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Spectrum of Trauma Care in the State of Ohio: Assessment and Improvement of Quality of Care

ANNUAL PROJECT REPORT

Submitted to

Division of Emergency Medical Services (EMS)
Ohio Department of Public Safety (ODPS)

Submitted by

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Executive Summary

The trauma triage system in the state of Ohio has not quite achieved their objectives of care access and delivery. This has prevented the growth and improvement of the current system beyond its present status. The primary objective of this research was to contribute to the state of Ohio's goals of improving trauma system by focusing on two key aims: (i) identifying over- and under-triage rates and study both clinical and system factors that may be affecting these rates, and (ii) deriving a statistical model and compare it with the current system and that of the National Field Triage Decision Scheme.

Our multidisciplinary team of medical and engineering researchers analyzed nearly 35,631 patient records from the 2008-12 data available from the ODPS that comprised of both EMSIRS and Trauma Registry data elements for each patient record. Over- and under-triage errors were calculated using the Injury Severity Score (ISS) method where over-triage (OT) was defined as the proportion of patients with ISS≤15 and were transported to a Level I/II trauma center. Similarly, under-triage (UT) was defined as the proportion of patients with ISS>15 and were transported to a Level 3/Non-trauma center (NTC).

Key findings from our study included the following. *First*, the mean over-triage (OT) and under-triage (UT) rates across all 5 years were 43.03% and 3.06%; these rates were stable year-to-year. It is essential to note that according to national trauma guidelines, the accepted range for over-triage is from 25-35%. The average over-triage rate observed for the state of Ohio for 5-year period, however, was significantly higher than that. Second, the over- and under-triage errors showed specific patterns per regions. For instance, regions 7 and 8 experienced the highest rates of UT and nearly zero OT. This might be due to the placement of trauma centers. If there are no L1/L2 trauma centers nearby these regions, then all trauma patients would have to be sent to the nearest non-trauma facilities. Similarly, regions 2 and 5 experienced the least UT errors and the highest OT errors probably due to the availability of large number of trauma centers. Thus, placement of trauma

centers could potentially affect quality, care access, and resource utilization in any trauma system. *Third,* the average mortality rate for 5-year period was 5.1%; nearly 0.52% of under-triaged and 0.81% of over-triaged patients died. *Fourth*, system level factors such as patient/family preference, proximity of hospital, and protocol were the top three reasons for triage decisions. *Fifth*, while blunt injury type was associated with higher triage errors (both OT and UT), an increase in patient's age appeared highly correlated with the patient's preference for a hospital type. *Finally*, the statistical model derived from EMSIRS 2, protocol only, dataset of 817 patients revealed significant factors that may be affecting triage decisions. Although it achieved nearly same levels of UT and OT rates, it can be viewed as a standardized approach compared to the current decentralized, non-standardized, approach adopted by EMS providers in the state; the model.

In summary, our study addresses several concerns related to on-field trauma triage currently under review within the state of Ohio. Our findings suggest that trauma care in the state of Ohio could be improved further by reducing the triage errors and resource utilization. Further, the study also proposed a statistical model to help standardize the trauma triage in the state. We strongly believe that our findings would help the state of Ohio in achieving their goal of providing a "Framework for Improving Ohio's Trauma System" that was included in the Ohio EMS 2015 Strategic Plan.

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1. Investigators

Priti Parikh, PhD (Role PI): Priti Parikh serves as a Research Director and faculty in the Department of Surgery at WSU. She has significant experience in healthcare systems and informatics areas where she has worked on predicting discharge disposition at a point of admission of trauma patients, system analysis of surgical operations, and developing ontologies to answer critical questions. She has over 15 peer-reviewed articles with many presentations and talks at national and international conferences.

Melissa Whitmill, MD (Role, co-PI): Melissa Whitmill has been a trauma and critical care surgeon for the past 6 years. Additionally she is currently a Medical Director of the Surgical Intensive Care Unit at Miami Valley Hospital. In these roles, she has been involved in the entire spectrum of patient care, including pre-hospital care, hospital care, and rehabilitation.

Randy Woods, MD (Role, co-PI): Randy Woods is a trauma surgeon and researcher for more than 15 years. As a trauma surgeon, he has expertise about the prehospital setting, to include inpatient care through rehabilitation. He is a fellow of the American College of Surgeons (ACS), and served as President of the Ohio Chapter of the ACS and also elected as a Governor to the ACS. He is an active researcher and has many peer-reviewed papers and publications.

Kimberly Hendershot, MD (Role, co-PI): Kimberly Hendershot has an active practice in the fields of trauma surgery, emergency general surgery, and surgical intensive care for the past 7 years. During that time, she has been involved in the entire spectrum of care for the injured patient, from injury prevention to pre-hospital care to hospital care to rehabilitation.

Pratik J. Parikh, PhD (Role, co-PI): For over 6 years, Pratik Parikh and his team have focused on exploring the interdependencies between various healthcare subsystems and identifying alternate methods to improve the system performance. He has been PI and/or Co-PI on federal and industry grants and has over 25 peer-reviewed journal and conference articles.

2. Study Rationale and Objectives

The primary objective of this research is to contribute to the state of Ohio's goals of improving the trauma system. Specifically, we plan to focus on the entire spectrum of trauma care through the study of care access, quality, and safety experienced by a trauma patient. The optimal triage of trauma patients has been the source of vigorous debate over the years. In the state of Ohio, the trauma system has experienced less-than-desirable goals towards improving trauma patient care and there has been no apparent decrease in potentially preventable deaths since 1999. These issues may likely be due to inefficient and/or poorly-defined triage regulations [6].

'Over-triage' (i.e., transporting less injured patients to major trauma centers, such as a Level I or II center) and 'under-triage' (i.e., transporting severely injured patients to a Level III or non-trauma center (NTC)) errors pose significant problems to any trauma system. As per Ohio's 2013 Trauma System Consultation Report "no knowledge exists regarding over- and under-triage rates and issues" for the state [1]. While clinical factors (e.g., patient's physiologic factors on scene, type of injuries) should determine the triage decision, often system-level factors (e.g., patient's choice, proximity to a trauma center) and non-physiologic factors (e.g., mechanism of injury alone) affect the EMS decision to transfer a patient from the scene to a hospital. Such limitations within the current system have significantly affected performance and statewide resource utilization. In response, the state of Ohio included "Framework for Improving Ohio's Trauma System" as one of the goals of the Ohio *EMS 2015 Strategic Plan* [1]. Our research agenda was to contribute to these goals.

3. Specific Aims

Following are the specific aims that we identified and planned in the original proposal:

- *Aim 1: Study over- and under-triage rates.* Using the state level trauma and emergency medical services (EMS) data from Ohio Department of Public Safety (ODPS), we will study pre-hospital over- and under-triage rates for the state of Ohio and also reveal a trend over the last 5 years. This will enable us to identify both clinical- and system-level factors contributing to over- and under-triage in the state of Ohio.

- *Aim 2: Develop and validate a new triage model.* We plan to utilize the information that is readily available to EMS providers in the field (such as Glasgow Coma Scale, blood pressure, respiratory rate, mechanism of injury, and/or anatomical factors) to develop a novel statistical model to accurately triage a trauma patient in the field.

4. Significance

The question regarding trauma triage and system utilization is a complex problem that the current literature does not address effectively [8]. Trauma care is the second highest contributor to total U.S. health care spending with an estimated cost of more than $163 billion (in 2008 dollars), which represents approximately 10% of the total US medical expenditures [5, 11]. The over- and under-triage rates play a significant role in trauma care costs. Therefore, more efficiently matching patients' needs to hospitals' resources and capabilities is vital if the value of a trauma system is to be improved. Recently, Newgard and others observed a 34.4% over-triage rate across 7 regions (94 EMS, 122 hospitals, and 301,214 patients) and suggested that improved triage methods could save up to $136.7 million annually [5]. Furthermore, researchers have also studied secondary over-triage; i.e., the phenomenon where a patient is discharged home shortly after transfer from another hospital. The secondary over-triage rates also help assess the quality and efficiency of trauma care and resource utilization [7].

Development of triage methods in the trauma system, however, remains a difficult problem for most states. The trauma system in the state of Ohio was created following an exclusive design where trauma centers could provide access within one hour for 99% of the population and 98% of the state's geographic area. However, it has not achieved the desired goals of care, likely due to inefficient pre-hospital triage guidelines. The annual case-fatality rate, since 1999, has been 4.2% with no decrease in potentially preventable deaths [6]. The state law requires that all severely injured patients be transported to a designated trauma center. Since the term 'severely injured' is not defined uniformly by trauma centers, a significant number of injured patients are actually transported to Level III or non-trauma centers. No knowledge, however, exists about pre-hospital over- and under-triage rates, issues, and resource utilization for the state of Ohio [1]. Such limitations within the current trauma system in the state of Ohio have prevented it from growing and improving beyond its present status.

Previous studies have shown that improved triage methods are required to enhance trauma patient care and resource utilization. A variety of methods and scores exist in the current literature for triaging trauma patients, such as Trauma Score (TS), Revised Trauma Score (rTS), Baxt Trauma Triage Rule (TTR), CRAMS (Circulation, Respiration, Abdomen, Motor, Speech) scale, and Glasgow Coma Score (GCS) [8]. Moreover, many studies have also focused on using various physiologic, anatomic, mechanistic, and/or demographic factors for triaging trauma patients. However, they all suggest that for field triage a combination of different factors and scores should be used to achieve the highest sensitivity (i.e., proportion of high severity trauma patients identified as such) and specificity (i.e., proportion of low severity trauma patients identified as such) [2-4]. Some 'mistriage' is, nevertheless, unavoidable as it depends not only on clinical factors, but also on system-level factors (e.g., patient's choice, proximity to a trauma center). The latter sometimes plays a key role in triaging patients on the field. Thus, there is clearly a gap in the current literature on an optimal solution to this very complex problem.

5. Approach

As a part of the proposal, we received 2008-2012 data (both EMSIRS 1 and 2 merged with Trauma Registry) from ODPS, which accounted to 40,819 patient records. Figure 1 shows the collaborative approach and responsibilities of each investigator for the project. The WSU investigators had several teleconferences with ODPS personnel (Mr. Tim Erskine and Mr. Schuyler Schmidt) to understand the data collection/extraction process. Based on these discussions, we excluded some of the patient records that did not have values of Injury Severity Scores (ISS). Table

1 shows the number of records removed per year. The total number of patient records finally included in our analysis of the 2008-2012 dataset was 35,631 for EMSIRS 1 and 2.

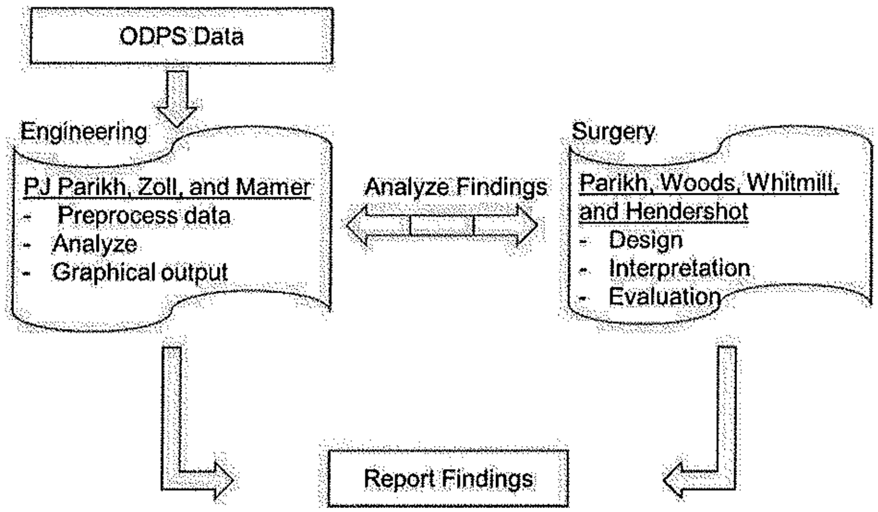

Figure 1: Our collaborative approach

Table 1. Number of patients removed per year (removal criteria: ISS=99)

Year	2008	2009	2010	2011	2012
Total (EMSIRS 1 + 2)	8881	8293	8065	7405	8175
# removed	1305	1152	851	854	1026
Final (EMSIRS 1 + 2)	7576	7141	7214	6551	7149

6. Results

We organize the key findings from our analysis of this data corresponding to each aim. Additional findings can be found in the appendix at the end of this report.

6.1 Aim 1a: Study the trauma triage and other trends

We studied the trauma triage trend by years and by county. We observed that the total triage numbers (Y-axis on the *right*) decreased from 2008 to 2012 (Figure 2). The rates of over- and under-triage (Y-axis on the *left*), however, appeared fairly stable over the years. We also studied the mortality and found that average mortality rate for 5-year period was 5.1% (Figure 3). As shown in Figure 4, in 2012 overall 4.8% patients died. Moreover, 0.52% of under-triaged and 0.81% of over-triaged patients died. Trauma triage trend by county showed that the top three counties that had the highest total triages were (i) Montgomery, (ii) Hamilton, and (iii) Summit (Figure 4).

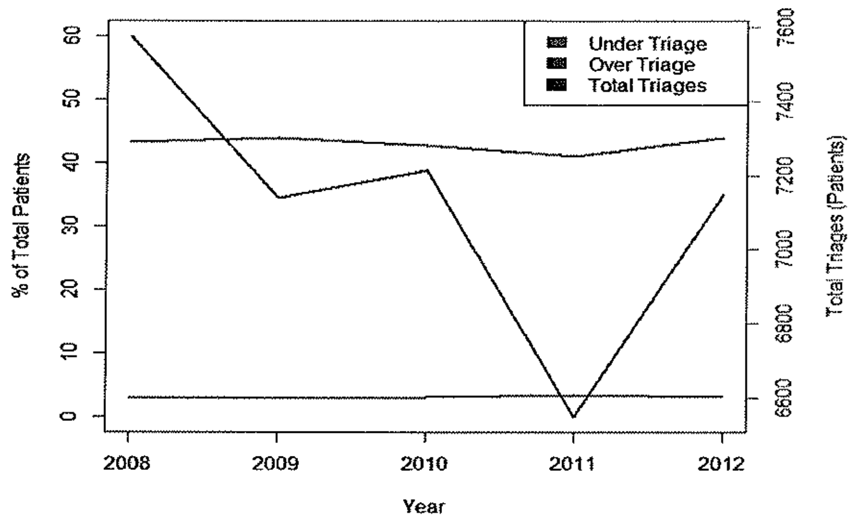

Figure 2: Annual trend of total triage and Over/Under Triage (EMSIRS 1+2)

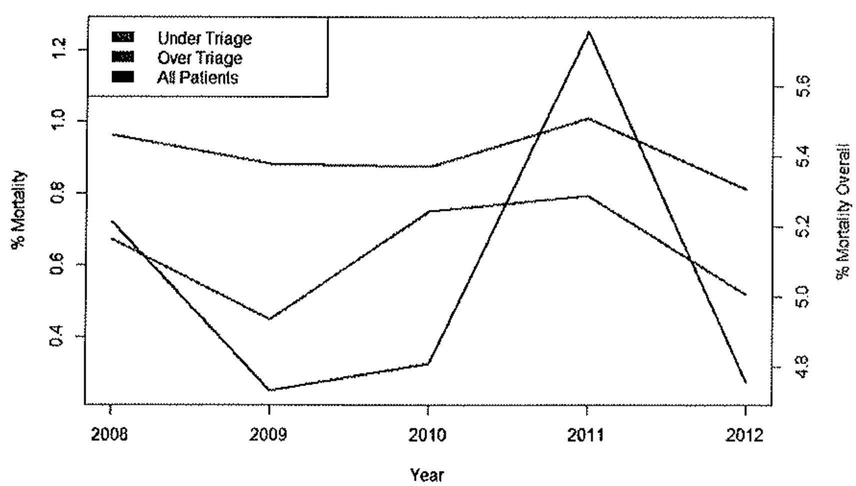

Figure 3: Annual trend of mortality of trauma patients (EMSIRS 1+2)

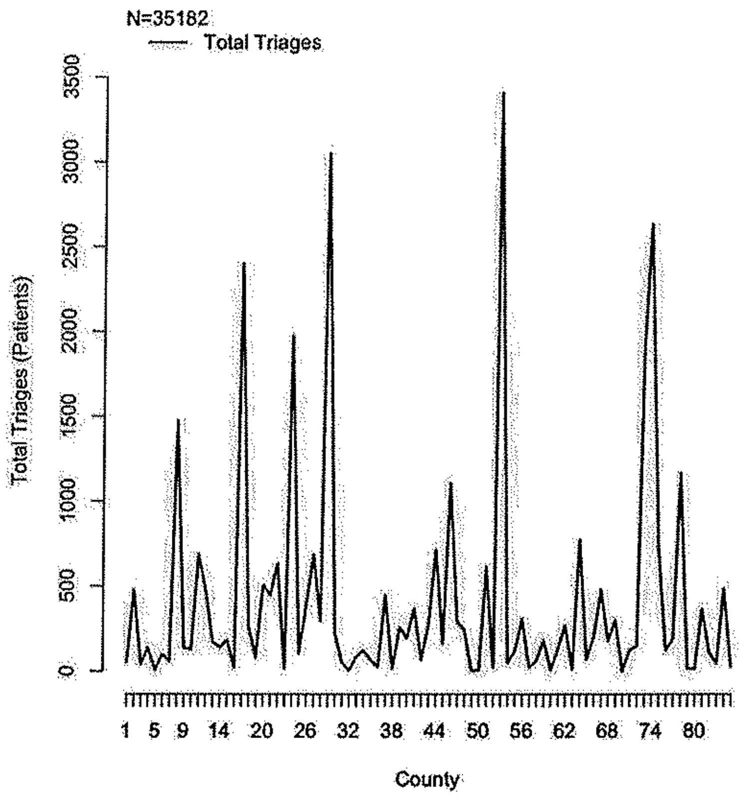

Figure 4: Total Triages by County

Note: County names and exact values associated with the X-axis in the graph are below.

[1]	"Adams"	"Allen"	"Ashland"	"Ashtabula"	"Athens"	"Auglaize"
[7]	"Brown"	"Butler"	"Carroll"	"Champaign"	"Clark"	"Clermont"
[13]	"Clinton"	"Columbiana"	"Coshocton"	"Crawford"	"Cuyahoga"	"Darke"
[19]	"Defiance"	"Delaware"	"Erie"	"Fairfield"	"Fayette"	"Franklin"
[25]	"Fulton"	"Geauga"	"Greene"	"Guernsey"	"Hamilton"	"Hancock"
[31]	"Hardin"	"Harrison"	"Henry"	"Highland"	"Hocking"	"Holmes"
[37]	"Huron"	"Jackson"	"Knox"	"Lake"	"Licking"	"Logan"
[43]	"Lorain"	"Lucas"	"Madison"	"Mahoning"	"Marion"	"Medina"
[49]	"Meigs"	"Mercer"	"Miami"	"Monroe"	"Montgomery"	"Morgan"
[55]	"Morrow"	"Muskingum"	"Not Applicable"	"Other"	"Ottawa"	"Paulding"
[61]	"Perry"	"Pickaway"	"Pike"	"Portage"	"Preble"	"Putnam"
[67]	"Richland"	"Ross"	"Sandusky"	"Scioto"	"Seneca"	"Shelby"
[73]	"Stark"	"Summit"	"Trumbull"	"Tuscarawas"	"Union"	"Unknown"
[79]	"Van Wert"	"Vinton"	"Warren"	"Wayne"	"Williams"	"Wood"
[85]	"Wyandot"					

[1]	52	480	41	139	8	99	61	1476	139	129	689	481	175	142	184	21	2401
[18]	263	82	506	449	632	17	1975	108	389	685	297	3049	224	54	5	84	124
[35]	65	27	448	17	257	195	369	69	275	714	165	1107	290	241	2	7	613
[52]	25	3405	49	116	309	21	60	183	8	132	269	14	772	70	202	480	178
[69]	299	2	123	148	1911	2632	713	123	188	1163	17	15	365	111	45	486	27

6.2 Aim 1b: Study pre-hospital over- and under-triage rates

For the datasets, we studied over- and under-triage rates for 2008-2012. We used the ISS method to calculate over- and under-triage. For example, patients who had ISS<16, but taken to Trauma Level1/2 Center were considered as *over-triage* patients. On the other hand, patients who had ISS≥16, but were taken to Trauma Level 3/NTC were considered as *under-triage* patients. Our analysis of the 2008-2012 dataset indicates the following:

- The over- and under-triage rates in the EMSIRS 1 and 2 dataset for all the patients were 43.03% and 3.06%, respectively (Table 2).
- The homeland security regions with high UT seem to have low OT and vice versa (Figure 5).
- The top three counties with the highest under-triage rates are: (i) Wyandot (31.9%), (ii) Guernsey (22.1%), and (iii) Holmes (19.9%) (Figure 6).
- There were several counties, such as Hancock, Madison, Mahoning, Richland, and Tuscarawas that had 100% over-triage rates (Figure 7). Other counties with high OT included: (i) Coshocton (89.3%), (ii) Allen (83.5%), and (iii) Portage (83.3%).
- OT and UT rates are not related to patient's age. The rate remains stable when stratified through patient's age (Figure 7).

Table 2: Triage of all patients (EMSIRS 1+2, N=35,631)

Ideal hospital-type from scene

		L1/L2	L3/NTC
Actual hospital-type from scene	**L1/L2**	Correct (4501) 12.63%	*Over-Triage (15331) 43.03%*
	L3/NTC	*Under-Triage (1092) 3.06%*	Correct (14707) 41.28%

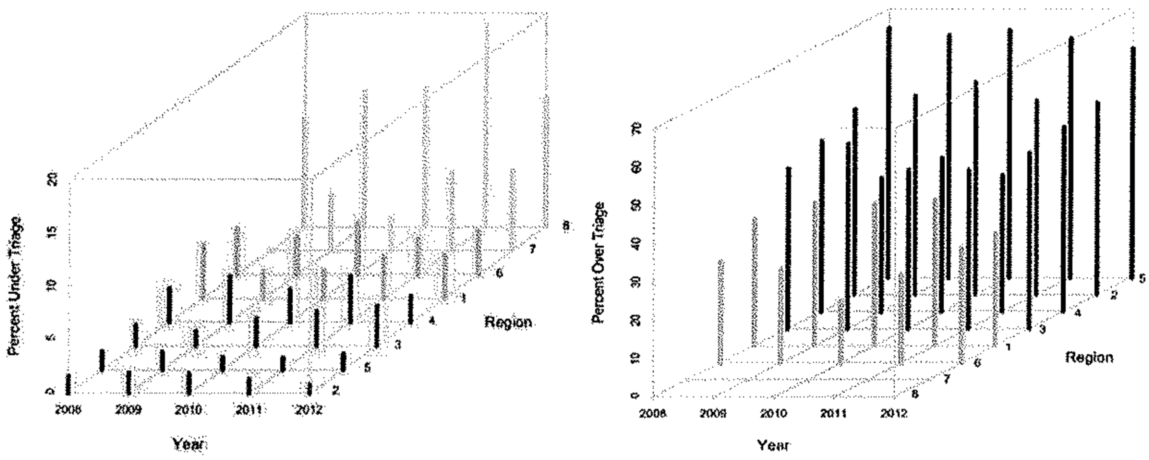

Figure 5: Under- and Over-Triage rates per homeland security regions

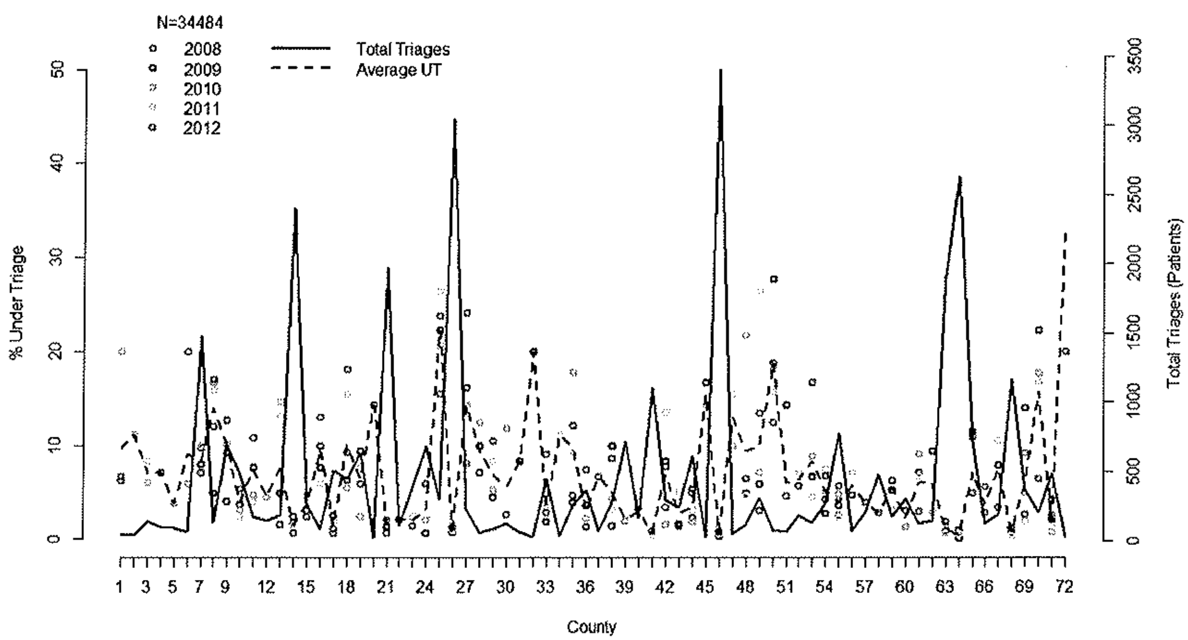

Figure 6: Under-Triage rates by county and year

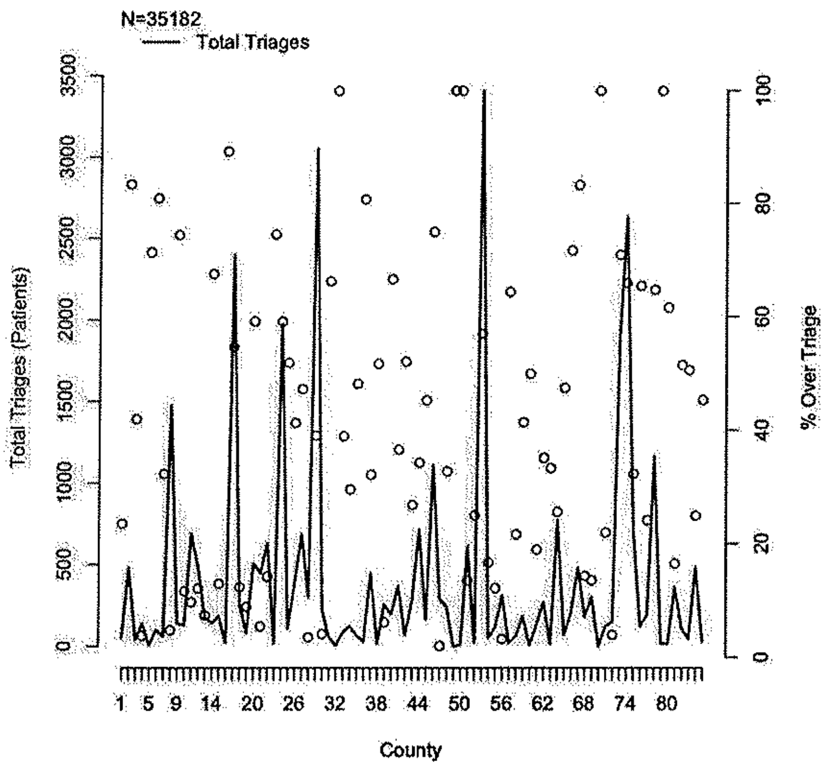

Figure 7: Over-Triage rates by county and year

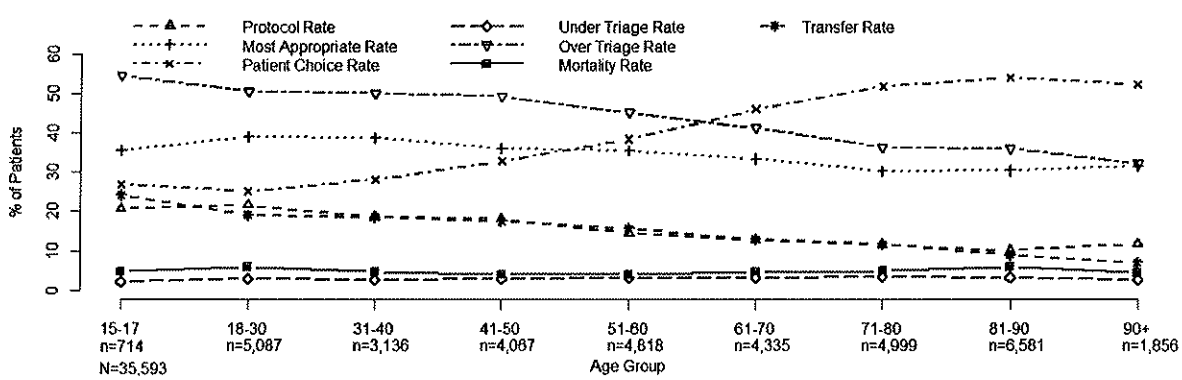

Figure 8: Trauma triage pattern stratified by patient's Age

Factors affecting triage decisions: We found that the top three reasons for high over-triage rate were (i) patient's preference, (ii) proximity, and (iii) triage protocol (Figure 9). Patient's or family preference accounted for approximately 45% of over-triages. Similarly, for under-triage errors, the top reasons were (i) proximity, (ii) patient's preference, and (iii) triage protocol

(Figure 10). When we analyzed the data based on injury type, we observed that blunt injuries are primarily associated with triage errors (Figure 11). Moreover, when stratified through age, we observed that patient's preference rate increases with age (Figure 8).

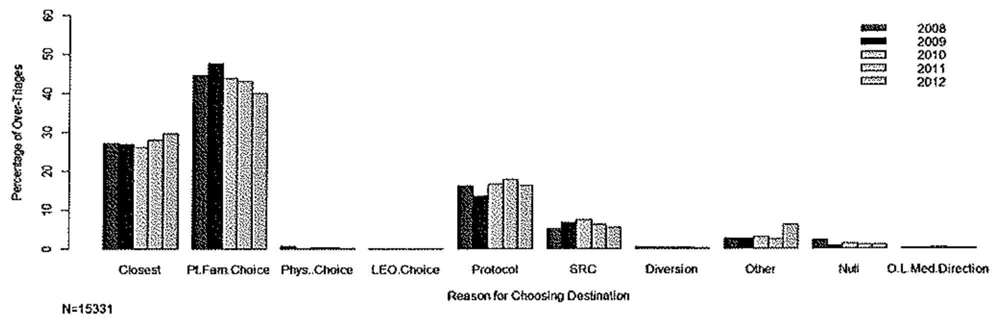

Figure 9: System level factors affecting Over-Triage rates

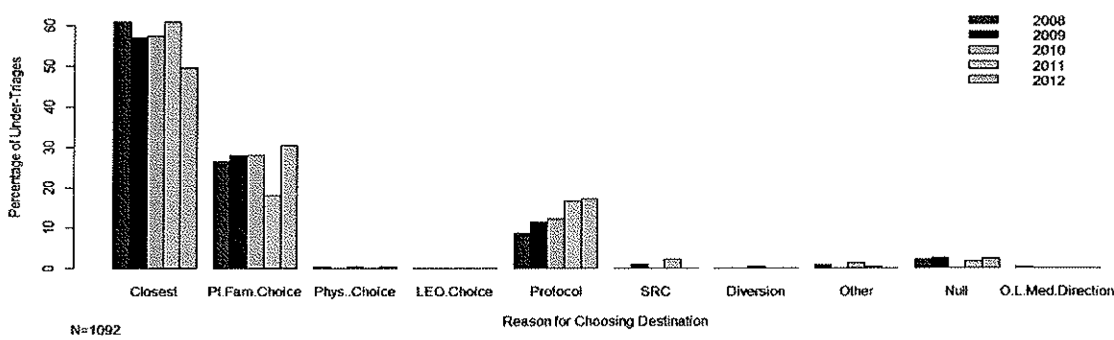

Figure 10: System level factors affecting Under-Triage rates

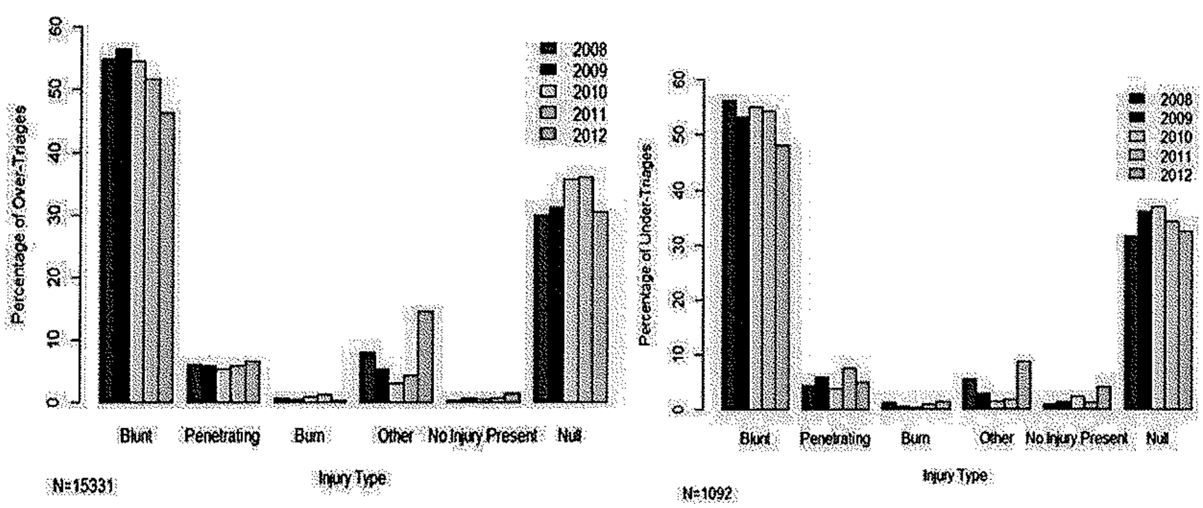

Figure 11: Over- and Under-triage rates by Injury Type

6.3 Aim 2: Investigate the development of a new trauma triage model

As mentioned above, the primary reason for triage errors was either patient/family choice or proximity to the accident site. Since these reasons were at the system level and so could not be controlled in developing new models, we extracted data of patients who were triaged based on protocol and used those for modeling. Specifically, we used EMSIRS2, 2008-12, "protocol-only" records. A final set of 817 patient records were obtained after excluding records with missing values and 2nd transfers. Using this dataset, we accomplished this aim in the following way:

- Step 1: Identify the UT and OT rates based on these data; we refer to them as "Actual."
- Step 2: We then used the Field Triage Decision Scheme – The National Trauma Triage Protocol (proposed in 2006 by the American College of Surgeons-Committee on Trauma and the National Highway Traffic Safety Administration) [9,10] to evaluate its applicability this dataset. The idea was to judge whether or not the "NFTDS" would have yielded better outcomes (UT and OT rates) if it were used since 2008.
- Step 3: Finally, we built a new logistic regression based model using the train-test methodology, and compared the outcomes from this model with the "Actual" and "NFTDS" approaches.

Below we describe each of these steps in appropriate detail.

6.3.1. UT and OT rates based on "Actual"

While we were told that there is no standardized protocol that EMS providers follow in the State of Ohio, each region seems to have their own version for triaging trauma patients on the scene. After correspondence with the ODPS-EMS personnel, we realized that it would be nearly impossible for us to decipher the actual decision making process even for the 817 records that indicated "protocol" as the criterion. With that understanding, we went ahead and used the process of identifying the UT and OT in the manner consistent with the previous sections. That is, we used the ISS score of ≥16 to indicate severe injuries and destined to L1/L2 versus ≤15 as more appropriate for L3/NTC. The following table indicates the UT and OT rates.

	% UT	% OT	% Correct (L1/L2)	% Correct (L3/NTC)
Actual	4.04	38.31	22.15	35.5

6.3.2. Evaluating the National Field Triage Decision Scheme (NFTDS)

One of the agendas for the NFTDS was to be the foundation for the development, implementation, and evaluation of local and regional field triage protocols. While not knowing whether or not the EMS providers in the State of Ohio used NFTDS to develop and implement their specific trauma triage decision making process, we wanted to evaluate the basic version of NFTDS on this data. *Could this standardized protocol have provided improved outcomes if it were being used by the EMS providers on this 817 patient records since 2008?*

To answer this question, we first had to understand how the NFTDS works and then map the factors stated therein with the factors available in our dataset. From what we know, the NFTDS is a hierarchical decision making process involving four steps, with each step either indicating the patient must be taken to a trauma center (L1/L2 in our case) or further evaluation may be required. When in doubt, the EMS providers are recommended to take the patient to a trauma center.

During the mapping of factors in the NFTDS and those available to us, we realized that either some factors were missing from our dataset or they had to be mapped using indirect measures. Appendix A summarizes our attempt to perform this mapping. Based on the directly available or indirect derivation of applicable factors, *we found the UT and OT rates to be 2.82% and 64.02%, respectively*. These are fairly different from the "Actual" – we discuss this a bit more in detail in Section 6.3.4.

6.3.3. A new, statistical, trauma triage model

Our final step as part of Aim 2 was to investigate if we could derive a new trauma triage model based on statistically significant factors. The idea was to that if such a model could be developed, then it can then be converted into a score which then can be tested in the field as an alternate, better, and standardized protocol throughout the state of Ohio. While there are several ways in which a prediction model can be developed, we opted for the standard logistic regression approach as it does not assume a linear relationship between the outcome and predictors, can handle nonlinear effects, and the predictors themselves need not be normally distributed. While we did not have a very large dataset, 817 records was good enough for us to split it into a 70-30 train-test approach; i.e., about 70% of the data (570 records) were used for training the model and the rest for testing the model. We ensured that the train and test datasets were reasonably balanced. The outcome was dichotomous; 1, if L1/L2 was appropriate, and 0, if L3/NTC was appropriate. This was determined using the ISS score for each record.

In consultation with our surgery and EMS colleagues, we determined that some of these factors are typically measured immediately upon EMS arrival and prompt the trauma triage decision, while the others are measured subsequently (and do not necessarily affect or alter this decision). The following factors (Table 3) were deemed to be vital and worth inclusion as potential predictors; total GCS score and IRR were derived per the NFTDS protocol.

Table 3. Factors deemed appropriate for inclusion as possible predictors

Field	Entries in the Field
Patient Age	Continuous
Patient Gender	650=Male, 655=Female, -10=Unknown
Condition Code	8001=Severe Abdominal Pain, 8010=Difficulty Breathing, 8012=Chest Pain, 8029=Neurologic Distress, etc.
Complaint Anatomic Location	1305=Abdomen, 1310=Back, 1315=Chest, 1320=Extremity-Lower, etc.
Patient's Primary Symptom	1405=Bleeding, 1410=Breathing Problem, 1415=Change in Responsiveness, 1420=Choking, etc.
Provider's Primary Impression	1615=Abdominal Pain/Problems, 1620=Airway Obstruction, 1625=Allergic Reaction, etc.
Cause of Patient's Injury	1885=Bites, 9500=Aircraft Related Accident, 9505=Bicycle Accident, 9515=Chemical Poisoning, etc.
Injury Type	2035=Blunt, 2050=Penetrating, 2040=Burns, 2045=Other, -25=No Injury Present
Initial Systolic Blood Pressure	Continuous
Initial Pulse Rate	Continuous
Total GCS Score	Derived per NFTDS, converted to binary (1, if <14)
Initial Respiratory Rate	Derived per NFTDS, converted to binary (1, if <10 or >29)

Table 4 lists factors that were statistically significant (at α=0.05) in the final model. The odds ratios indicate the odds of a patient exhibiting that factor to be taken to L1/L2 versus L3/NTC. For instance, if a patient's combined GCS score was <14, then that patient is >2.8 times (odds ratio = 2.82) more likely to go to an L1/L2 than L3/NTC

Table 4. Significant factors from the Logistic Regression model (N=817)

Factor	Specific Field in the Dataset	In NFTDS?	Estimate	*p*-Value	Odds Ratio	95% Conf Interval
Severe Pain	Code_8030	No	0.5334	0.0243	2.907	1.105 – 7.207
Facture or Dislocation	Code_8046	Yes*	0.4946	0.0038	2.690	1.384 – 5.301
Complaint in Abdomen	Complaint_A_Location_1305	No	0.6659	0.0438	3.788	0.975 – 13.518
Change in Responsiveness	Complaint_A_Location_1310	No	0.7295	0.0025	4.302	1.662 – 11.143
Complaint in Chest	Complaint_A_Location_1315	No	1.0262	<.0001	7.787	2.939 – 20.882
Complaint in Back	Complaint_A_Location_1330	No	0.5187	0.0033	2.822	1.436 – 5.756
Complaint in Whole Body/General	Complaint_A_Location_1340	No	0.6389	0.0027	3.589	1.569 – 8.397
Complaint in Head	P_Symptom_1415	No	0.3562	0.0372	2.039	1.040 – 3.988
Falls	Cause_Injury_9550	Yes**	-0.4293	0.0037	0.424	0.233 - 0.746
Blunt Injury Type	Injury_Type_2035	No	0.4586	0.0049	2.502	1.340 – 4.825
Penetrating Injury Type	Injury_Type_2050	Yes	0.5750	0.0308	3.158	1.090 – 8.895
Initial Pulse Rate	IPR	No	-0.0085	0.0603	0.992	0.983 – 1.000
Initial Respiratory Rate	IRR	Yes	0.5455	0.0017	2.977	1.509 – 5.925
Combined Glasgow Coma Score	GCS (verbal, motor, and eye)	Yes	0.5204	0.0003	2.832	1.608 – 5.018

* NFTDS indicates "two or more proximal long-bone fractures" and "pelvic fractures"
**NFTDS indicates ">20 ft are considered to be severe" and so to be taken to L1/L2.

The following things must be noted though. First, note that there are 5 factors that appear to be common between our model and the NFTDS. For the other factors which we found significant, we could not identify a direct or indirect factor in NFTDS. Second, we retained "IPR" even though its p-value was slightly higher than 0.05 owing to its medical significance. Finally, although "Falls" was identified as significant, the interpretation of it is a little intriguing in our model compared to NFTDS. In the NFTDS, if a fall was recorded to be >20ft, then the patient would be taken to L1/L2. However, in our dataset the height of a fall was not available. In that case, the model seems to indicate that a fall suggested a decision in favor of L3/NTC. This finding must be considered carefully in the current model and is worth further investigation. The area under receiver operating curve (AUC or ROC) was found to be 0.76, which indicates a very good model. The AUC corresponding to the test dataset (247 records) was comparable (0.72) suggesting model's generalizability.

7. Discussion

Below we provide summary of findings and discuss our results for both Aim 1 and 2.

7.1 Findings from Aim 1

Analysis of 2008-2012 data showed that several factors affect trauma triage decisions. These include system level factors, such as patient/family preference and proximity of location, along with patient level factors, such as triage protocol and mechanism of injury. It is interesting to note that in the state of Ohio, only about 50% of the time trauma patients are triaged appropriately. According to national trauma guidelines [9], the accepted range for over-triage is from 25-35%. The average over-triage rate observed for the state of Ohio for 5-year period, however, was significantly higher than that (~43%). Since patient/family preference is the number one reason for high over-triage rates in the state of Ohio, steps need to be taken to educate patients/families and EMS providers. A score based system might be able to help the EMS providers and might give some insights and objectivity in discussion with patients to help them select the appropriate facility for their optimum care.

The detailed analysis of over- and under-triage errors based on regions and/or counties suggest that regions with highest under-triage had the lowest over-triage errors and vice versa. This suggests that the placement and location of trauma centers in the state of Ohio is probably not adequate. There are some regions where no trauma center is available, and so have the highest rate of under-triage. On the other hand, some regions have more trauma centers than needed so very high rate of over-triage. A systematic analysis of placement of trauma centers, therefore, would certainly help overcome such errors and resource utilization in the future.

7.2 Findings from Aim 2

We now summarize the findings based on our research as part of Aim 2. Recall, we used 817 patient records obtained from EMSIRS2 "protocol" only data for the period 2008-12. We analyzed three approaches, "Actual," "NFTDS," and our proposed statistical model, and summarize the resulting UT and OT rates in the table below.

Table 5. Comparison of three approaches on 2008-12 EMSIRS 2 "protocol" dataset

Approach	% UT	% OT	Remarks
Actual	4.04	38.31	As realized during 2008-12
NFTDS	2.82	64.02	If NFTDS were used
Statistical Model			
vs. Actual	--	40.18	For similar % UT
vs. Actual	4.74	--	For similar % OT
vs. NFTDS	--	43.68	For similar % UT
vs. NFTDS	0.18	--	For similar % OT

It is worth noting that while the NFTDS is a standardized protocol that is relatively easy to understand and implement, it would have resulted in a much lower UT rate (2.82%) compared to the "Actual" values; however, that could have been at the cost of a much higher OT rate (64.02%). So there is no conclusive evidence that the NFTDS would have been a better or worse model compared to the current, non-standardized, protocol used by EMS providers in the State of Ohio.

Comparing the findings from the statistical model, the story is much different. First, when comparing the model to the "Actual" values, we see that it is comparable for similar UT or OT rates. That is, the model tends to perform very similar to the "Actual" system. On one hand, this means that now there is a standardized approach to achieve nearly identical system performance compared to the current one. However, this also means that the statistical model could not improve upon the current performance either. We avoided exploring more advanced models as they tend to behave like a black-box model; possibly higher prediction quality, but poor interpretability. Second, the statistical model clearly surpassed the UT and OT measures that would have been achieved had NFTDS been used. This means that if a standardized model were to be used for the State of Ohio, then a model proposed by our research would yield better outcomes.

8. Summary and Recommendations

The optimal triage of trauma patients has been a source of vigorous debate over the years. While clinical factors should determine the triage decision, often system-level factors and non-physiologic factors affect the EMS decision to transfer a patient from the scene to a hospital. It is, therefore, essential to study the state's trauma system to identify any such limitations that could significantly affect performance and statewide resource utilization.

While the trauma triage system in the state of Ohio was created for increased accessibility of trauma care to severely injured patients, it has not quite achieved these objectives. This has prevented the growth and improvement of the current system beyond its present status. The primary objective of this research was to focus on two key aims: (i) identify over- and under-triage rates and study both clinical and system factors that may be affecting these rates, and (ii) derive a statistical model and compare it with the current system and that of the Field Triage Decision Scheme. Our multidisciplinary team of medical and engineering researchers analyzed nearly 35,631 patient records from the 2008-12 data available from the ODPS that comprised of both EMSIRS and Trauma Registry data elements for each patient record. The following are the key findings:

- The mean over- and under-triage rates across all 5 years were 43.03% and 3.06%; these rates were stable year-to-year.

- The average mortality rate for 5-year period was 5.1%; nearly 0.52% of under-triaged and 0.81% of over-triaged patients died.
- System level factors such as patient preference, proximity of hospital, and protocol were the top three reasons for triage decisions.
- While blunt injury type was associated with higher triage errors (both OT and UT), an increase in patient's age appeared highly correlated with the patient's preference for a hospital type.
- On the EMSIRS 2, protocol only, dataset of 817 patients, the statistical model revealed significant factors that may be affecting triage decisions. Although it achieved nearly same levels of UT and OT rates, it can be viewed as a standardized approach compared to the current decentralized, non-standardized, approach adopted by EMS providers in the state; the model.

Further analysis of the data revealed several important aspects of the trauma system. For instance, nearly 15.45% patients out of 7576 trauma patients in 2008 were transferred during their care. Additionally, nearly 85.82% of patients that were correctly triaged (according to their ISS) were also transferred to another hospital. While there may be medical reasons necessitating transfer, patients may also be transferred to Level I trauma centers for nonmedical reasons. Unnecessary inter-facility transfer of patients, including secondary over-triage, presents a resource-sensitive challenge to the state's trauma system and trauma centers. Moreover, it also delays definitive care and can be costly and inconvenient for patients and their families.

Analyzing data for counties and regions showed that there are specific patterns of OT and UT errors in the counties and regions. For instance, regions 7 and 8 have highest UT and nearly zero OT. This might be due to the placement of trauma centers. There may not be any L1/L2 trauma centers nearby these regions, resulting in all trauma patients being transferred from seen to the nearest available non-trauma facilities. Similarly, regions 2 and 5 have the least UT errors and the highest OT errors probably due to availability of large number of trauma centers. Clearly, the location of trauma centers in the region can directly affect quality care access and resource utilization in any trauma system.

In summary, our study findings suggest that trauma care in the state of Ohio could further be improved by reducing the triage errors and resource utilization. Based on our discussion with regional EMS providers, triage protocol is not standardized in the state and so it varies by the regions and/or EMS providers on scene. Therefore, a score-based system for triaging patients (such as one derived from the statistical model) could be very valuable and might help standardize the triage process in the state. Furthermore, studying transfer rates and reasons, and possible secondary triages — aims of our ongoing grant with the ODPS — would shed further light on the inherent dynamics of trauma triages and their impact. Leveraging these findings to develop a system-wide model that would correlate the regional and county statistics (UT, OT, transfer, and secondary OT) to the proportion of triage centers in that region (L1/L2 vs. L3/NTC) can provide quantitative evidence to reallocate specific services between the hospital and the opening/closure of future trauma centers.

9. Dissemination Plan

Part of the work presented in this report has been accepted and will be presented as an oral presentation at the Academic Surgical Congress Annual Meeting (February 2016). A manuscript is planned based on this work and will be submitted either to Journal of Trauma and Acute Care Surgery or Journal of Surgical Research. We also plan to disseminate the results to trauma surgeons and staff through Surgery grand rounds at Miami Valley Hospital (a Level 1 trauma center) in 2016.

10. References

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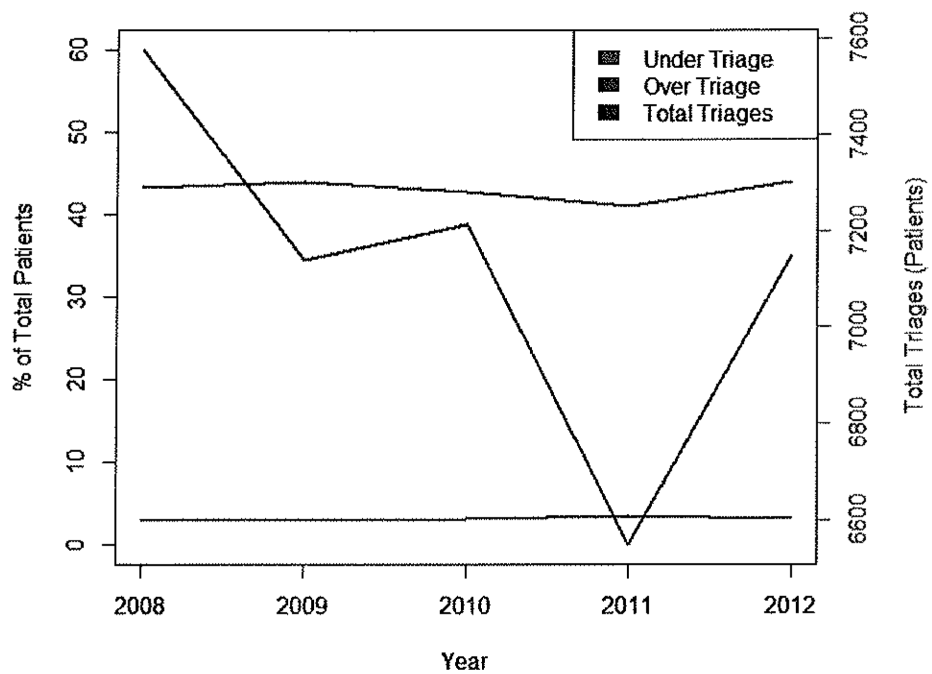
Appendix A: Data Corresponding to Figures in the Report and Additional Descriptive Statistics

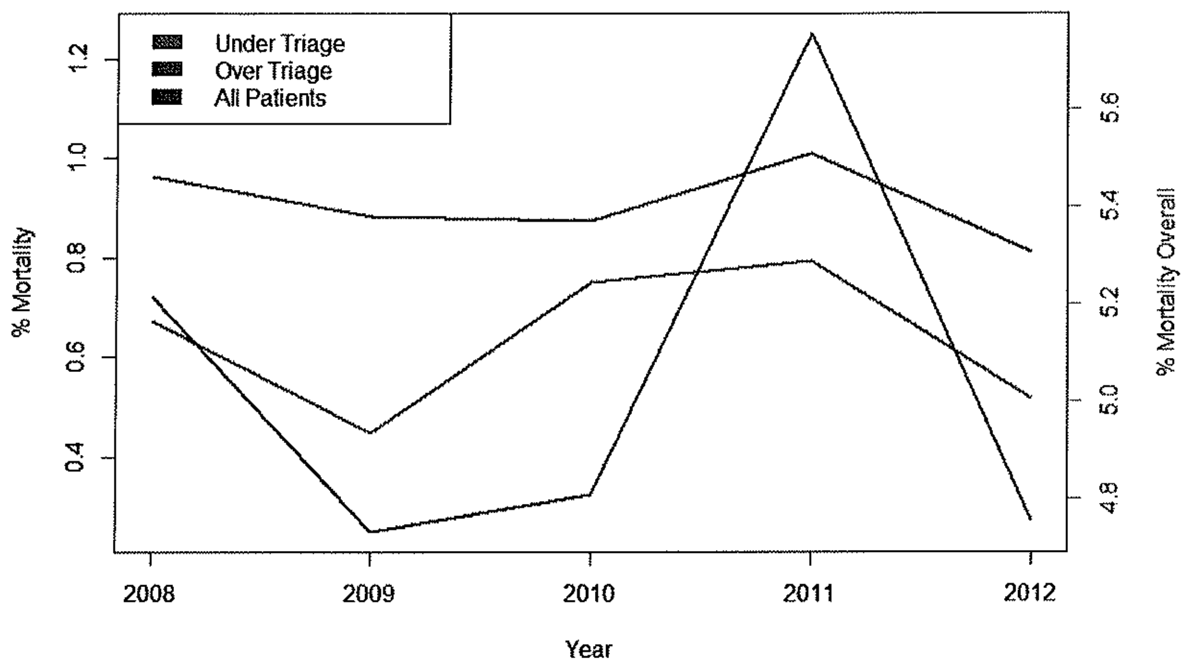
1. **Triage Trends (Figure 2 in the report)**



N = 35,631

Triage Trends	**2008**	**2009**	**2010**	**2011**	**2012**
Total triages	7576	7141	7214	6551	7149
Under-triage (#/%)	231/3.1%	203/2.8%	214/2.9%	228/3.5%	216/3%
Over-triage (#/%)	2175/43.2%	3142/44%	3082/42.7%	2687/41%	3145/44%

2. Mortality Trends (Figure 3 in the report)



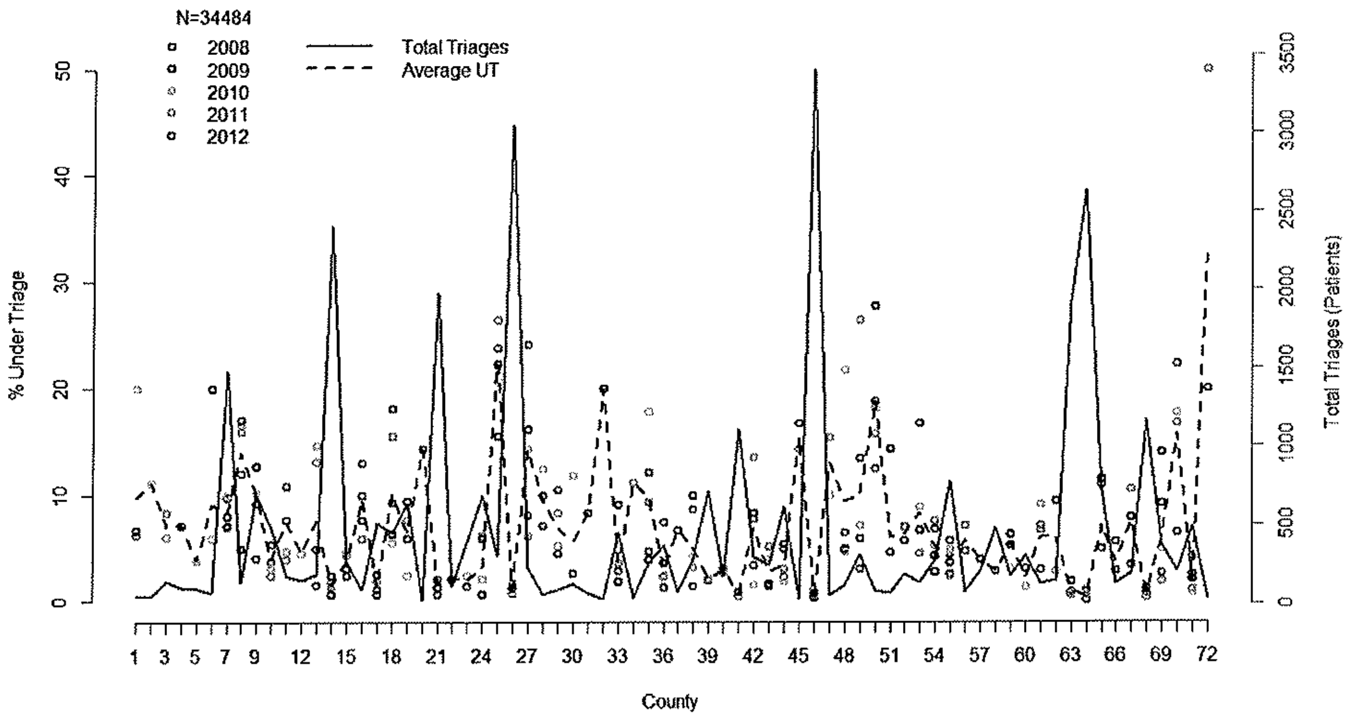
This trend chart should be read as:

- "In 2008, 5.21% of patients died."
- "In 2008, 0.67% of all patients were under triaged patients who died."
- "In 2011, 1.01% of all patients were over triaged patients who died."

N = 35,631

Mortality Trends	2008	2009	2010	2011	2012
Total triages	7576	7141	7214	6551	7149
Mortality (#/%)	395/5.2%	338/4.7%	347/4.8%	377/5.7%	340/4.7%
via UT (#/%)	51/0.67%	32/0.45%	54/0.75%	52/0.79%	37/0.52%
via OT (#/%)	73/0.96%	63/0.88%	63/0.87%	66/1.01%	58/0.81%

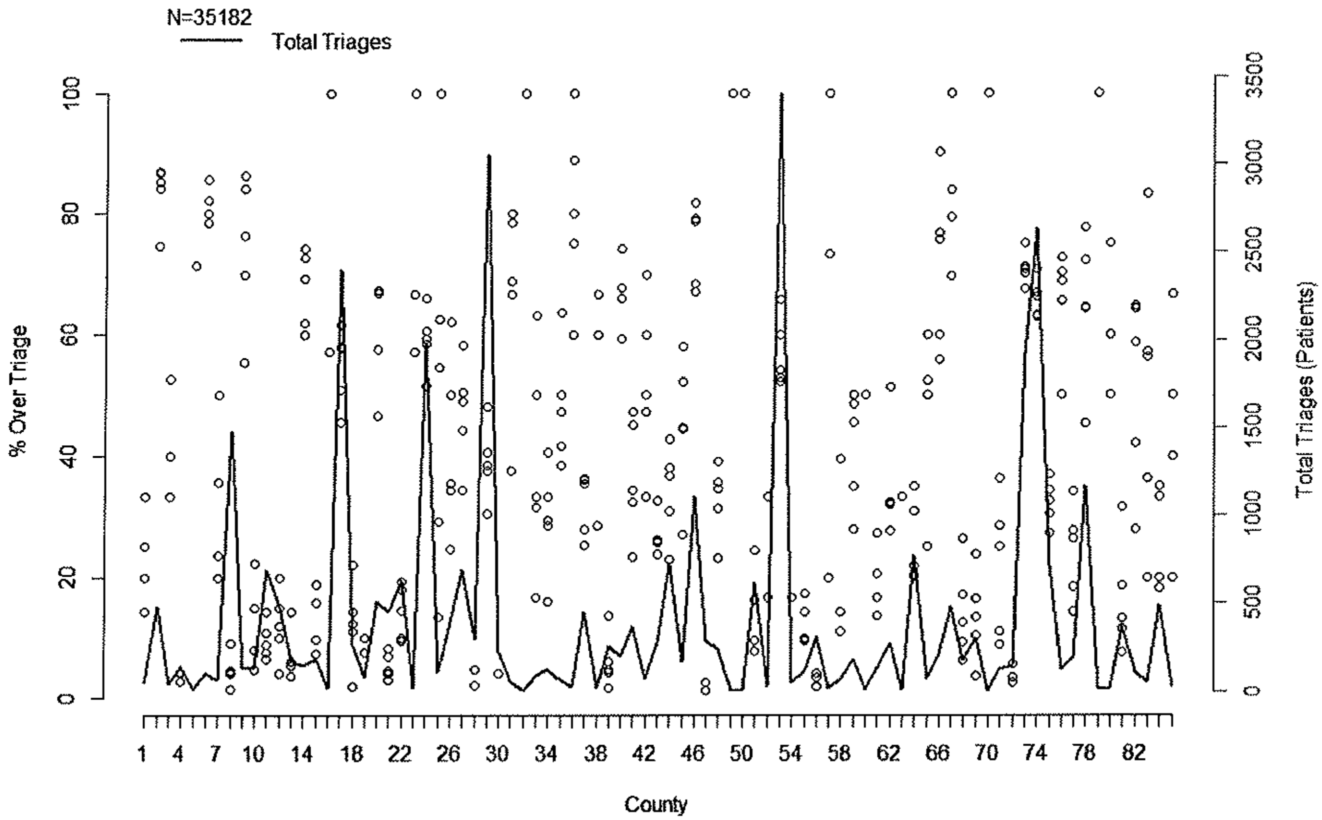
3. Under-Triage % by County and Year (Figure 6 in the report)



County Names (some counties did not experience any UT, so excluded):

[1]	"Adams"	"Ashland"	"Ashtabula"	"Auglaize"	"Belmont"
[6]	"Brown"	"Butler"	"Champaign"	"Clark"	"Clermont"
[11]	"Clinton"	"Columbiana"	"Coshocton"	"Cuyahoga"	"Darke"
[16]	"Defiance"	"Delaware"	"Erie"	"Fairfield"	"Fayette"
[21]	"Franklin"	"Fulton"	"Geauga"	"Greene"	"Guernsey"
[26]	"Hamilton"	"Hancock"	"Hardin"	"Henry"	"Highland"
[31]	"Hocking"	"Holmes"	"Huron"	"Jefferson"	"Knox"
[36]	"Licking"	"Logan"	"Lorain"	"Lucas"	"Madison"
[41]	"Mahoning"	"Marion"	"Medina"	"Miami"	"Monroe"
[46]	"Montgomery"	"Morgan"	"Morrow"	"Muskingum"	"Noble"
[51]	"Other"	"Ottawa"	"Perry"	"Pickaway"	"Portage"
[56]	"Preble"	"Putnam"	"Richland"	"Ross"	"Sandusky"
[61]	"Seneca"	"Shelby"	"Stark"	"Summit"	"Trumbull"
[66]	"Tuscarawas"	"Union"	"Unknown"	"Warren"	"Washington"
[71]	"Wood"	"Wyandot"			

4. Over-Triage % by County for 2008 to 2012 (Figure 7 in the report)



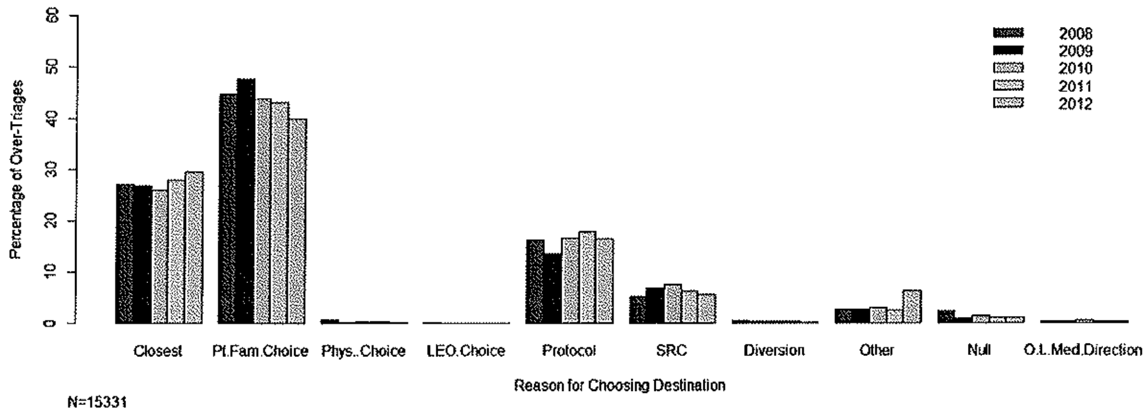
County Names (some counties did not experience any OT, so excluded):

[1]	"Adams"	"Allen"	"Ashland"	"Ashtabula"	"Athens"	"Auglaize"
[7]	"Brown"	"Butler"	"Carroll"	"Champaign"	"Clark"	"Clermont"
[13]	"Clinton"	"Columbiana"	"Coshocton"	"Crawford"	"Cuyahoga"	"Darke"
[19]	"Defiance"	"Delaware"	"Erie"	"Fairfield"	"Fayette"	"Franklin"
[25]	"Fulton"	"Geauga"	"Greene"	"Guernsey"	"Hamilton"	"Hancock"
[31]	"Hardin"	"Harrison"	"Henry"	"Highland"	"Hocking"	"Holmes"
[37]	"Huron"	"Jackson"	"Knox"	"Lake"	"Licking"	"Logan"
[43]	"Lorain"	"Lucas"	"Madison"	"Mahoning"	"Marion"	"Medina"
[49]	"Meigs"	"Mercer"	"Miami"	"Monroe"	"Montgomery"	"Morgan"
[55]	"Morrow"	"Muskingum"	"Not Applicable"	"Other"	"Ottawa"	"Paulding"
[61]	"Perry"	"Pickaway"	"Pike"	"Portage"	"Preble"	"Putnam"
[67]	"Richland"	"Ross"	"Sandusky"	"Scioto"	"Seneca"	"Shelby"
[73]	"Stark"	"Summit"	"Trumbull"	"Tuscarawas"	"Union"	"Unknown"
[79]	"Van Wert"	"Vinton"	"Warren"	"Wayne"	"Williams"	"Wood"
[85]	"Wyandot"					

5. System Level Factors

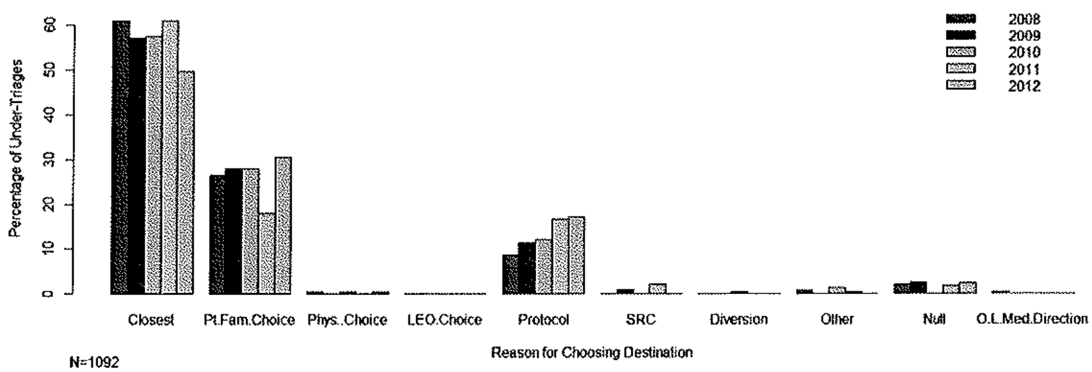
(i) Reason for choosing destination

Over-Triage (Figure 9 in the report)



	Closest	Pt.Fam.Choice	Phys..Choice	LEO.Choice	Protocol	SRC	Diversion	Other	Null	O.L.Med.Direction
2008	889	1465	22	4	534	168	18	90	74	11
2009	847	1500	9	1	426	216	14	86	30	13
2010	804	1351	10	2	513	233	10	97	45	17
2011	750	1160	11	0	481	170	11	67	28	9
2012	933	1257	9	1	515	175	7	198	36	14

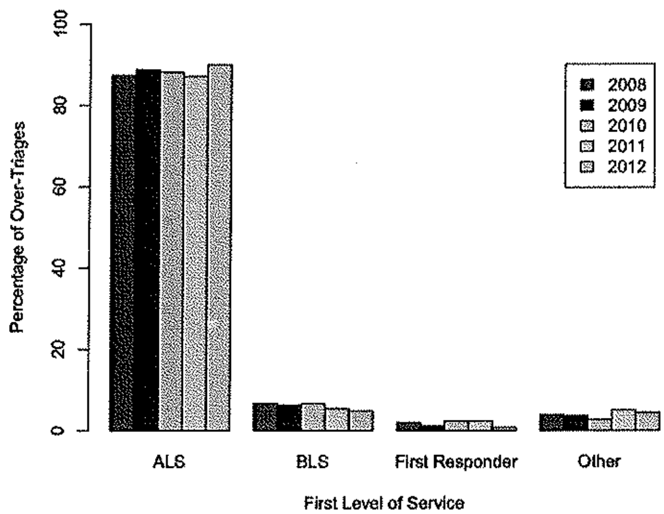
Under-Triage (Figure 10 in the report)



	Closest	Pt.Fam.Choice	Phys..Choice	LEO.Choice	Protocol	SRC	Diversion	Other	Null	O.L.Med.Direction
2008	141	61	1	0	20	0	0	2	5	1
2009	116	57	0	0	23	2	0	0	5	0
2010	123	60	1	0	26	0	1	3	0	0
2011	139	41	0	0	38	5	0	1	4	0
2012	107	66	1	0	37	0	0	0	5	0

(ii) First Unit Level of Service

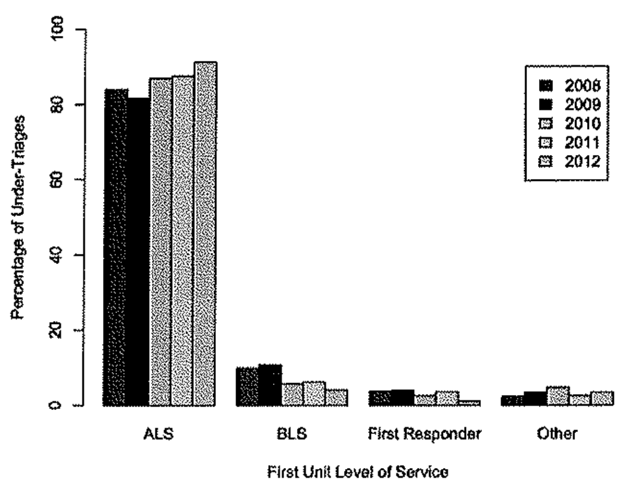
Over-Triage



N=13147

	ALS	BLS	First Responder	Other
2008	2549	197	58	114
2009	2540	180	37	104
2010	2478	188	68	75
2011	2052	129	56	118
2012	1983	108	16	97

Under-Triage

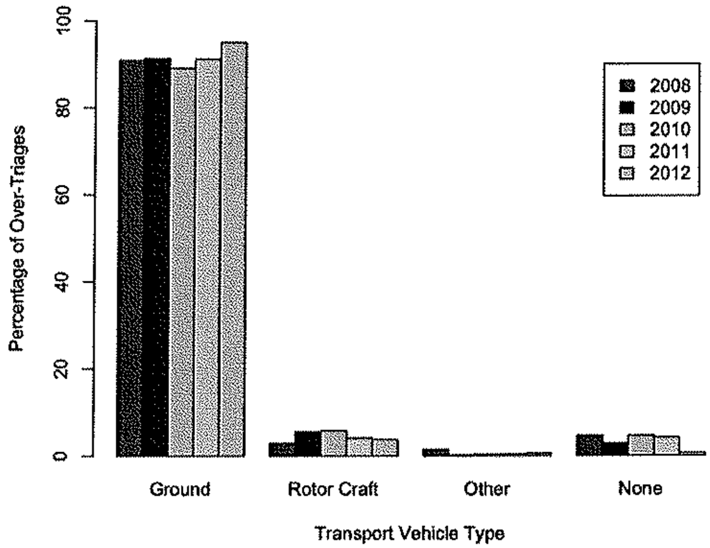


N=943

	ALS	BLS	First Responder	Other
2008	83.96226	9.905660	3.773585	2.358491
2009	81.71429	10.857143	4.000000	3.428571
2010	86.91099	5.759162	2.617801	4.712042
2011	87.56477	6.217617	3.626943	2.590674
2012	91.27907	4.069767	1.162791	3.488372

(iii) Transport Vehicle Type

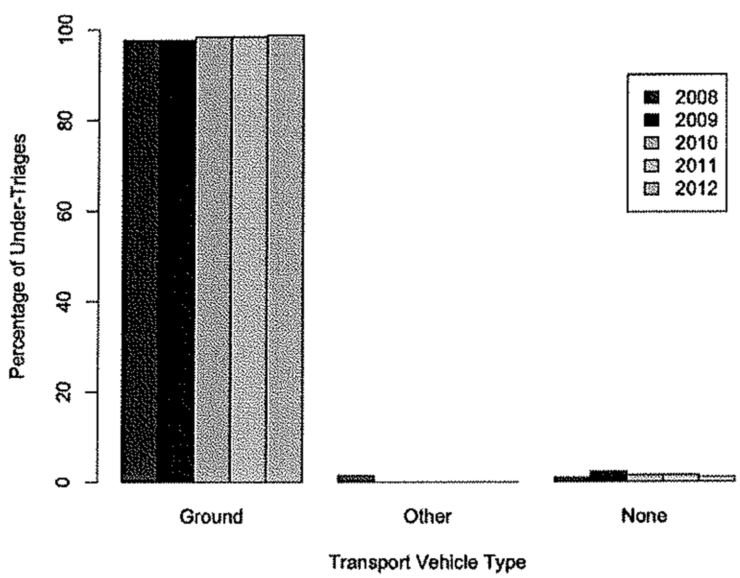
Over-Triage



	Ground	Rotor Craft	Fixed Wing	Other	None
2008	2650	85	4	43	136
2009	2614	158	0	6	83
2010	2503	164	1	11	130
2011	2149	96	0	10	100
2012	2094	82	0	13	15

N=13142
***Factors not Included: Fixed Wing (n=5)

Under-Triage



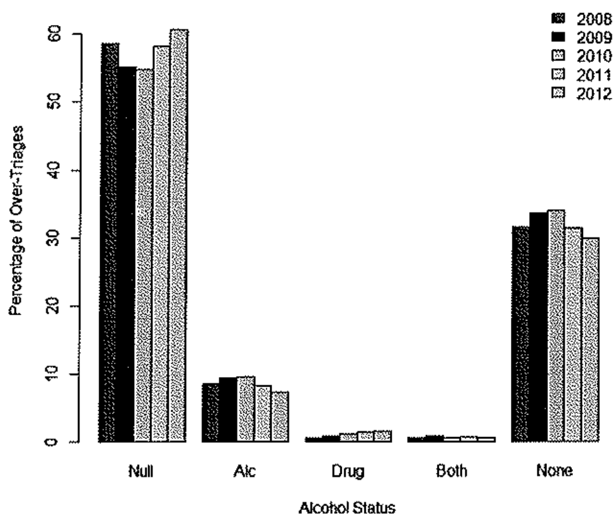
	Ground	Rotor Craft	Fixed Wing	Other	None
2008	207	0	0	3	2
2009	171	0	0	0	4
2010	188	0	0	0	3
2011	190	0	0	0	3
2012	170	0	0	0	2

N=943
***Factors not Included: Rotor Craft (n=0), Fixed Wing (n=0)

6. Clinical Factors

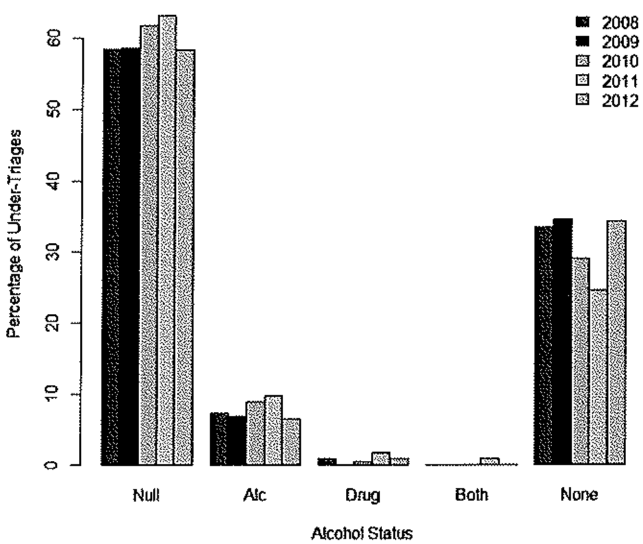
(i) Drug Alcohol Status

Over-Triage



N=15331

Under-Triage

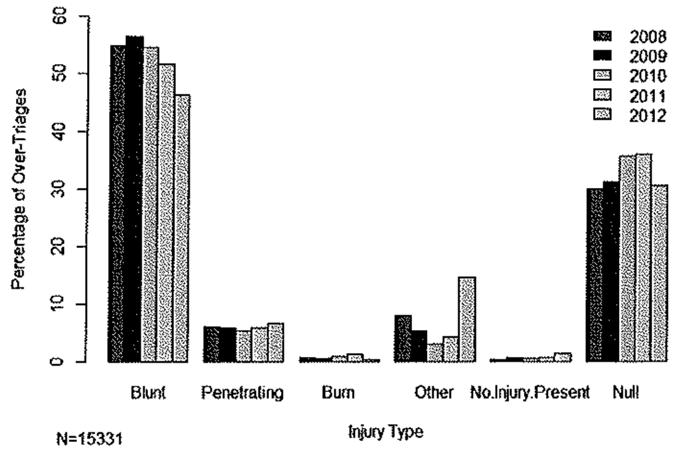


	Null	Alc	Drug	Both	None
2008	135	17	2	0	77
2009	119	14	0	0	70
2010	132	19	1	0	62
2011	144	22	4	2	56
2012	126	14	2	0	74

N=1092

(ii) Injury Type

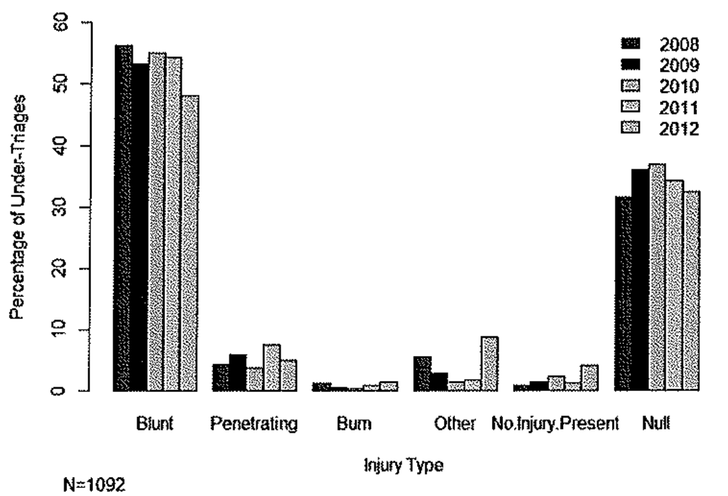
Over-Triage



	Blunt	Penetrating	Burn	Other	No.Injury.Present	Null
2008	1799	197	27	263	11	978
2009	1773	183	15	168	21	982
2010	1678	168	27	95	16	1098
2011	1388	159	35	116	21	968
2012	1456	211	15	462	44	957

- No.Injury.Present is from EMSIRS 2 only (EMSIRS 2 contributed 2170 patients to this plot)

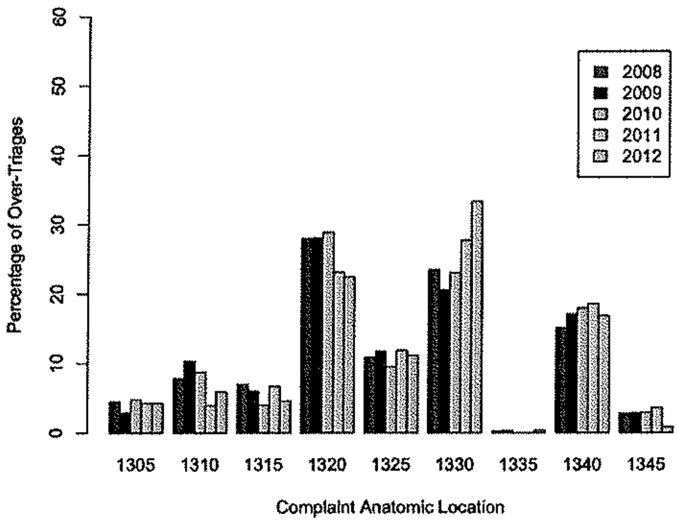
Under-Triage



	Blunt	Penetrating	Burn	Other	No.Injury.Present	Null
2008	130	10	3	13	2	73
2009	108	12	1	6	3	73
2010	118	8	1	3	5	79
2011	124	17	2	4	3	78
2012	104	11	3	19	9	70

(iii) Complaint Anatomic Location

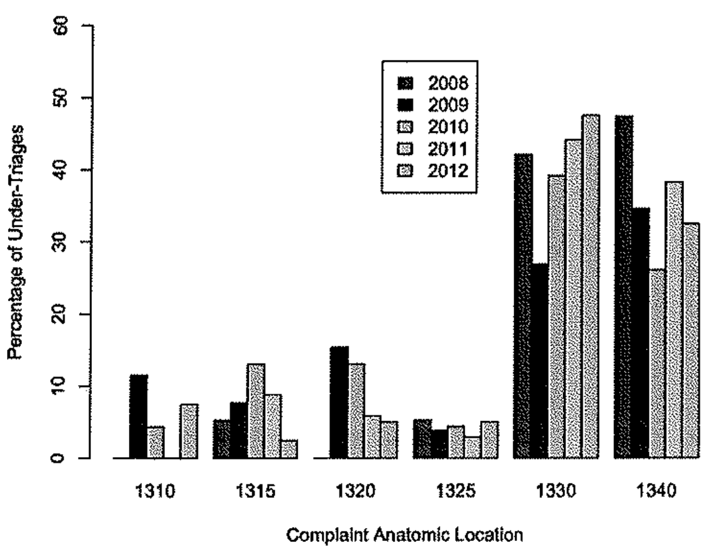
Over-Triage



	1305	1310	1315	1320	1325	1330	1335	1340	1345
2008	16	28	25	100	39	84	1	54	10
2009	8	29	17	79	33	58	1	48	8
2010	13	24	11	79	26	63	0	49	8
2011	14	13	22	76	39	91	0	61	12
2012	40	55	43	209	104	311	4	157	8

N=2170

Under-Triage



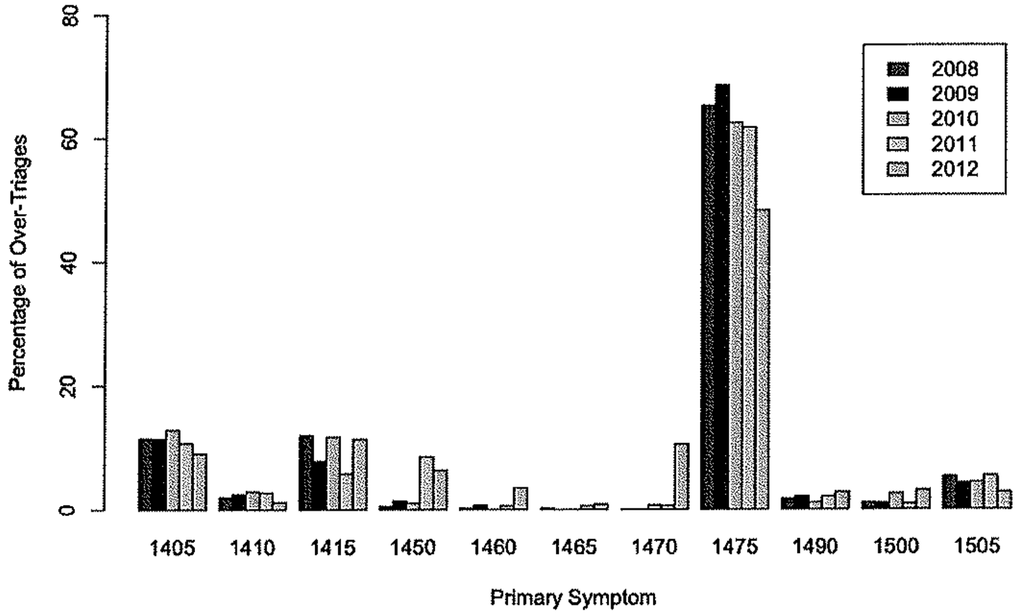
N=142
***Factors not included: 1305 (n=4), 1345 (n=3)

	1305	1310	1315	1320	1325	1330	1340	1345
2008	0	0	1	0	1	8	9	0
2009	1	3	2	4	1	7	9	1
2010	0	1	3	3	1	9	6	0
2011	1	0	3	2	1	15	13	0
2012	2	3	1	2	2	19	13	2

Complaint Anatomic Location Key:
-25....Not Applicable
1305....Abdomen
1310....Back
1315....Chest
1320....Extremity-lower
1325....Extremity-upper
1330....General/ global/ whole body
1335....Genitalia
1340....Head
1345....Neck

(iv) Primary Symptom

Over-Triage



N=2164

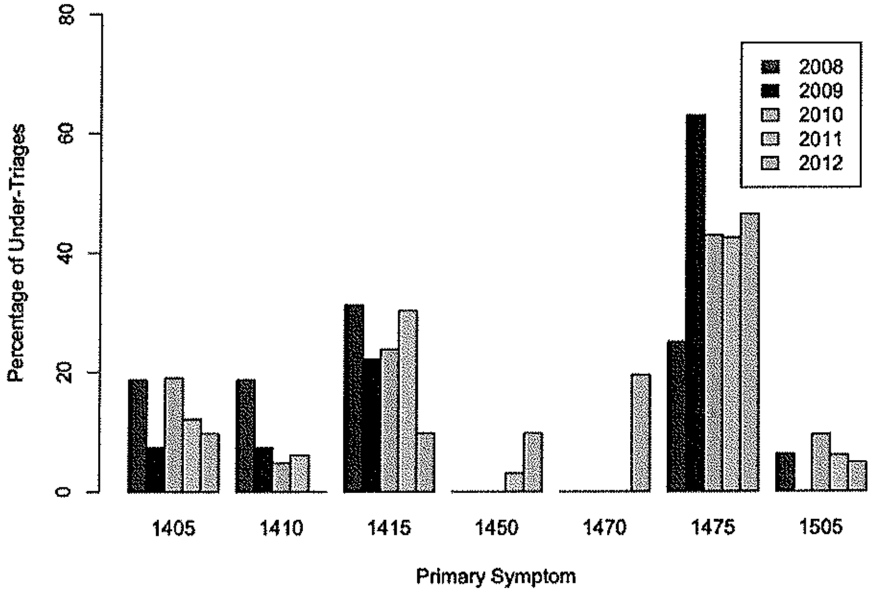
***Factors not included: 1420 (n=2), 1425 (n=2), 1440 (n=1), 1485 (n=1)

	1405	1410	1415	1420	1425	1440	1450	1460	1465	1470	1475	1485	1490	1500	1505
2008	41	7	43	0	0	0	2	1	1	0	233	0	6	4	19
2009	32	7	22	0	1	0	4	2	0	0	192	0	6	3	12
2010	35	8	32	1	0	0	3	0	0	2	170	0	3	7	12
2011	35	9	19	0	1	0	28	2	2	2	202	0	7	3	18
2012	84	11	106	1	0	1	59	33	8	98	448	1	26	29	26

Primary Symptom Key

-25....Not Applicable
1405....Bleeding
1410....Breathing Problem
1415....Change in responsiveness
1420....Choking
1425....Death
1430....Device/ Equipment Problem
1435....Diarrhea
1440....Drainage/ discharge
1445....Fever
1450....Malaise (general, non-specific feeling of illness)
1455....Mass/ lesion
1460....Mental/ psychiatric
1465....Nausea/ vomiting
1470....None
1475....Pain
1480....Palpitations
1485....Rash/ itching
1490....Swelling
1500....Weakness
1505....Wound

Under-Triage

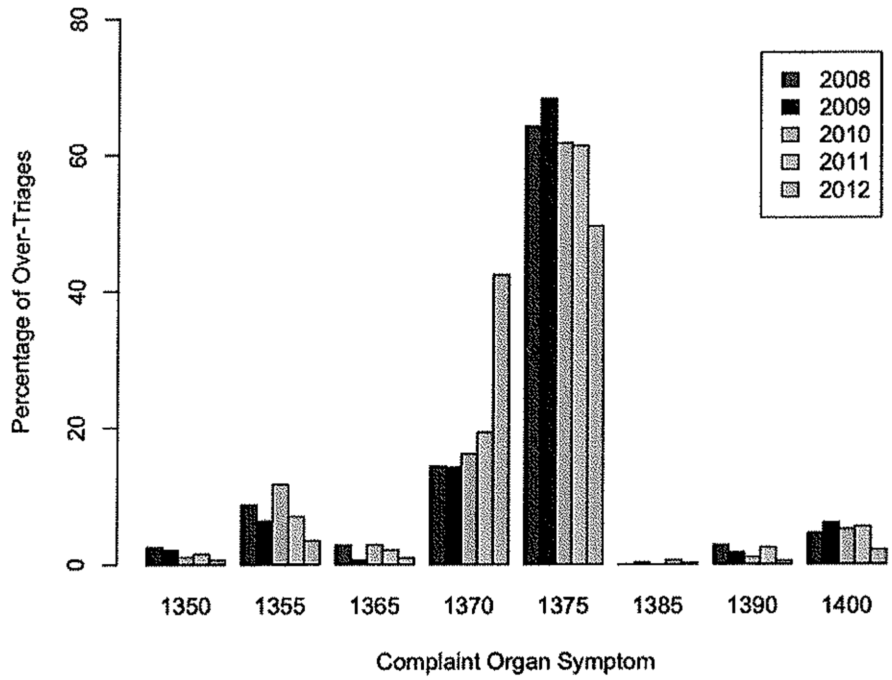


N=138
***Factors not included: 1425 (n=4), 1460 (n=1), 1465 (n=3), 1490 (n=2), 1500 (n=1)

	1405	1410	1415	1425	1450	1460	1465	1470	1475	1490	1500	1505
2008	3	3	5	2	0	0	1	0	4	0	0	1
2009	2	2	6	0	0	0	1	0	17	0	0	0
2010	4	1	5	0	0	0	1	0	9	0	1	2
2011	4	2	10	1	1	1	0	0	14	0	0	2
2012	4	0	4	1	4	0	0	8	19	2	0	2

(v) Complaint Organ System

Over-Triage

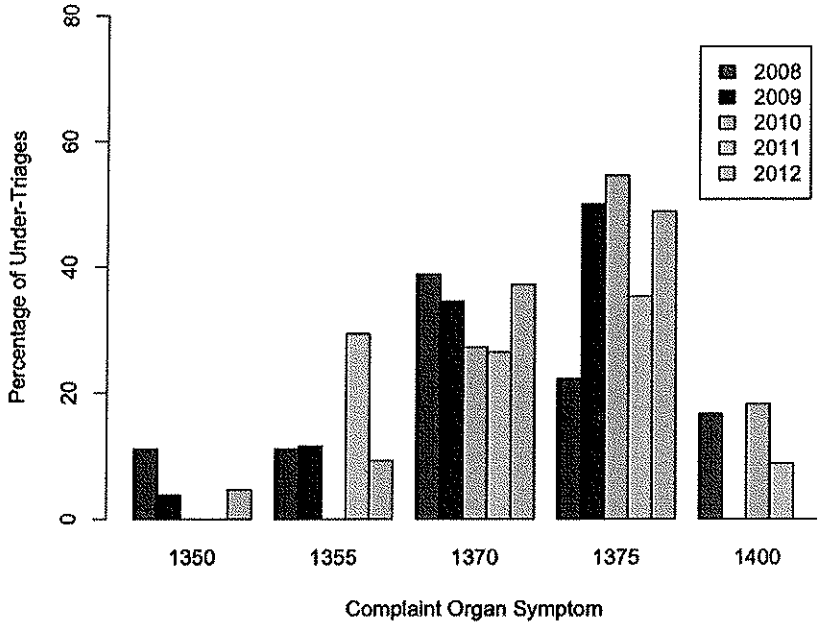


N=2164
***Factors not included: 1360 (n=2), 1380 (n=1), 1395 (n=3)

	1350	1355	1360	1365	1370	1375	1380	1385	1390	1395	1400
2008	9	31	0	10	51	228	1	0	10	1	16
2009	6	18	0	2	40	192	0	1	5	0	17
2010	3	32	1	8	44	168	0	0	3	0	14
2011	5	23	1	7	63	200	0	2	8	1	18
2012	6	33	0	9	394	461	0	2	5	1	20

Complaint Organ Symptom Key:
-25...Not Applicable
1350....Cardiovascular
1355....CNS/ Neurologic
1360....Endocrine/ Metabolic
1365....Gastrointestinal
1370....Global/ Whole body
1375....Musculoskeletal
1380....Obstetric/ Gynecologic
1385....Psychiatric
1390....Pulmonary
1395....Renal
1400....Skin

Under-Triage

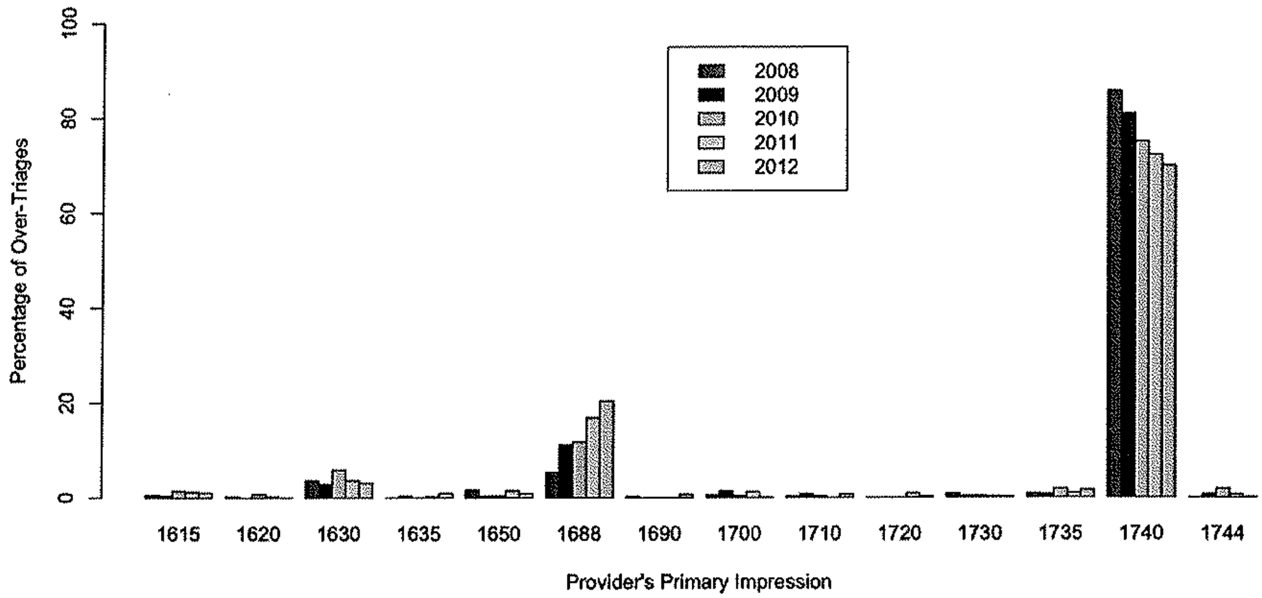


N=143
***Factors not included: 1365 (n=3), 1390 (n=2), 1395 (n=1)

	1350	1355	1365	1370	1375	1390	1395	1400
2008	2	2	1	7	4	0	0	3
2009	1	3	1	9	13	1	0	0
2010	0	0	0	6	12	1	0	4
2011	0	10	1	9	12	0	0	3
2012	2	4	0	16	21	0	1	0

(vi) Provider's Primary Impression

Over-Triage

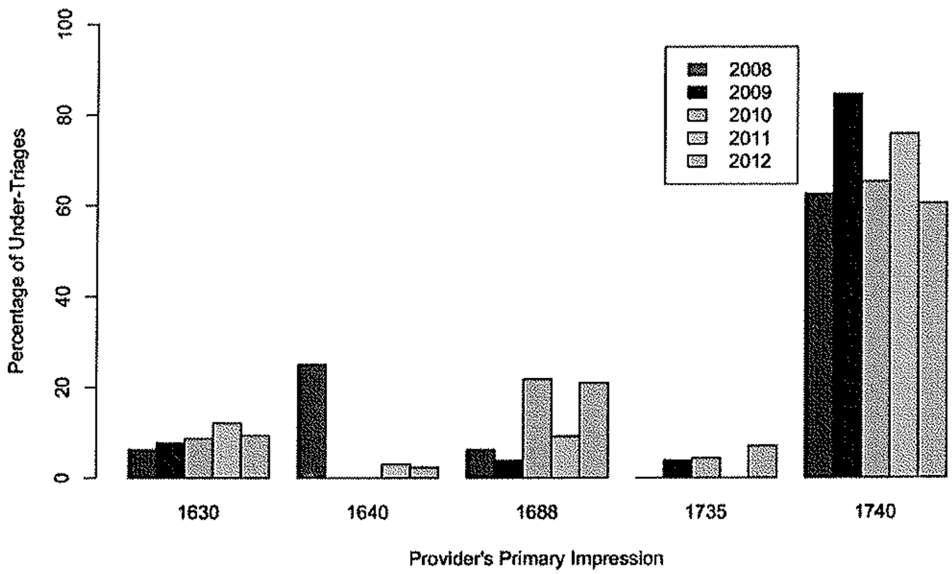


N=2156
***Factors not included: 1640 (n=3), 1645 (n=1), 1655 (n=2), 1665 (n=1), 1670 (n=3), 1675 (n=1), 1705 (n=1), 1725 (n=2)

	1615	1620	1630	1635	1640	1645	1650	1655	1665	1670	1675	1688	1690	1700	1705	1710
2008	2	1	13	0	0	0	6	0	0	0	0	19	1	2	0	1
2009	1	0	8	1	0	0	1	0	1	1	1	31	0	4	0	2
2010	4	2	16	0	0	0	1	0	0	1	0	32	0	1	0	1
2011	4	1	12	1	1	0	5	0	0	0	0	55	0	4	0	0
2012	10	0	29	9	2	1	8	2	0	1	0	188	6	1	1	6

	1720	1725	1730	1735	1740	1744
2008	0	0	3	3	306	0
2009	0	0	1	2	225	2
2010	0	0	1	5	204	5
2011	3	0	1	3	236	2
2012	2	2	2	15	645	1

Under-Triage



N=141
***Factors not included: 1615 (n=2), 1650 (n=1), 1670 (n=1), 1705 (n=1), 1710 (n=1), 1720 (n=1), 1730 (n=1)

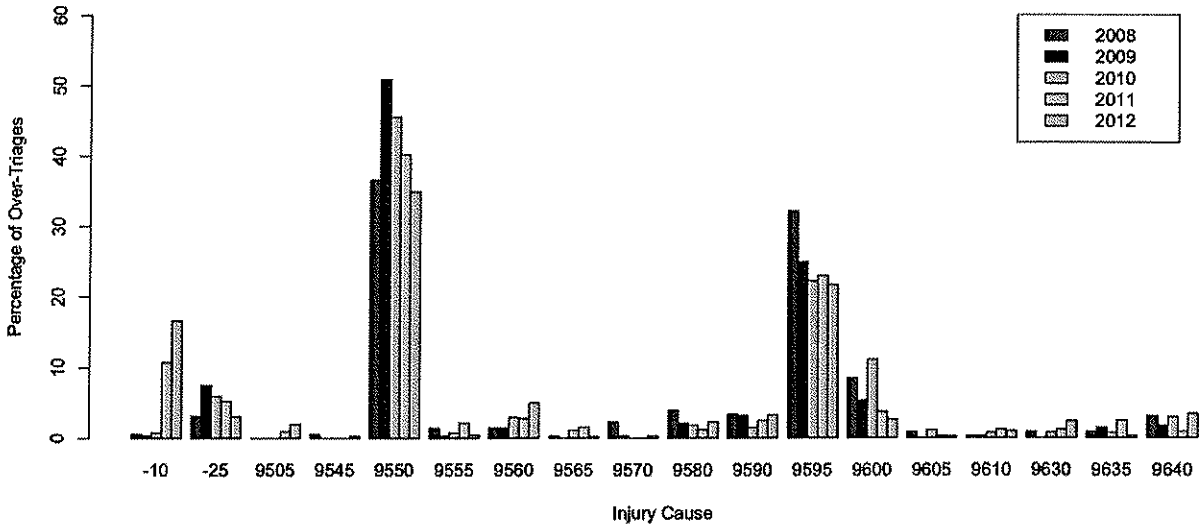
	1615	1630	1640	1650	1670	1688	1705	1710	1720	1730	1735	1740
2008	0	1	4	0	0	1	1	0	1	1	0	10
2009	0	2	0	0	1	1	0	1	0	0	1	22
2010	0	2	0	0	0	5	0	0	0	0	1	15
2011	1	4	1	1	0	3	0	0	0	0	0	25
2012	1	4	1	0	0	9	0	0	0	0	3	26

Provider's Primary Impression key:

-25....Not Applicable
1615....Abdominal pain/ problems
1620....Airway obstruction
1625....Allergic reaction
1630....Altered level of consciousness
1635....Behavioral/ psychiatric disorder
1640....Cardiac arrest
1645....Cardiac rhythm disturbance
1650....Chest pain/ discomfort
1655....Diabetic symptoms
1660....Electrocution
1688....General medical, not otherwise listed
1665....Hyperthermia
1670....Hypothermia
1675....Hypovolemia/ shock
1680....Inhalation injury (toxic gas)
1685....Obvious death
1690....Poisoning/ drug ingestion
1695....Pregnancy/ OB delivery
1700....Respiratory distress
1705....Respiratory arrest
1710....Seizure
1715....Sexual assault/ rape
1720....Smoke inhalation
1725....Stings/ venomous bites
1730....Stroke/ CVA
1735....Syncope/ fainting
1740....Traumatic injury
1744....Non-traumatic injury
1745....Vaginal hemorrhage

(vii) Injury Cause

Over-Triage

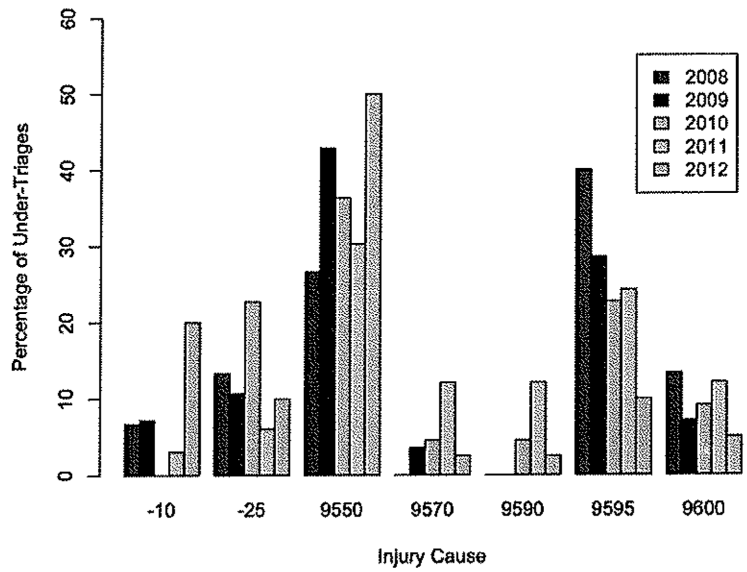


N=2154
***Factors not included: 1885 (n=3), 9530 (n=1), 9540 (n=1),9575 (n=1)
9585 (n=3), 9607 (n=3), 9625 (n=2), 9650 (n=2)

	-10	-25	1885	9505	9530	9540	9545	9550	9555	9560	9565	9570	9575	9580	9585	9590
2008	2	11	0	0	0	0	2	130	5	5	1	8	0	14	0	12
2009	1	21	0	0	0	0	0	143	1	4	0	1	0	6	0	9
2010	2	16	0	0	0	1	0	123	2	8	3	0	0	5	0	4
2011	35	17	0	3	0	0	0	131	7	9	5	0	0	4	1	8
2012	153	28	3	18	1	0	3	322	4	46	2	3	1	21	2	30

	9595	9600	9605	9607	9610	9625	9630	9635	9640	9650
2008	114	30	3	2	1	0	3	3	11	0
2009	70	15	0	0	1	0	0	4	5	0
2010	60	30	3	1	2	1	2	2	8	0
2011	75	12	1	0	4	1	4	8	3	0
2012	200	24	2	0	9	0	22	3	32	2

Under-Triage



N=138
***Factors not included: 9505 (n=1), 9545 (n=1), 9555 (n=1),9580 (n=2) 9605 (n=1), 9630 (n=2), 9640 (n=3)

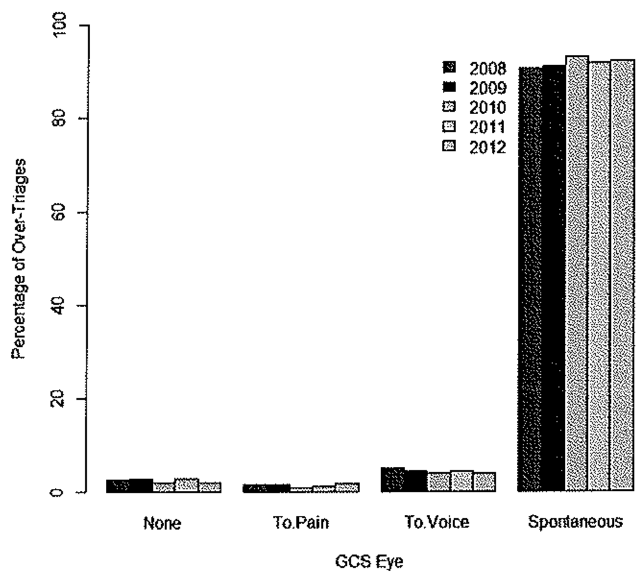
	-10	-25	9505	9545	9550	9555	9570	9580	9590	9595	9600	9605	9630	9640
2008	1	2	0	0	4	1	0	2	0	6	2	0	1	0
2009	2	3	0	0	12	0	1	0	0	8	2	0	0	0
2010	0	5	0	1	8	0	1	0	1	5	2	0	0	0
2011	1	2	1	0	10	0	4	0	4	8	4	0	1	0
2012	8	4	0	0	20	0	1	0	1	4	2	1	0	3

Injury Cause Key:

-10....Unknown
-25....Not Applicable
1885....Bites
9500....Aircraft related accident
9505....Bicycle accident
9515....Chemical poisoning
9520....Child battering
9525....Drowning
9530....Drug poisoning
9535....Electrocution
9540....Excessive cold
9545....Excessive heat
9550....Falls
9555....Fire and flames
9560....Firearm (assault)
9565....Firearm injury (accidental)
9570....Firearm(self-inflicted)
9575....Lightning
9590....Motor vehicle non-traffic accident
9595....Motor vehicle traffic accident
9600....Motorcycle crash
9605....Non-motorized vehicle crash
9607....Overexertion/ strenuous movements
9610....Pedestrian traffic accident
9615....Radiation exposure
9620....Rape
9625....Smoke inhalation
9630....Stabbing/ cutting unintentional
9635....Stabbing/ cutting assault
9640....Struck by blunt/ thrown object
9645....Venomous stings (plants, animals)
9650....Water transport accident
9580....Machinery accidents
9585....Mechanical suffocation

(viii) GCS Eye

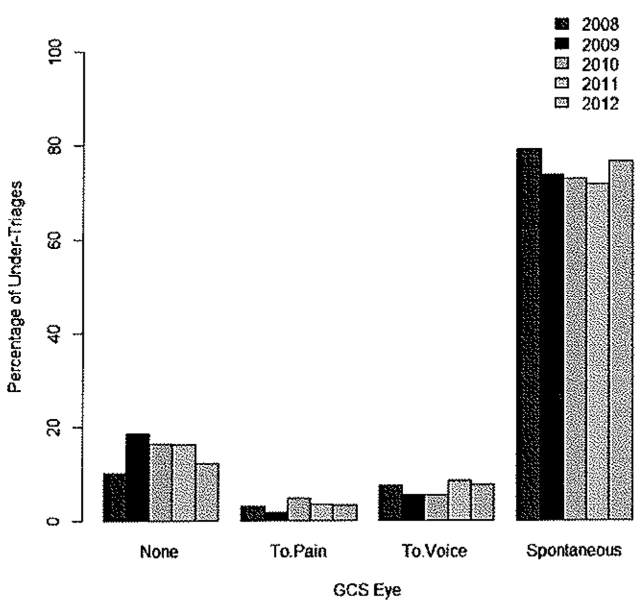
Over-Triage



N=14361

	None	To.Pain	To.Voice	Spontaneous
2008	81	49	149	2692
2009	87	48	127	2654
2010	59	27	119	2712
2011	72	28	112	2341
2012	63	56	119	2766

Under-Triage

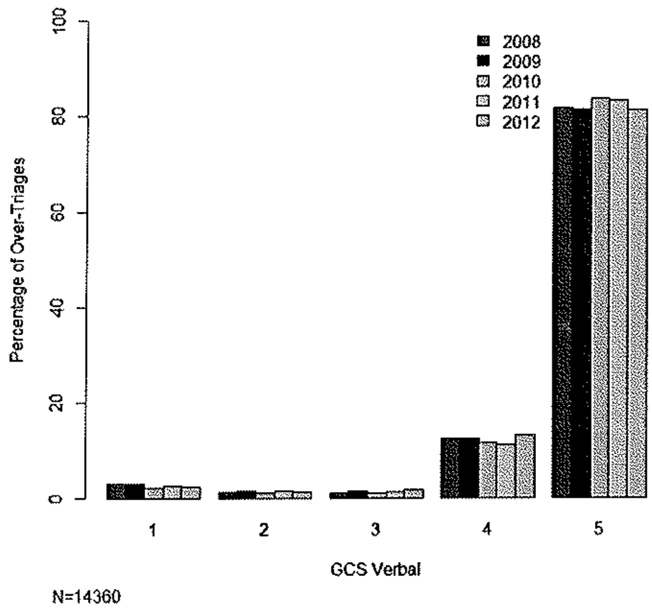


N=907

	None	To.Pain	To.Voice	Spontaneous
2008	19	6	14	149
2009	30	3	9	118
2010	30	9	10	132
2011	32	7	17	142
2012	22	6	14	138

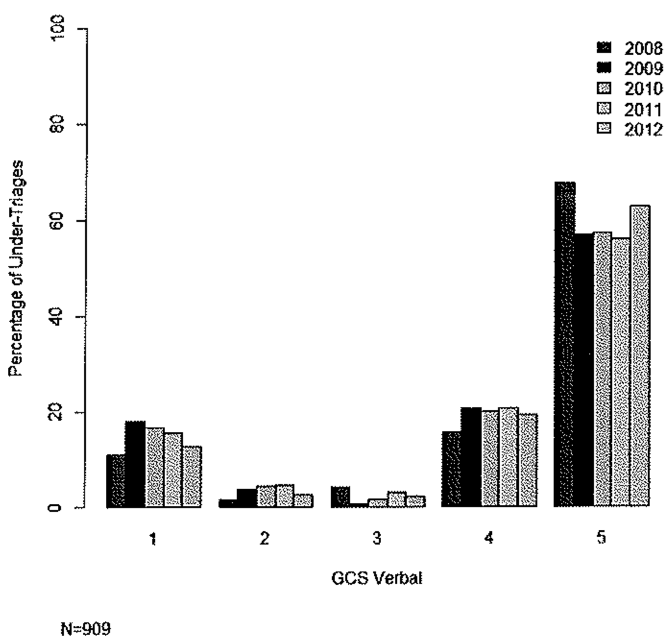
(ix) GCS Verbal

Over-Triage



	1	2	3	4	5
2008	93	43	33	374	2428
2009	91	43	43	364	2375
2010	62	36	36	343	2437
2011	67	40	37	284	2127
2012	76	38	53	396	2441

Under-Triage

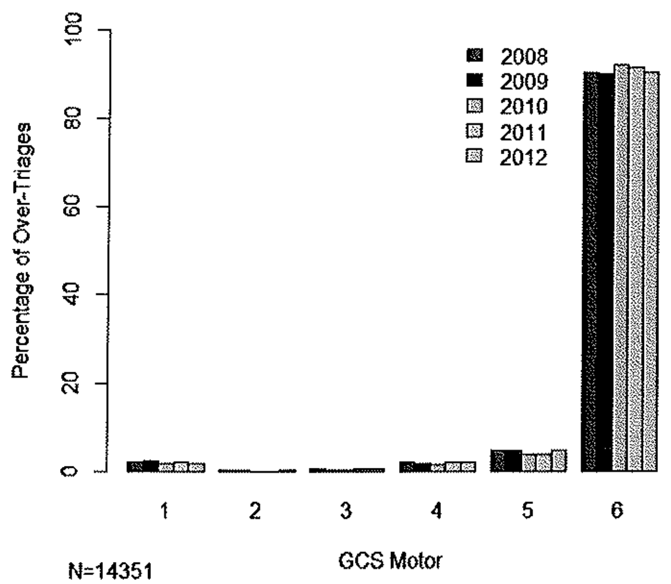


	1	2	3	4	5
2008	21	3	8	30	129
2009	29	6	1	33	91
2010	30	8	3	36	103
2011	31	9	6	41	111
2012	23	5	4	35	113

GCS Verbal key:
1.... None
2.... Incomprehensible sounds
3.... Inappropriate words
4.... Confused
5.... Oriented

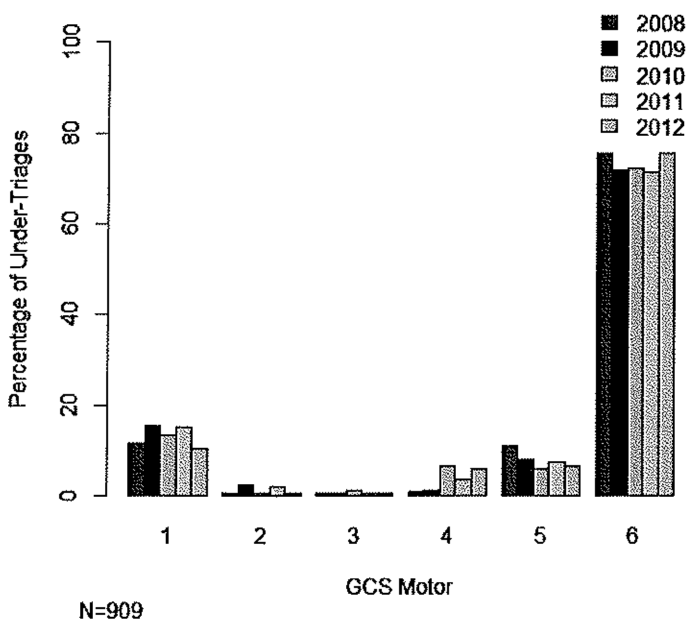
(x) GCS Motor

Over-Triage



	1	2	3	4	5	6
2008	67	6	18	59	140	2677
2009	67	13	14	54	143	2625
2010	52	3	13	47	113	2685
2011	54	2	15	51	98	2333
2012	56	8	19	67	142	2710

Under-Triage

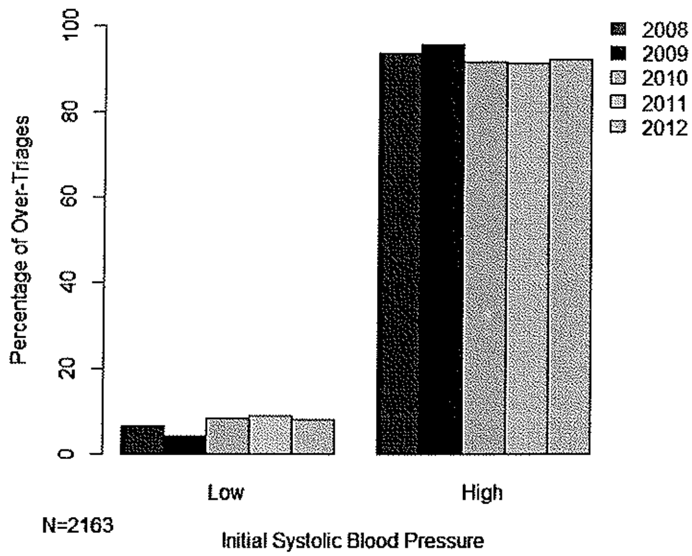


	1	2	3	4	5	6
2008	22	1	1	2	21	144
2009	25	4	1	2	13	115
2010	24	1	2	12	11	130
2011	30	4	1	7	15	141
2012	19	1	1	11	12	136

GCS Motor key:
1.... None
2.... Extensor posturing in response to painful stimulation
3.... Flexor posturing in response to painful stimulation
4.... Withdraws from painful stimulation
5.... Localizes painful stimulation
6.... Obeys commands

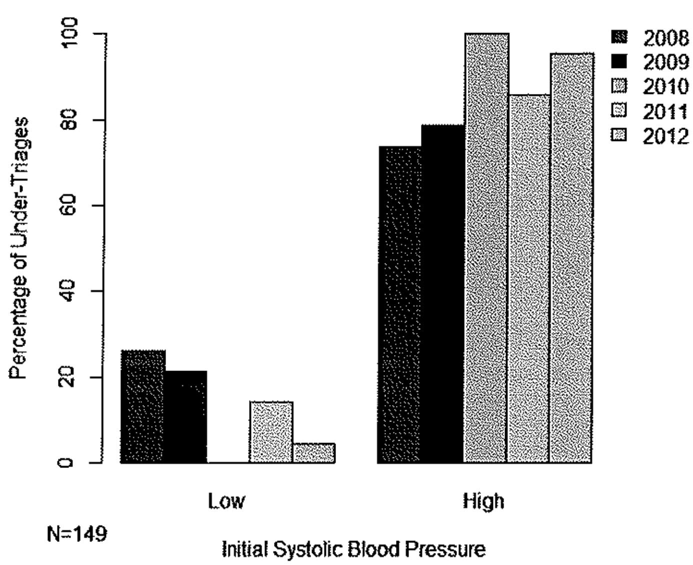
(xi) Initial Systolic Blood Pressure (Low = 0-100, High = 101+)

Over-Triage



	High	Low
2008	327	23
2009	269	12
2010	250	23
2011	299	29
2012	857	74

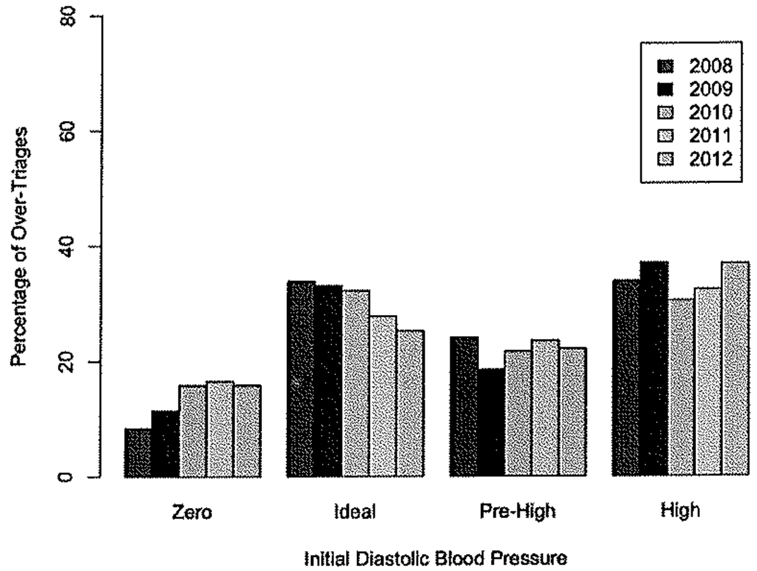
Under-Triage



	High	Low
2008	14	5
2009	22	6
2010	23	0
2011	30	5
2012	42	2

(xii) Initial Diastolic Blood Pressure

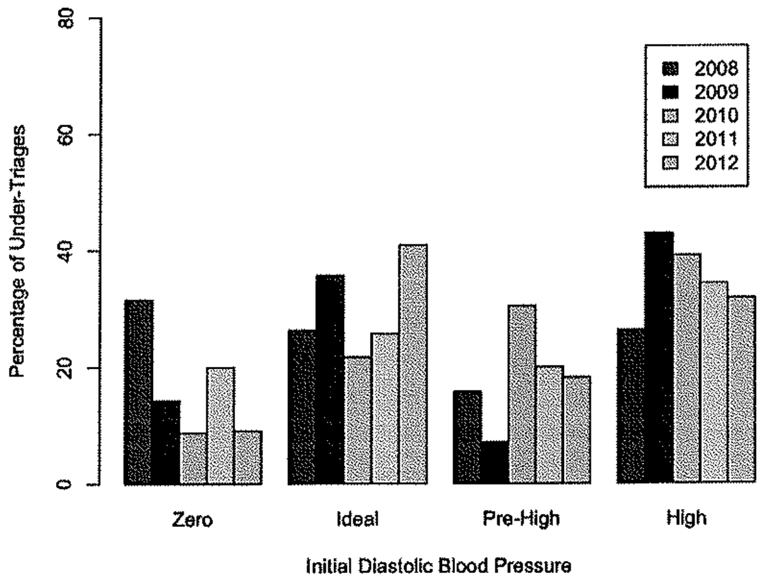
Over-Triage



	Zero	Low	Ideal	Pre-High	High
2008	29	0	118	84	118
2009	32	0	93	52	104
2010	43	0	88	59	83
2011	54	0	91	77	106
2012	147	0	235	206	343

N=2162
***Factors not included: Low (n=0)

Under-Triage

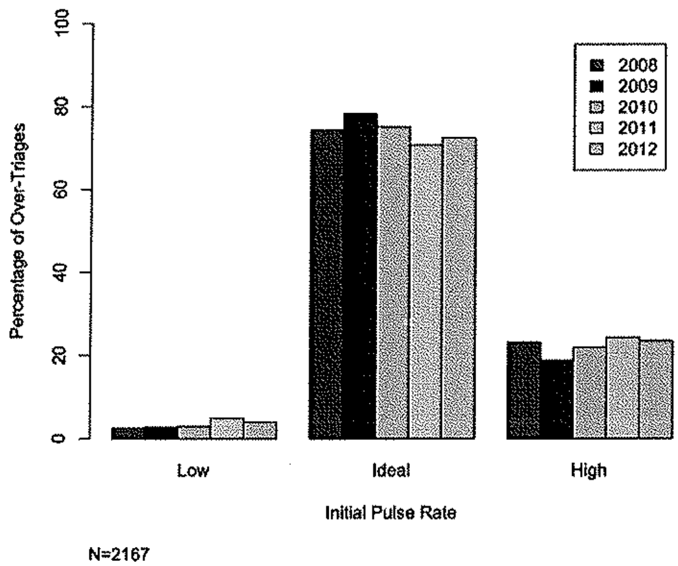


	Zero	Low	Ideal	Pre-High	High
2008	6	0	5	3	5
2009	4	0	10	2	12
2010	2	0	5	7	9
2011	7	0	9	7	12
2012	4	0	18	8	14

N=149
***Factors not included: Low (n=0)

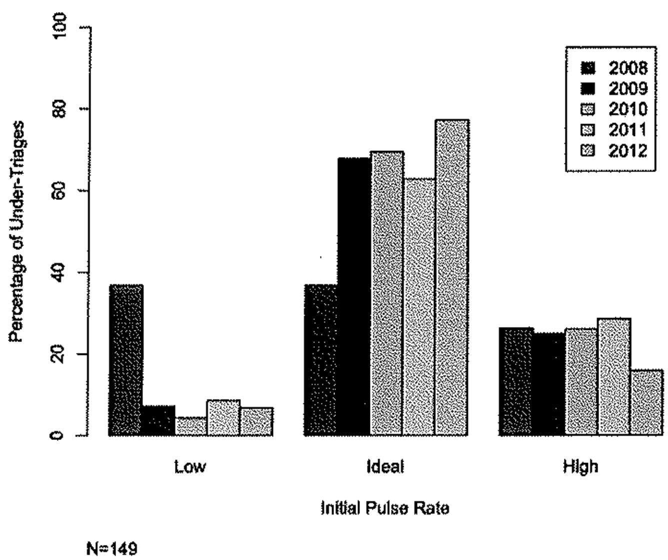
(xiii) Initial Pulse Rate

Over-Triage



	Low	Ideal	High
2008	9	263	82
2009	8	220	53
2010	8	205	60
2011	16	232	80
2012	37	675	219

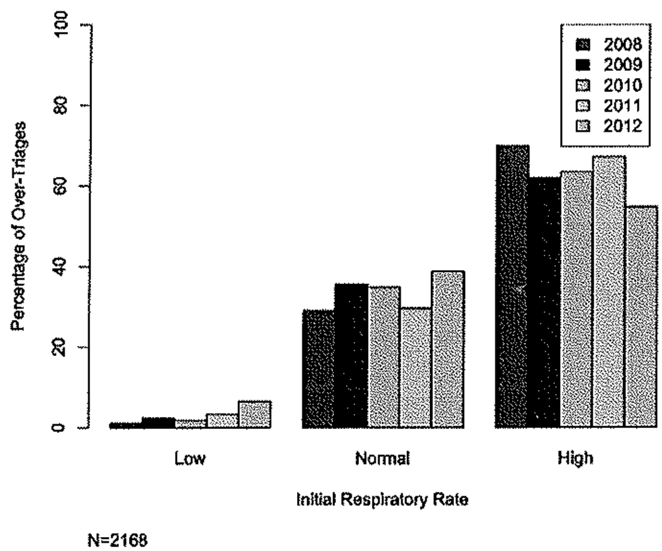
Under-Triage



	Low	Ideal	High
2008	7	7	5
2009	2	19	7
2010	1	16	6
2011	3	22	10
2012	3	34	7

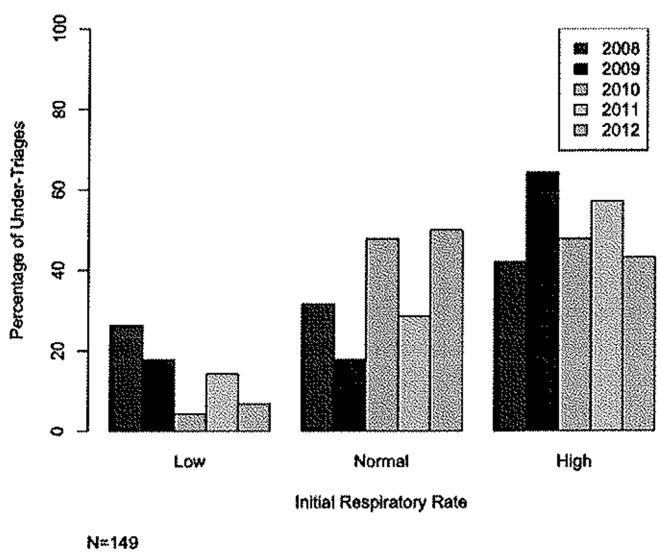
(xiv) Initial Respiratory Rate

Over-Triage



	Low	Normal	High
2008	4	103	248
2009	7	100	174
2010	5	95	173
2011	11	97	220
2012	61	361	509

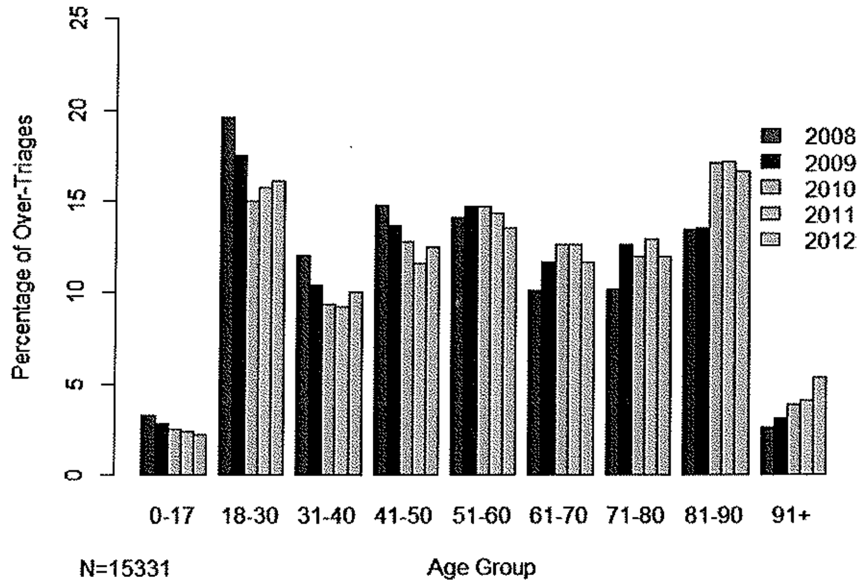
Under-Triage



	Low	Normal	High
2008	5	6	8
2009	5	5	18
2010	1	11	11
2011	5	10	20
2012	3	22	19

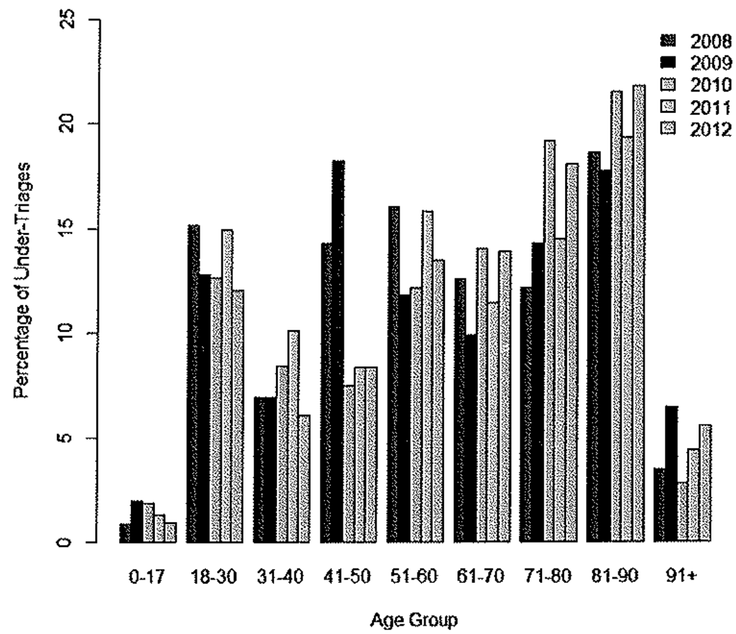
(xv) Age

Over-Triage



	0-17	18-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
2008	108	641	393	484	461	330	333	440	85
2009	88	550	327	430	461	367	396	425	98
2010	79	462	289	393	454	390	369	526	120
2011	64	422	247	311	385	340	347	460	111
2012	70	506	316	393	424	366	377	524	169

Under-Triage

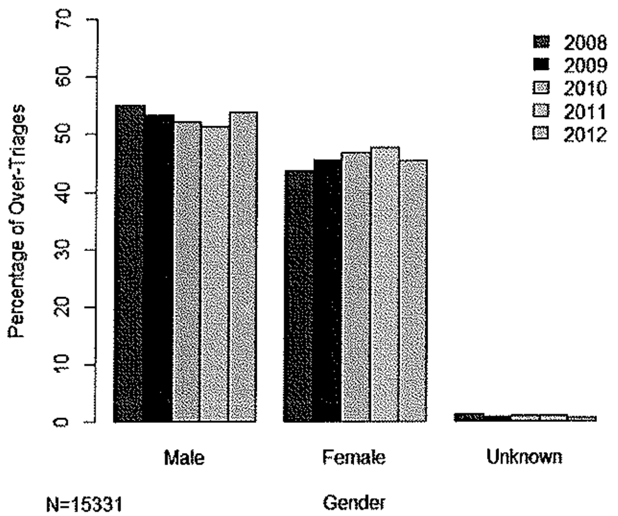


N=1092

	0-17	18-30	31-40	41-50	51-60	61-70	71-80	81-90	91+
2008	2	35	16	33	37	29	28	43	8
2009	4	26	14	37	24	20	29	36	13
2010	4	27	18	16	26	30	41	46	6
2011	3	34	23	19	36	26	33	44	10
2012	2	26	13	18	29	30	39	47	12

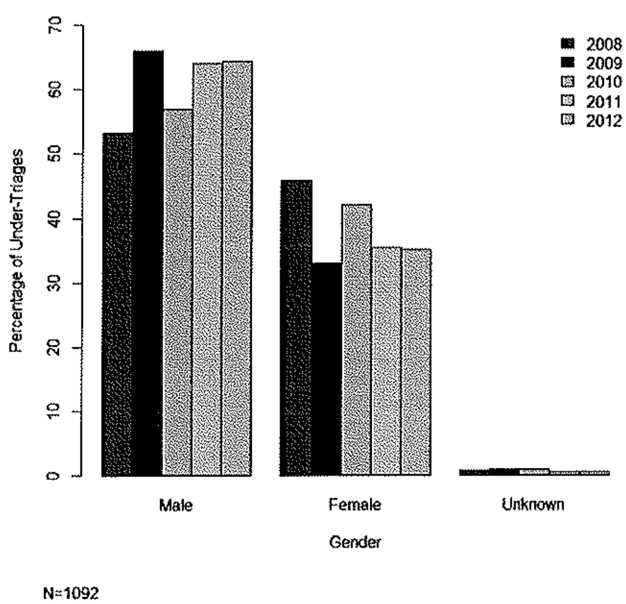
(xvi) Gender

Over-Triage



	Male	Female	Unknown
2008	1804	1432	39
2009	1681	1433	28
2010	1607	1442	33
2011	1379	1280	28
2012	1695	1428	22

Under-Triage

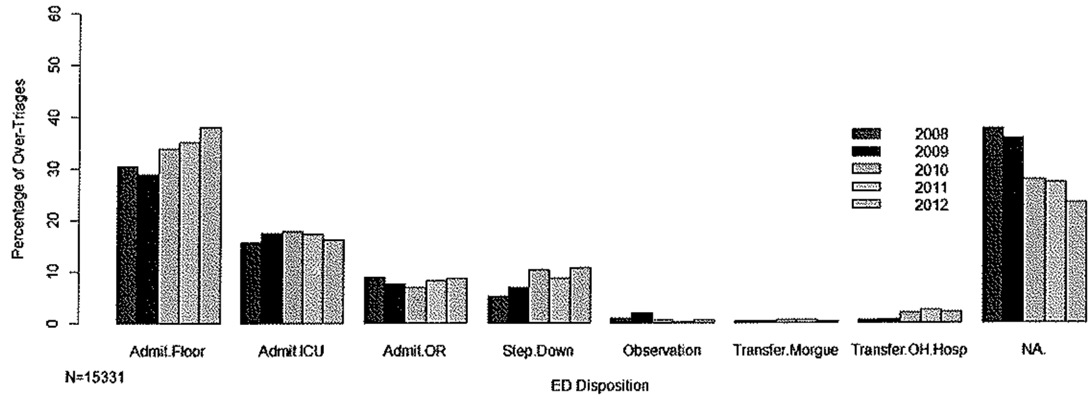


	Male	Female	Unknown
2008	123	106	2
2009	134	67	2
2010	122	90	2
2011	146	81	1
2012	139	76	1

7. Trauma Factors

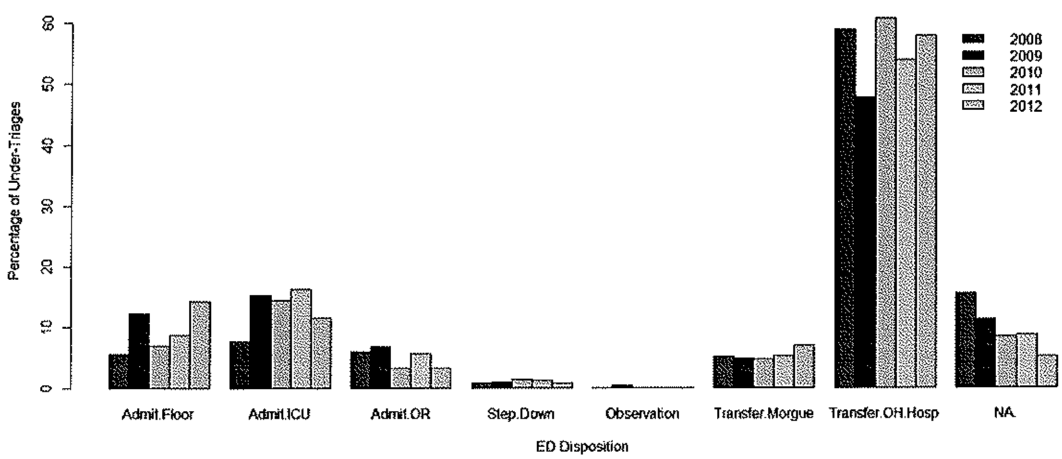
(i) ED Disposition

Over-Triage



	Admit.Floor	Admit.ICU	Admit.OR	Step.Down	Observation	Transfer.Morgue	Transfer.OH.Hosp	NA.
2008	1001	514	293	172	33	13	16	1233
2009	906	550	244	217	62	11	25	1127
2010	1046	552	213	318	16	18	61	858
2011	945	464	219	236	7	13	68	735
2012	1196	509	276	336	18	12	66	732

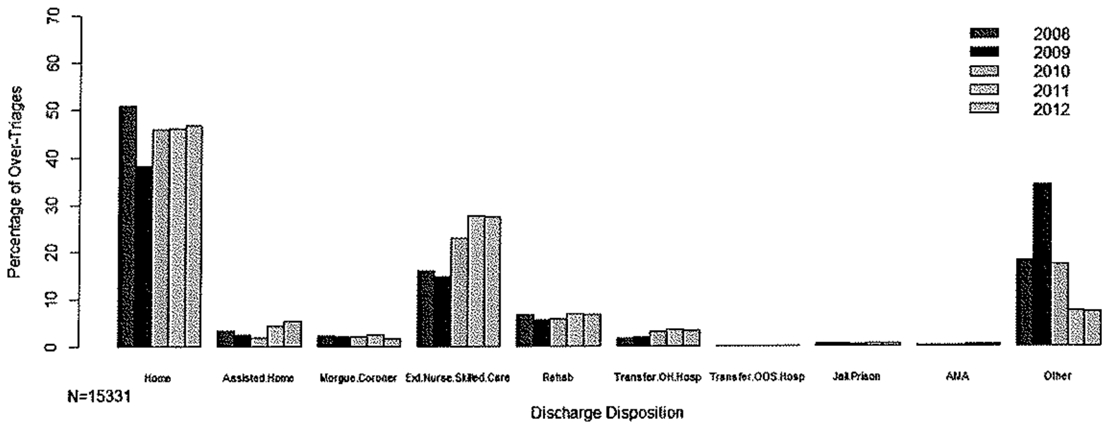
Under-Triage



	Admit.Floor	Admit.ICU	Admit.OR	Step.Down	Observation	Transfer.Morgue	Transfer.OH.Hosp	NA.
2008	13	18	14	2	0	12	136	36
2009	25	31	14	2	1	10	97	23
2010	15	31	7	3	0	10	130	18
2011	20	37	13	3	0	12	123	20
2012	31	25	7	2	0	15	125	11

(ii) Discharge Disposition

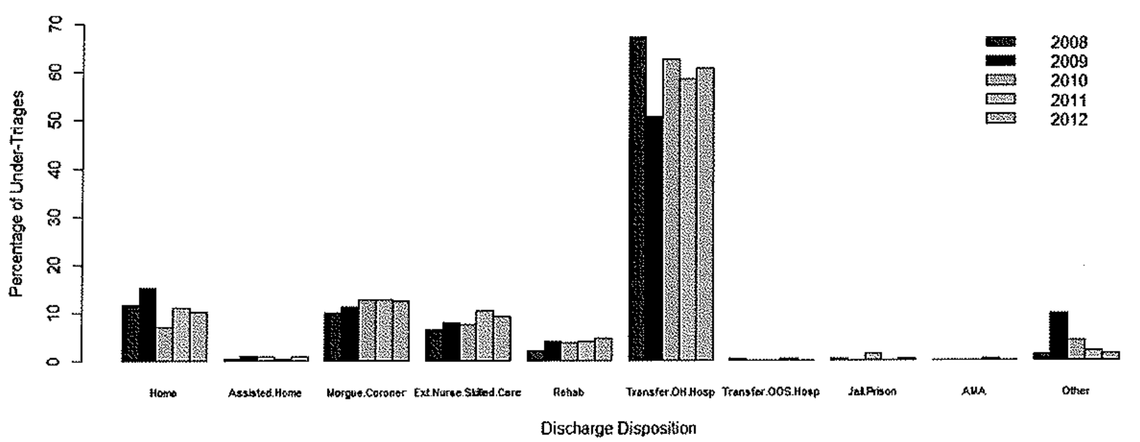
Over-Triage



N=15331

	Home	Assisted.Home	Morgue.Coroner	Ext.Nurse.Skilled.Care	Rehab	Transfer.OH.Hosp	Transfer.OOS.Hosp	Jail.Prison	AMA	Other
2008	1668	109	74	527	217	57	0	22	8	593
2009	1201	77	64	467	176	60	2	19	5	1071
2010	1419	58	62	708	182	97	1	16	9	530
2011	1241	119	67	742	188	96	2	17	11	204
2012	1469	173	56	865	213	106	0	18	12	233

Under-Triage

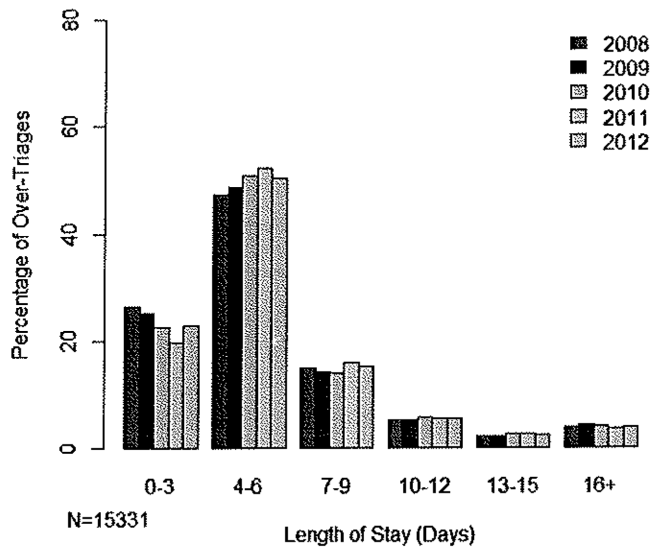


N=1092

	Home	Assisted.Home	Morgue.Coroner	Ext.Nurse.Skilled.Care	Rehab	Transfer.OH.Hosp	Transfer.OOS.Hosp	Jail.Prison	AMA	Other
2008	27	1	23	15	5	155	1	1	0	3
2009	31	2	23	16	8	103	0	0	0	20
2010	15	2	27	16	8	134	0	3	0	9
2011	25	1	29	24	9	133	1	0	1	5
2012	22	2	27	20	10	131	0	1	0	3

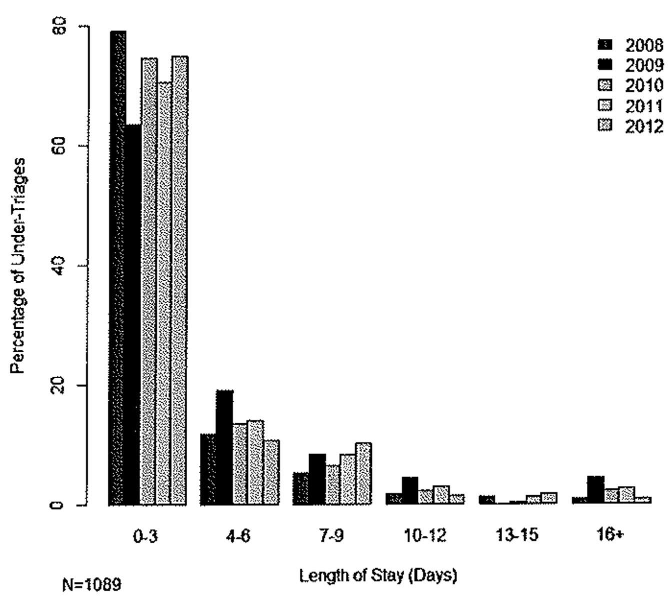
(iii) Hospital Length of Stay (for scene-to-first hospital only)

Over-Triage



	0-3	4-6	7-9	10-12	13-15	16+
2008	867	1545	494	169	72	128
2009	790	1530	448	165	72	137
2010	695	1570	436	174	80	127
2011	531	1405	431	148	74	98
2012	716	1583	477	174	74	121

Under-Triage



	0-3	4-6	7-9	10-12	13-15	16+
2008	182	27	12	4	3	2
2009	129	39	17	9	0	9
2010	159	29	14	5	1	5
2011	161	32	19	7	3	6
2012	161	23	22	3	4	2

Appendix B. An Attempt to Emulate the National Field Triage Decision Scheme (NFTDS) (Used 2008-2012, EMSIRS 2, "Protocol-Only," Data)

Step 1: Used everything as is.

Step 2:
1: Injury Type 2050 (penetrating), Complaint Anatomic Location 1305 (abdomen), 1310 (back), 1315 (chest), 1320 (extremity-lower), 1325 (extremity-upper), 1340 (head), 1345 (neck)

2: Flail Chest: not included

3: Two or more proximal long-bone fractures: There was no way to determine if there were multiple long-bone fractures, so we just used one long-bone fracture; Condition Code 8046 (Other Trauma- fracture/dislocation), Complaint Anatomic Location 1320 (extremity-lower), 1325 (extremity-upper).

4: Crush, degloved, mangled extremity: not included

5: Amputation proximal to wrist and ankle: Condition Code 8048 (Other Trauma- amputation digits), Complaint Anatomic Location 1320 (extremity-lower), 1325 (extremity-upper)

6: Pelvic Fractures: not included (none)

7: Open or depressed skull fracture: Condition Code 8046 (Other Trauma- fracture/dislocation), Complaint Anatomic Location 1340 (head)

8: Paralysis: Condition Code 8029 (neurologic distress)

Step 3:
1: Falls: Do not have any data based on the heights of falls, so only used Cause of Injury 9550 (Falls)

2: High-risk auto crash: Cause of Injury 9595 (Motor vehicle traffic accident), Airbag Deployment 2225 (Airbag deployed front). We used these because there was no data on mechanism of injury.

3: Auto vs. pedestrian/bicyclist thrown, run over, or with significant (>20 mph) impact: No velocities. Just used Cause of Injury 9610 (Pedestrian Traffic Accident)

4: Motorcycle crash >20 mph: No Velocity. Cause of Injury 9600 (Motorcycle crash)

Step 4:
1: Age: Just used age >55 (don't have data for patients <16 years and don't have information about pediatric hospitals either)

2: Anticoagulation and bleeding disorders: Condition Code 8045 (Other trauma-major bleeding) or Primary Symptom 1405 (Bleeding)

3: Burns: Injury Type 2040 (Burns)