation/antiplatelet agents excluding ASA/bleeding disorder with MOI of fall within 24 hours and history/evidence of striking head. • ACT ALERT will consist of the DEM provider evaluating pt within 15 mins and Surgical Resident responding to the DEM within 30 mins. • Transferred from outside facility, meet higher activation criteria. 	<p>Trauma Resident/Service will be consulted by DEM physician when trauma injuries or potential injuries are identified that require further evaluation. Response within 30 minutes of notification.</p>	<p>Trauma Services are not inquired regarding the care of a patient.</p>

Note: SBP: Systolic Blood Pressure; GCS: Glasgow Coma Score; pt: Patient; resp: Respiratory; fx: Fracture; mph: mile per hours; MVA: Motor Vehicle Accident, BSA: Body Surface Area, ASA: Aspirin, DEM: Department of Emergency Medicine

resource utilization following the definitions of under- and over-triage.

Data of trauma patients who were seen in our rural level I trauma center between January 1, 2018 to January 31, 2020 was obtained. Those meeting inclusion criteria, Table 1, have been included in this study. Inclusion criteria consisted of adults, age 65 years and older, those receiving second level trauma alert or trauma consultation, admission or observation status, and under-triage status via CMM. Exclusion criteria consisted of those patients younger than 65 years, prisoners, and CMM over-triage status.

TTA at this institution follows a tiered system which attempts to allocate appropriate resources to match patient needs and optimize outcomes. Tiers are classified as first level, second level, consult, or none. Table 2 for Trauma Team Activation levels and criteria.

The authors utilized a modified version of CMM

incorporating ISS. Evaluation by this model, CMM+ISS, categorized patients as either under- or over-triaged. Patients determined to be under-triaged by CMM+ISS were then evaluated by NFTI standards; if NFTI positive (NFTI +), the categorization remained as under-triaged; if NFTI negative (NFTI -), then the patient was re-categorized as appropriately triaged, Table 3 for NFTI Adjusted CMM Model.

Statistical significance testing of the change in percent of patients categorized as under-triaged utilized a test for dependent proportions (binomial distribution) with an alpha set at 0.05. For patients categorized as under-triaged by CMM+ISS, IBM SPSS version 24 was used to assess patient homogeneity on age, arrival systolic blood pressure (SBP, mm HG) and ISS between years 2018 and 2019 (Table 4).

Results

Total study sample size was 3,123 trauma admissions

Table 3: NFTI Adjusted CMM Model.

Trauma Triage Status	CMM (Cribari Matrix Method)	ISS (Injury Severity Score)	NFTI (Need for Trauma Intervention)
	<p>CMM offers trauma facilities the opportunity to evaluate under-triaging and over-triaging percentages among trauma patient populations.</p> <p>This matrix couples the degree of trauma team activation (none, partial, full) with one category of ISS score dichotomized into > 15 and ≤ 15 [3].</p>	<p>ISS criteria consist of a complex rating system that utilizes Abbreviated Injury Scales (AIS) for six body regions:</p> <ul style="list-style-type: none"> • Head and neck, • Face, • Chest, • Abdomen or pelvis, • Extremities or pelvic girdle, • External surface. <p>To create a generalized injury score, ISS = sum of the individually squared three highest AIS scored body regions (sum of squares)</p> <p>ISS score > 15 is major trauma and requires trauma activation [2].</p>	<p><u>NFTI positive (NFTI⁺) = Major Trauma:</u></p> <ul style="list-style-type: none"> • Receiving packed red blood cells (PRBC) within the first four hours of arrival, • Transferred from emergency room (ER) to operating room (OR) within 90 minutes of arrival, • Transferred from ER to interventional radiology (IR), • Transferred to intensive care unit (ICU) <i>and</i> have a total ICU LOS ≥ 3 days • Receiving mechanical ventilation other than procedural anesthesia for the first three days • Having a length of stay (LOS) of ≥ 3 calendar days, • And/or death within 60 hours of hospital arrival [6].
UNDER		ISS > 15 AND receiving <i>partial or no</i> trauma activation	If <u>NFTI⁺</u> , then <u>under-triaged</u> ; If <u>NFTI⁻</u> , then <i>appropriately</i> triaged.
Appropriate		ISS > 15 AND <i>trauma activation</i> ;	<u>NFTI⁺</u> ;
		ISS ≤ 15 and <i>no trauma activation</i>	<u>NFTI⁻</u>
Over		ISS ≤ 15 and receiving <i>full</i> trauma team activation	If <u>NFTI⁺</u> , then <i>appropriately</i> triaged; If <u>NFTI⁻</u> , then <u>over-triaged</u> .

This is a revised version of CMM that re-evaluates triage appropriateness by applying NFTI criteria to patients if triage status was not appropriate.

NFTI: Need for Trauma Intervention; CMM: Cribari Matrix Method; ISS: Injury Severity Score; AIS: Abbreviated Injury Score; PRBC: Packed Red Blood Cells; ER: Emergency Room; OR: Operating Room; IR: Interventional Radiology; ICU: Intensive Care Unit; LOS: Length of Stay.

Table 4: Measures and outcomes from data collection.

Measures	Outcomes
Age, years	Percentage of patients determined to be under-triaged by: CMM+ISS model
Sex	Percentage of patients determined to be under-triaged by: NFTI-adjusted CMM model
Date of arrival (presentation)	
Trauma alert, (yes/no)	
Trauma consult, (yes/no)	
Through the Emergency Department. (yes/no)	
Patient type (observation/inpatient)	
GCS	
AIS	
ISS	
CMM criteria: Determination of under-triaged	
NFTI criteria: Determination of under-triaged	

Note: GCS: Glasgow Coma Score; AIS: Abbreviated Injury Score; NFTI: Need for Trauma Intervention; CMM: Cribari Matrix Method;

ISS: Injury Severity Score; NTDS: National Trauma Database Standard [8]

and of those, 1,041 were trauma activations. Comparing 2018 with 2019, patients categorized as under-triaged by CMM+ISS were homogeneous on age, 82.3 vs. 82.5 years (independent samples t-test, $P = 0.889$), and ISS, median of 17 and rounded means of 21 vs. 19 (Mann-Whitney U test, $P = 0.158$). Arrival SBP differed between 2018-19 with a median of 136 vs. 150 and rounded means of 144 vs. 154 (Mann-Whitney U test, $P = 0.047$).

Under-triaged patients were identified from 1,041 trauma activations and total of 79 patients were as under-triaged by CMM+ISS. Application of the NFTI tool reduced the study period under-triage rate from 7.6% to 0.8% for 1,041 trauma activations ($P < 0.0003$) and 2.5% to 0.3% for 3,123 trauma admissions ($P < 0.0003$). Using NFTI resulted in 71 of the 79 patients having been appropriately triaged. These reclassified patients were determined to have received a partial trauma team activation, trauma consult, or were not a part of the trauma services population.

Following secondary evaluation with NFTI, 2019 under-triage rates declined from 8.2% to 1.1% for 524 trauma activations which includes prehospital activations plus those patients not meeting activation criteria but subsequently discovered to have an injury which meets criteria and "stat" activated ($P < 0.0003$). Under-triage rates decreased from 2.8% to .4% for 1,534 trauma admissions which is a combination of activations plus non activations, ($P < 0.0003$). A total of 43 patients categorized as under-triaged by CMM+ISS, underwent secondary review using NFTI-criteria, which resulted in 37 of the 43 patients being classified as appropriately triaged. Resource utilization was captured in patients that were CMM + ISS > 15, received limited TTA, and NFTI +. [Table 5](#) for NFTI Re-classifications and Outcomes.

Discussion

Trauma centers ensure that appropriate care is provided at the time of injury through improving the process for pre-hospital proficiency and identification of metrics appropriate for TTA, especially in the geriatric population. The trauma system establishes the trauma team activation criteria. The activation and proven need for evaluation can have an impact on the geriatric patient, as well as the trauma system. The needs of these patients can present a challenge to hospital and trauma services' resources. A way to determine appropriate care for the geriatric patient is through performance improvement measures and evaluation of the system as a whole and the use of specific methods such as the CMM + ISS.

Application of NFTI-adjusted triage scores have demonstrated that our level I trauma center had appropriate care and resource allocation. Reductions were observed in under-triage categorizations for geriatric trauma patients. A total of 79 under-triaged geriatric patients were identified with application of CMM. Utilizing NFTI-adjusted triage scores, 71 patients were reclassified as appropriately triaged, only eight patients were determined to have been under-triaged. Improvements of triage score is related to newly implemented practice allowing for triaging designations to be changed if not appropriately categorized by CMM. If patients are under-triaged and found to be NFTI -, then the patient is triaged appropriately under NFTI guidelines; patients over-triaged and found to be NFTI + are triaged correctly. Traditional triage assessment scales misrepresent the actions of trauma centers especially those with high volumes of geriatric patients. The use of ISS and CMM for triage classification resulted

Table 5: 2019 Under-triage reclassifications by NFTI and outcomes.

Total Trauma Activations	524	
Full TTA	481	
No Alert	1	
Consult	15	
ACT/Transfer Alert	27	
	Under-triage Rate	
CMM + ISS > 15 (Under-triaged) (Limited TTA or Less)	43/524 (8.2%)	
NFTI + (Under-triaged)	6/524 (1.1%)	
	Over-triage Rate	
CMM + ISS < 15 (Over-triaged) (Full TTA)	111/524 (21.1%)	
Outcomes	Under-triage	Over-triage
Average of Age	82.4	77.4
Average of ISS	19	6
Average of Arrival GCS	15	14
Average of Arrival SBP	153	138
Sum of ED to OR	0	11
Sum of ED to ICU	4	14
Average of ICU days	1	1
Average LOS of days	5	5
Average of Scene Time	19	22
Average of Scene SBP	157	135

Note: TTA: Trauma Team Activation; CMM: Cribari Matrix Method; ISS: Injury Severity Score; NFTI: Need for Trauma Intervention; GCS: Glasgow Coma Score; SBP: Systolic Blood Pressure; ED: Emergency Department; OR: Operating Room; ICU: Intensive Care Unit; LOS: Length of Stay

in a substantial misrepresentation of the urgent care provided by our institution, particularly those classified as under-triaged patients. However, using NFTI in addition to current triage protocols showed our institution had a significantly lower under-triage rate at 1.1% compared to an acceptable rate of 5%. Categorizing appropriate care as under-triaged results in an overburden on the trauma system which is required to increase activations. This results in resource depletion simply to meet a statistical requirement.

A performance improvement initiative involves reviewing case scenarios and identifying lapses in patient care that can be discussed and reviewed in a secondary or tertiary format. During a performance improvement initiative, inaccurate determination of TTA appropriateness by ISS and CMM can call for a change in assessing triage appropriateness for geriatric patients. The addition of the NFTI criteria has demonstrated its usefulness in measuring components of major trauma missed by ISS and can be the new standard for analyzing the appropriateness of care delivered by trauma services in terms of matching resources to patient needs. Applying NFTI-adjusted model enhances the ability of the CMM(+ISS) model to detect major trauma in the geriatric population both in terms of both over triage which has been previously reported as well as under triage which is the focus of this study.

Thus, when reviewing a center's triage performance, addition of NFTI criteria can ensure that patient care is appropriate, and the trauma center is utilizing resources appropriately.

Several limitations exist, namely, the retrospective study design and data from a single center. Further research on a multi-center scale is warranted to comprehensively evaluate NFTI-adjusted score performance. Trauma team activation criteria is specific to each institution and are utilized to appropriately allocate resources for each trauma patient. The activation criteria may differ from institution to institution but many of the criteria are mandated by the state. It is within the mandated criteria which many of the geriatric trauma patients fall out resulting in under triage classification as they do not meet activation criteria by mechanism or physiology until their routine evaluation is already complete and the anatomic derangement is identified. This model was developed based on the capabilities of the trauma center and tailored to the surrounding patient population.

There is not a significant body of research in under-triage using the NFTI criteria as an evaluation tool for ever increasing geriatric trauma population. The retrospective nature of the study is less impactful since NFTI itself is a retrospective tool. NFTI measures interventions provided to an individual patient within

a time context, hence, proper documentation of services provided, and the times are important. Future research can investigate the influence of comorbidities and mechanism and complications of injury on the determination of under-triage. Patient outcomes should also be reviewed within the context of and consistency with the assigned triage classification matched with resource requirements.

NFTI has demonstrated its usefulness in measuring components of major trauma missed by ISS and can be the new standard for evaluating trauma services ability to triage patients. The NFTI in addition to standard triage assessment can help improve a trauma system's ability for self-analysis and ensure a system where the right resources can reach the right patient at the right time. Although overall over- and under-triage rates are not overtly affected, when drilling down on those classified as under-triaged, an institution can determine if appropriate resources were allocated based on NFTI. The trauma center can then either modify activation criteria which may eventually result in increasing over-triage rates in order to avoid future verification citations or simply justify their existing overall under-triage rate as appropriate based upon NFTI and patient outcomes.

Author Contributions

All authors contributed to data collection, design, analysis, interpretation, article preparation, and critical review.

Disclosure

All authors declare no funding or conflicts of interest.

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