Boonshoft School of Medicine
WRIGHT STATE UNIVERSITY
Department of Surgery

Impact of Inter-Facility Transfers and Secondary Over-Triage on Trauma Care in the State of Ohio

ANNUAL PROJECT REPORT

Submitted to

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

Submitted by

Principal Investigator: Priti Parikh, PhD

Co-Investigators: Randy Woods, MD, Melissa Whitmill, MD, Pratik Parikh, PhD

Department of Surgery
Department of Biomedical, Industrial and Human Factors Engineering
Wright State University, Dayton, OH

May 31, 2017

Executive Summary

The primary goal of the regionalization of trauma systems is to deliver the right care to the right patients at the right time. The American College of Surgeons (ACS) Advance Trauma Life Support (ATLS) algorithms recommend transfer of patients to verified trauma centers when appropriate. Our research goal was to identify the burden of inter-facility transfer of trauma patients in the state of Ohio and provide insights into how the overall care access and quality experienced by a trauma patient can be improved. Specifically, this study focused on (i) identifying patterns, rates, and correlation of transfer times to mortality, and (ii) studying secondary over-triage for the state.

Our multidisciplinary team of medical and engineering researchers analyzed nearly 34,494 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 who were transported to a Level 1/2 trauma center. Similarly, under-triage (UT) was defined as the proportion of patients with ISS>15 who were transported to a Level 3/non-trauma center (NTC). Furthermore, secondary over-triage (SO) was defined as those patients transferred from a facility to a Level 1/2 trauma center who, at the latter facility, did not require a surgical procedure, had an ISS≤15, and were discharged alive within 48 hours of admission.

The key findings from our study included the following. *First*, the mean interfacility transfers across all 5 years was 14.27%, and it was stable year-to-year. This is higher than transfers some recent studies identified for other states or regions. *Second,* the correlation of mortality of transferred patients with hospital LOS (specifically, the second hospital) was positive and statistically significant. This may indicate that the patient's condition may have deteriorated during the stay in the first hospital (mean LOS across transferred patients was 1.5 days. Transferring severely injured patients from Hospital 1 (i.e., the first receiving facility from the scene) to Hospital 2 (second receiving facility) soon after initial admission is, therefore, essential. *Third*, the mean SO

for the state was 20.2%; it decreased from 24.78% in 2008 to 18.78% in 2012. It is essential to note that both transfers and SO for Ohio are higher than some recent studies for other states or regions in the US. Moreover, the SO showed specific patterns per regions. For instance, regions 7 and 8 experienced higher number of SO than others. This is likely due to the lack of trauma centers and the fact that rural hospitals do not have all the required resources and specialties.

In summary, our study addresses several concerns related to inter-facility transfers in the state of Ohio. Our findings suggest that trauma care in the state of Ohio could be improved further by transferring severely injured patients directly to L1/2 centers as soon as possible and by reducing unnecessary transfers and resource utilization. Moreover, telemedicine approach could certainly be explored further to reduce the number of unnecessary transfers and SO. 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 25 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.

Pratik J. Parikh, PhD (Role, co-PI): For over 8 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 51 peer-reviewed journal and conference articles.

2. Study Rationale and Objectives

Our research goal is to identify the burden of inter-facility transfer of trauma patients in the state of Ohio and provide insights into how the overall care access and quality experienced by a trauma patient can be improved.

The Emergency Medical Treatment and Active Labor Act, passed in 1986, mandates that emergency departments evaluate and stabilize any injured patient. Once stabilized, patients may be transferred to a higher-level facility if the initial receiving hospital lacks the resources to provide definitive care [1-3]. Our preliminary analysis of the data obtained from the Ohio Department of Public Safety (ODPS) showed that, in 2008, 1171 (15.45%) patients out of 7576 trauma patients (with complete records) were transferred during their care. Further, the data showed that 1005 (85.82%) of patients that were correctly triaged (per their Injury Severity Score), were also transferred to another hospital. While there might be medical reasons necessitating transfer, it has been shown that patients are often transferred to Level 1 trauma centers for nonmedical reasons [4]. Consequently, a proportion of patients are discharged home shortly after transfer to a Level 1 trauma center from another facility, which is referred to as secondary over-triage (SO). 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.

3. Study Specific Aims

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

- *Aim 1: Study rates and patterns of patient transfers*. Using the state level trauma and emergency medical services (EMS) data from Ohio Department of Public Safety (ODPS), we identified (i) rates of patient transfers by region, (ii) if patients had more than one transfers during their care, and (iii) clinical reasons for transfers.

- *Aim 2: Study inter-facility transfer time and mortality*. We studied the amount of time (in days), excluding travel times, spent in transferring over-, under-, and correctly-triaged patients from one facility to another.
- *Aim 3: Study secondary over-triage*. We studied the rate of secondary over-triage (SO) for the state.

4. Significance

Trauma systems are designed to bring the injured patient to definitive care in the shortest and most practical amount of time. This depends on prehospital triage criteria (primary triage) and inter-facility transfer guidelines (secondary triage). Patient transfers between facilities have increased because of regionalization, specialization, and facility designation by payers [5]. The emergence of specialty systems, such as cardiac and stroke centers often determine the ultimate destination of patients rather than proximity of facility and needs [5]. Previous studies show that patients are often transferred to Level 1 trauma centers for non-medical reasons and may be discharged shortly after their admission; this phenomenon is referred to as secondary over-triage (SO) [4,6,7].

Although under-triage from the scene is associated with increased costs and worse outcomes for selected injuries, over-triage from the scene can overwhelm the system resources and delay definitive care [8]. Secondary over-triages, on the other hand, affect the quality and efficiency of trauma care and resource utilization. Further, the time spent in unnecessary inter-facility transfer (IFT) also hinders in maintaining continuity of care and meeting patients' needs [5]. That is, SO, along with unnecessary IFT, put burden on the trauma centers and overall trauma system of the state; both SO and IFT of patients has, thus, become a national issue for Emergency Medical Services (EMS) [5]. It is, therefore, necessary to understand and determine the rate of IFT and SO to improve the performance of the trauma system in the state.

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 from scene to a hospital. Figure 1 shows the collaborative approach and responsibilities of each investigator for the project. Based on our discussions with the ODPS team, we excluded some of the patient records that had missing Injury Severity Score (ISS), ISS=99, and secondary transfers. We also reanalyzed the assignment of regions originally provided to us and fixed the incorrect one. Table 1 shows the total number of patient records finally included in our analysis (N=34,494) by year.

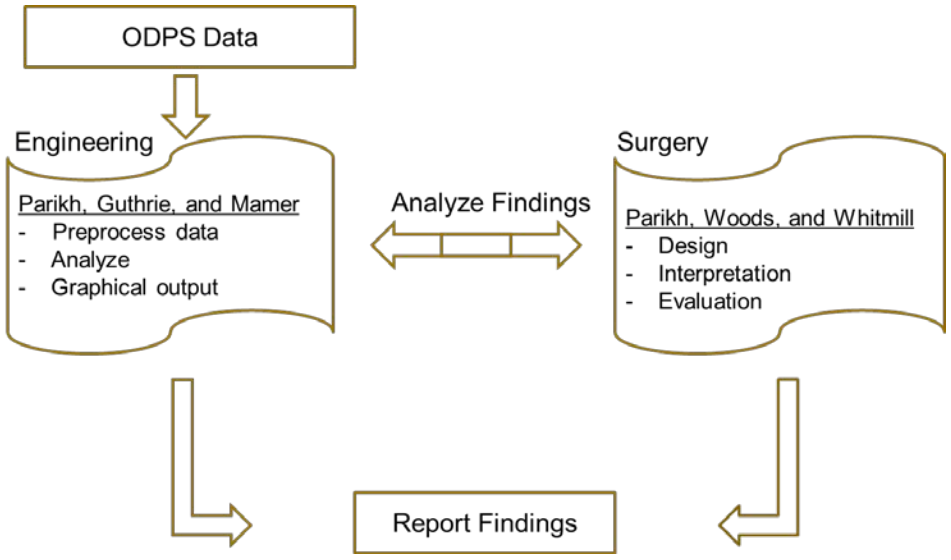


Figure 1: Our collaborative approach

Table 1. Number of records from scene to the first hospital

Year	2008	2009	2010	2011	2012
Total in EMSIRS 1 + 2 (N=40,819)	8881	8293	8065	7405	8175
Included in the final dataset (N=34,494)	7274	6897	6957	6319	7047

6. Results

Figure 2 illustrates the distribution of trauma incidences in the state during 2008-12. We organize the key findings from our analysis of these data corresponding to each aim below.

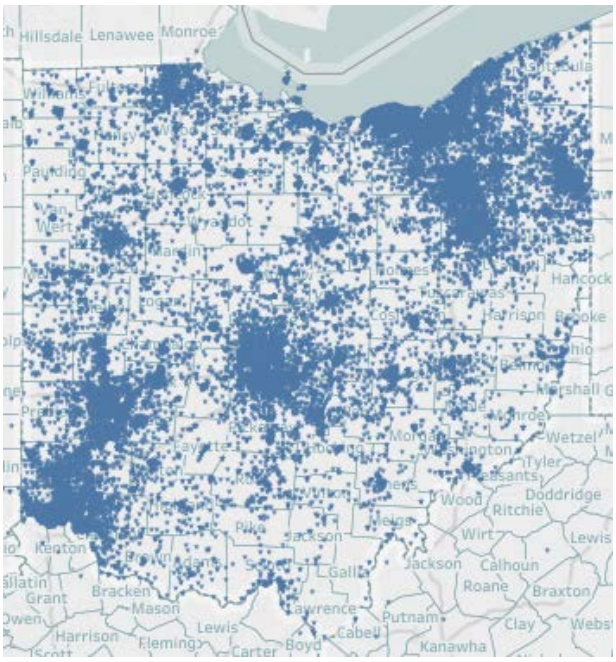


Figure 2: Distribution of triage incidences in Ohio during 2008-2012 (N=40,819)

6.1 Aim 1a: Study patient transfer patterns and other trends

Out of 34,494 records of trauma patients taken from the scene to the first facility during 2008-12, 5,003 patients were transferred (14.27%) from that facility to another. We studied the patient transfer trend for the state and further categorized it by locations (i.e., regions and counties) and triage status where we used ISS to identify the patient triage (i.e., correct, over, and under). For example, patients who had ISS≤15, but taken to Level 1 or 2 trauma center were considered as over-triage patients. On the other hand, patients who had ISS>15, but were taken to Level 3 or non-trauma center (NTC) were considered as under-triage patients. We then identified number of transferred patients in each category. Table 2 and figures 3-5 summarize these results. The following are the key findings:

- The average rate of patient transfer for the state (n=34,494) was 14.27% over the 5-year time frame (2008-2012). Table 2 describes inter-facility transfer trend based on the facility type. Approximately 89% and 86% of the patients who were transferred from a non-trauma center

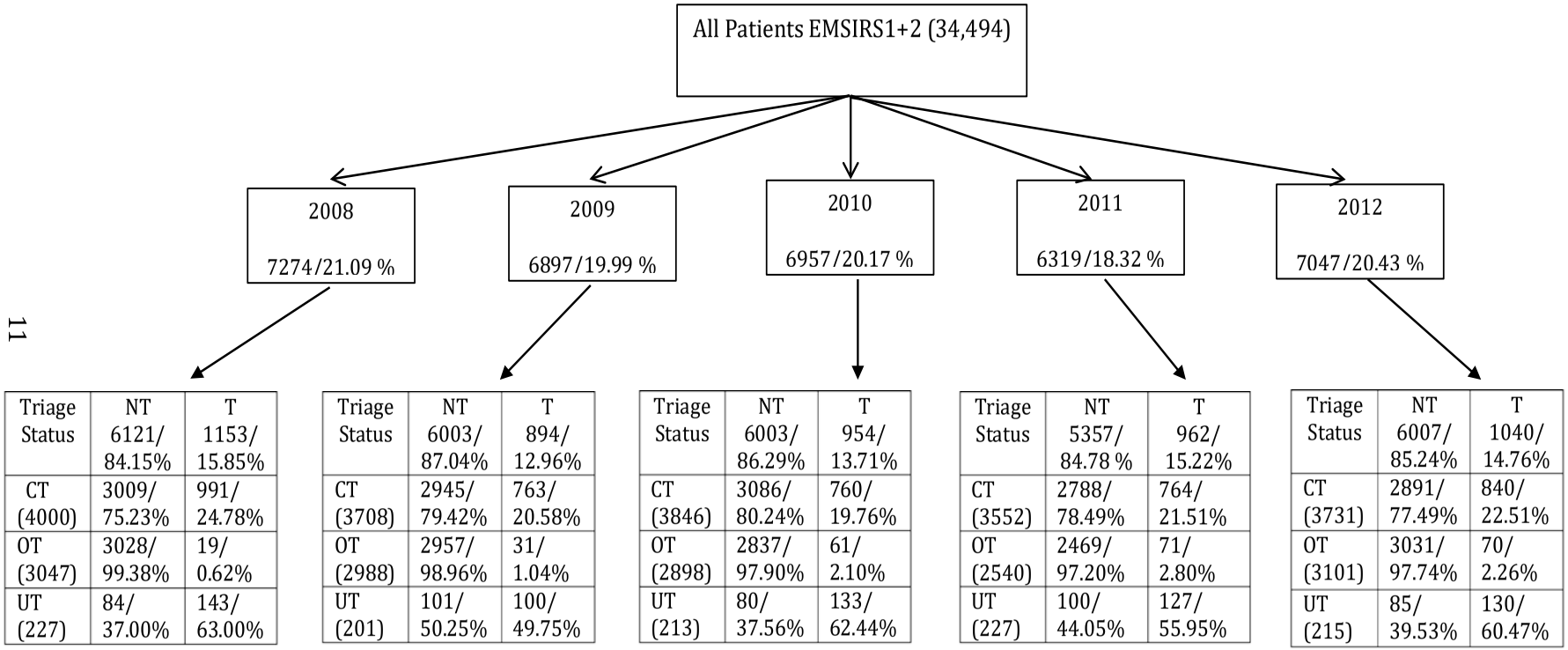
(NTC) to L1 and L2, respectively, had ISS≤15. We also found a trend where patients were being transferred from L1/2 to L3/NTC, although the numbers were low.

- In terms of patient transfers based on triage status, 21.72% correctly triaged (CT) patients and 1.92% over-triaged (OT) patients were transferred in this time-frame; see Figure 3.
- The average rate of patient transfer from 2008-2012 was highest in regions 7 and 8 (61% and 43%, respectively). The transfer rate increased from 2008-2012 in region 7 (57.6%-62.5%), however, decreased substantially in region 8 (62.1%-25.8%); see Figure 4.
- Transfer of patients in region 5 increased steadily from 3.8% in 2008 to 9.6% in 2012.
- The top 5 counties with the highest transfer rates were: (i) Marion (76.9%), (ii) Shelby (73.65%), (iii) Pike (71.43%), (iv) Morrow (63.79%), and (v) Champaign (58.91%); Figure 5.

As mentioned in specific aims (Aim 1, #ii), we also studied if patients had more than one transfers during their care, however, in the dataset that was provided to us, we found no patients who had more than one transfer.

Table 2. Trend of Inter-Facility Transfers Based on the Facility Type (N=5,003)

Sending Facility (H1)	Receiving Facility (H2)	Mean ISS	Total No. of Patients	No. of Patients with ISS≤15(%)
NTC	NTC	5.18	74	74 (100%)
NTC	L3	6.82	17	16 (94.1%)
NTC	L2	8.01	561	483 (86.1%)
NTC	L1	7.53	3107	2763 (88.9%)
L3	NTC	12.17	12	9 (75.0%)
L3	L3	9.00	1	1 (100%)
L3	L2	8.68	66	53 (80.3%)
L3	L1	10.65	808	614 (76.0%)
L2	NTC	14.33	3	2 (66.7%)
L2	L2	7.76	38	32 (84.2%)
L2	L1	13.07	274	189 (69.0%)
L1	NTC	5.47	17	17 (100%)
L1	L3	17.00	1	0 (0.0%)
L1	L2	14.86	7	3 (42.9%)
L1	L1	14.47	17	9 (52.9%)



Triage Status	NT 6121/ 84.15%	T 1153/ 15.85%
CT (4000)	3009/ 75.23%	991/ 24.78%
OT (3047)	3028/ 99.38%	19/ 0.62%
UT (227)	84/ 37.00%	143/ 63.00%

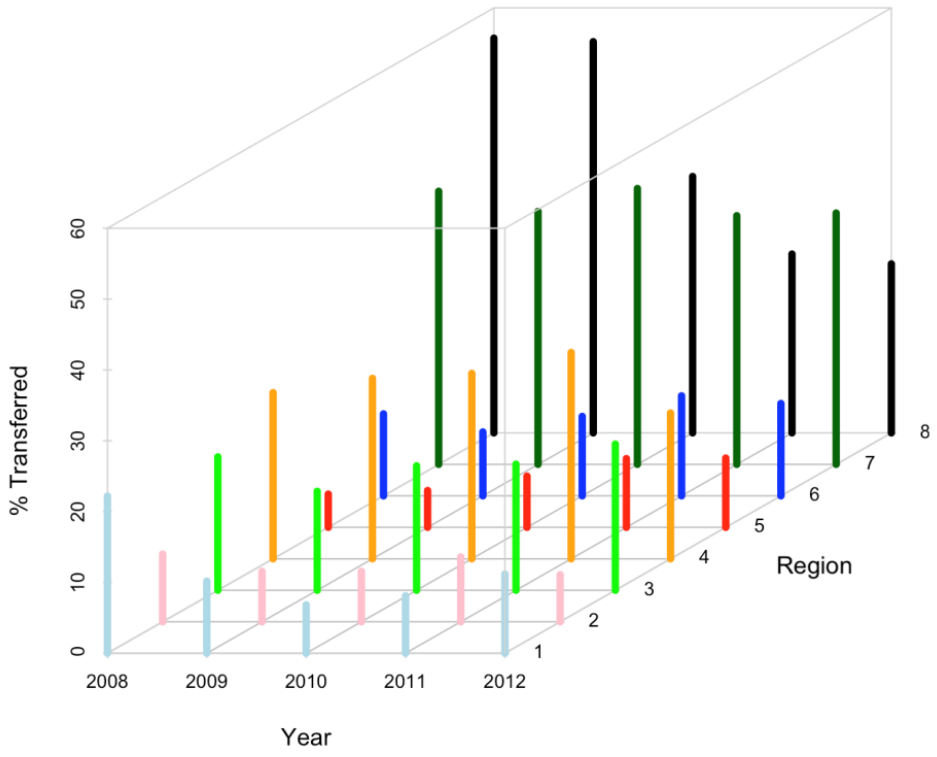
Triage Status	NT 6003/ 87.04%	T 894/ 12.96%
CT (3708)	2945/ 79.42%	763/ 20.58%
OT (2988)	2957/ 98.96%	31/ 1.04%
UT (201)	101/ 50.25%	100/ 49.75%

Triage Status	NT 6003/ 86.29%	T 954/ 13.71%
CT (3846)	3086/ 80.24%	760/ 19.76%
OT (2898)	2837/ 97.90%	61/ 2.10%
UT (213)	80/ 37.56%	133/ 62.44%

Triage Status	NT 5357/ 84.78 %	T 962/ 15.22%
CT (3552)	2788/ 78.49%	764/ 21.51%
OT (2540)	2469/ 97.20%	71/ 2.80%
UT (227)	100/ 44.05%	127/ 55.95%

Triage Status	NT 6007/ 85.24%	T 1040/ 14.76%
CT (3731)	2891/ 77.49%	840/ 22.51%
OT (3101)	3031/ 97.74%	70/ 2.26%
UT (215)	85/ 39.53%	130/ 60.47%

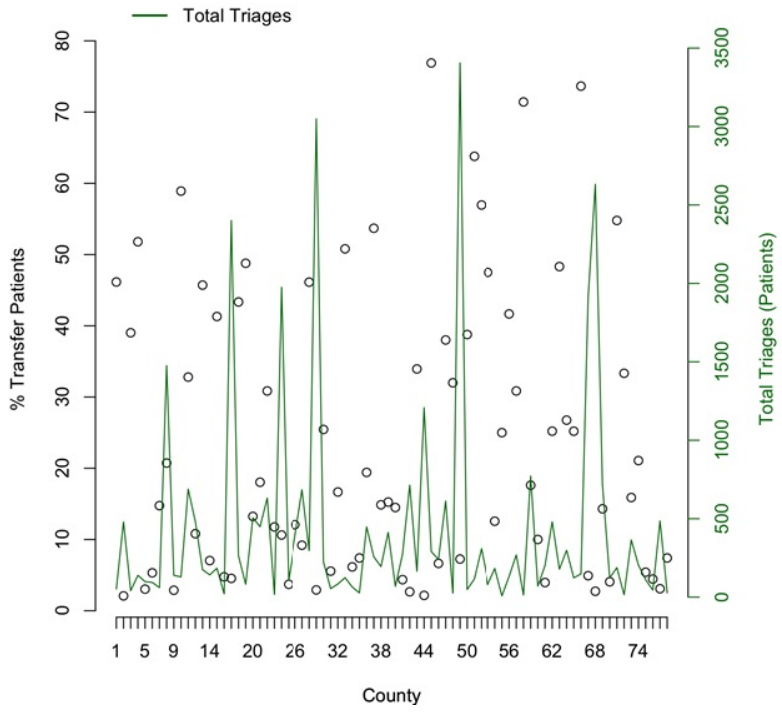
Figure 3: Pattern of patient transfer based on triage status



Note: Regions and exact values associated with the X-axis (Year) in the graph are summarized below.

	1	2	3	4	5	6	7	8
2008	187	59	224	263	84	158	32	146
2009	84	46	150	257	100	100	25	132
2010	60	52	219	239	126	120	37	101
2011	63	69	206	233	136	146	33	76
2012	82	43	276	238	164	157	33	47

Figure 4: Patient transfer rates by regions (N=34,494)

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> CountyNames
 [1] "Adams"       "Allen"       "Ashland"     "Ashtabula"   "Auglaize"    "Belmont"     "Brown"       "Butler"
 [9] "Carroll"     "Champpaign"  "Clark"       "Clermont"    "Clinton"     "Columbiana"  "Coshocton"   "Crawford"
[17] "Cuyahoga"    "Darke"       "Defiance"    "Delaware"    "Erie"        "Fairfield"   "Fayette"     "Franklin"
[25] "Fulton"      "Geauga"      "Greene"      "Guernsey"    "Hamilton"    "Hancock"     "Hardin"      "Henry"
[33] "Highland"    "Hocking"     "Holmes"      "Huron"       "Knox"        "Lake"        "Licking"     "Logan"
[41] "Lorain"      "Lucas"       "Madison"     "Mahoning"    "Marion"      "Medina"      "Miami"       "Monroe"
[49] "Montgomery"  "Morgan"      "Morrow"      "Muskingum"   "Noble"       "Ottawa"      "Paulding"    "Perry"
[57] "Pickway"     "Pike"        "Portage"     "Preble"      "Putnam"      "Richland"    "Ross"        "Sandusky"
[65] "Seneca"      "Shelby"      "Stark"       "Summit"      "Trumbull"    "Tuscarawas"  "Union"       "Vinton"
[73] "Warren"      "Washington"  "Wayne"       "Williams"    "Wood"        "Wyandot"
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Figure 5: Patient transfer rates by counties (N=34,494)

6.2 Aim 1b: Clinical factors responsible for transfer

We used primary diagnosis for transferred patients to identify any potential clinical reasons for transfer. The analysis showed that almost all (99.8%) patients were in the category of "injury and poison" (Figure 6). Therefore, we decided to study this population in detail and found that the top 5 diagnosis for transfer patients were: (i) fracture of neck and trunk (27.7%), (ii) intracranial injury, excluding those with skull fracture (21.1%), (iii) fracture of lower limb (11.4%), (iv) fracture of skull

(9.5%), and (v) open wound of head, neck, and trunk (6.7%) (Figure 7).

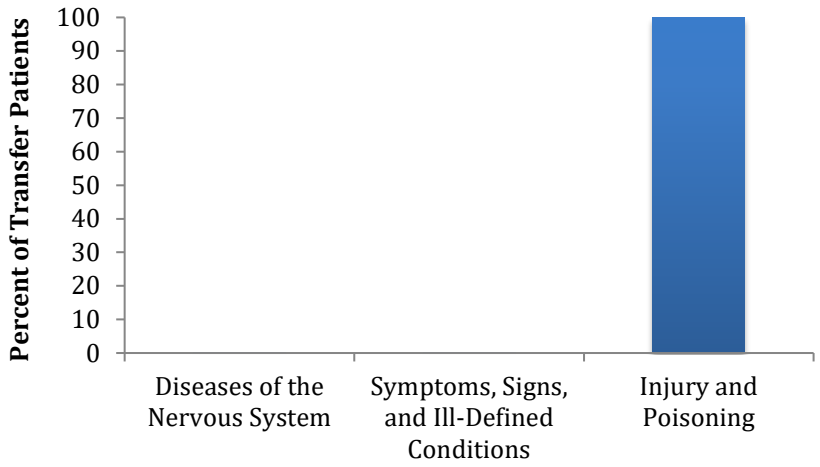
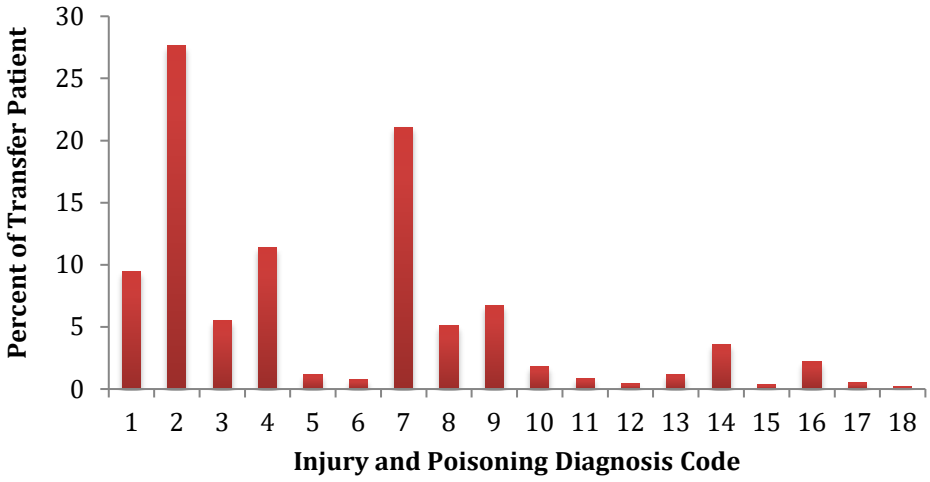


Figure 6: Patient transfers by primary diagnosis code



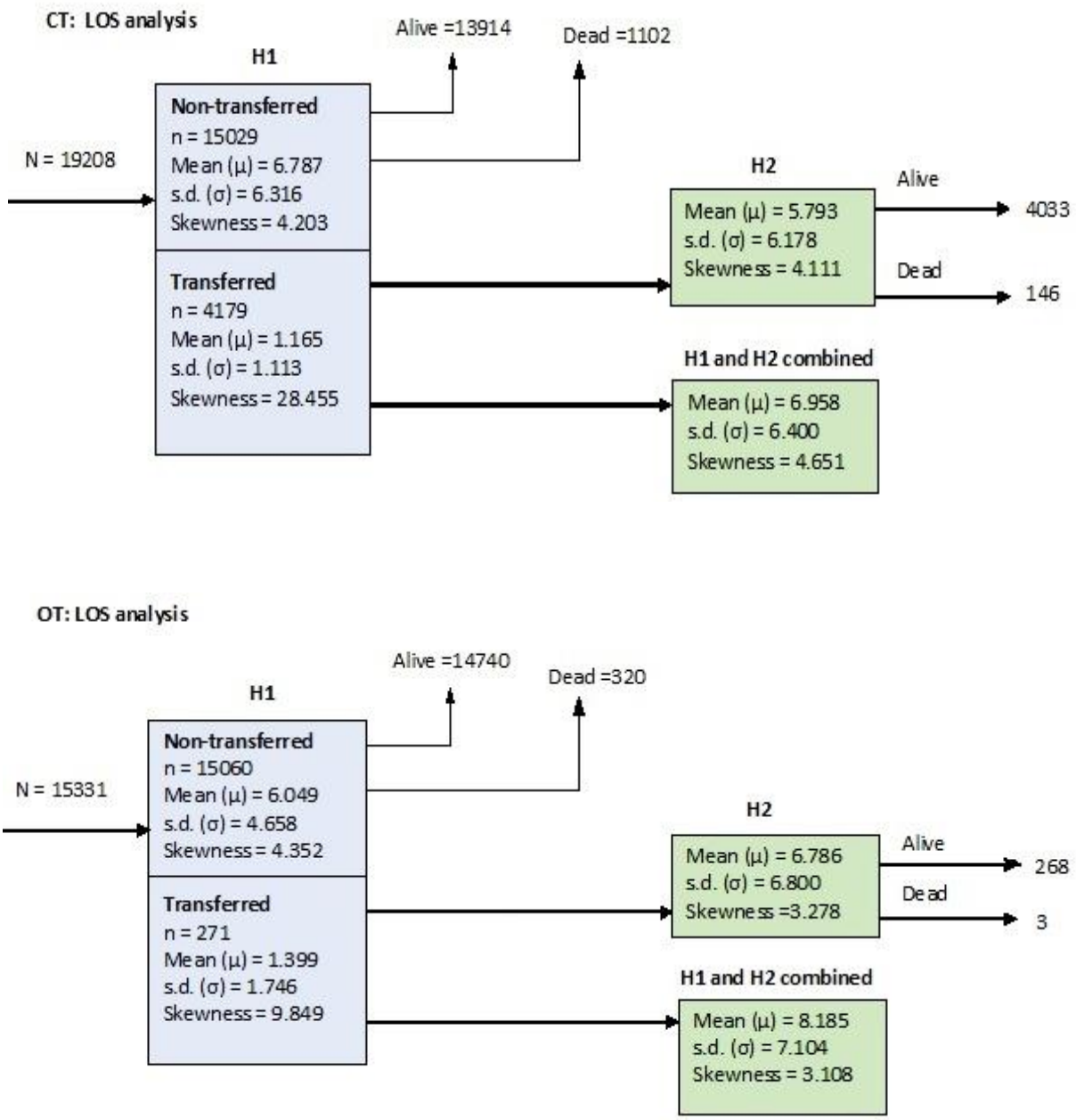
Note: Diagnosis codes associated with the X-axis in the graph are summarized below.

1. Fracture of skull
2. Fracture of neck and trunk
3. Fracture of upper limb
4. Fracture of lower limb
5. Dislocation
6. Sprains and strains of joints and adjacent muscles
7. Intracranial injury, excluding those with skull fracture
8. Internal injury of thorax, abdomen, and pelvis
9. Open wound of head, neck, and trunk
10. Open wound of upper limb
11. Open wound of lower limb
12. Injury to blood vessels
13. Superficial injury
14. Contusion with intact skin surface
15. Crushing injury
16. Burns
17. Injury to nerves and spinal cord
18. Other and unspecified effects of external causes

Figure 7: Patient transfer by Injury and Poisoning codes

6.3 Aim 2: Study inter-facility transfer time and mortality

We analyzed inter-facility transfer time (measured in terms of length of stay, LOS) in each facility based on triage status (correctly triaged, over-triaged and under-triaged). Our analysis is illustrated schematically below (Figure 8). For this analysis, we excluded the travel time (in minutes) from hospital 1 (H1) to hospital 2 (H2).



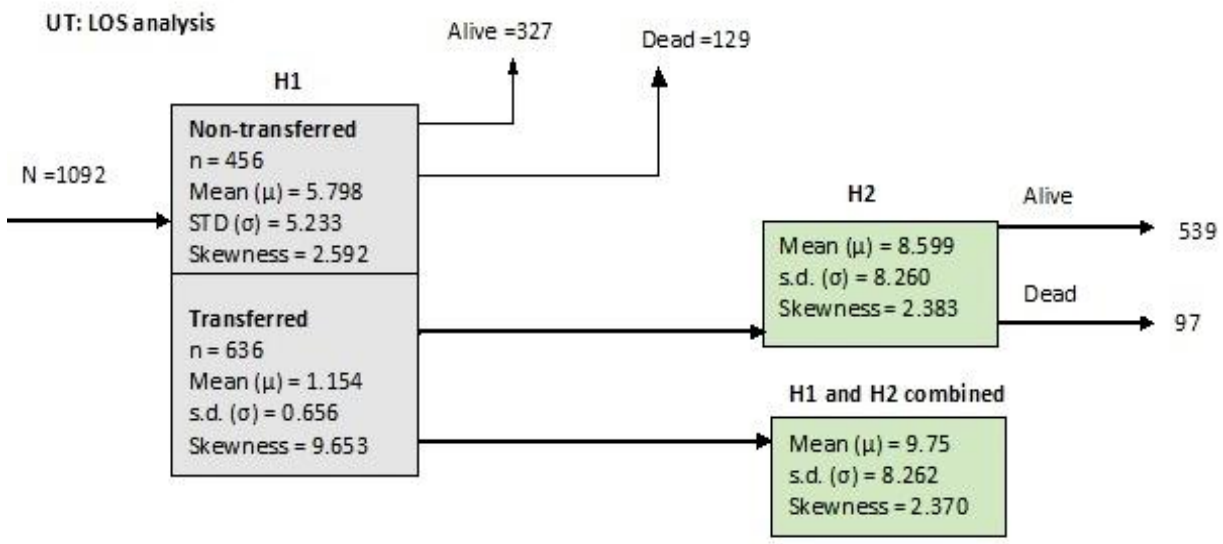


Figure 8: Summary of length of stay (LOS) analysis based on triage status

We also determined correlation of LOS with patient mortality. As shown in Table 3, UT mortality for transferred patients is positive and statistically significant compared to OT or CT mortality, specifically, the LOS at H2 (P value = <0.0001). Our data did not indicate any significant correlation between transfer of CT and OT patients and mortality.

Table 3. Correlation of patient transfers and mortality based on triage

Triage Status	Hospital Transfer	Mean LOS (std. dev.)	% Mortality	Spearman correlation (ρ)	P value
Correctly Triaged (n=4179)	Hospital 1 (H1)	1.16 (1.11)	3.49% (146)	0.0085	0.585
	Hospital 2 (H2)	5.79 (6.18)		0.0023	0.882
	Combined (H1+H2)	6.96 (6.40)		0.0017	0.912
Over-triaged (n=271)	Hospital 1 (H1)	1.40 (1.75)	1.11 % (3)	-0.0320	0.599
	Hospital 2 (H2)	6.79 (6.80)		0.0378	0.535
	Combined (H1+H2)	8.18 (7.10)		0.0283	0.643
Under-triaged (n=636)	Hospital 1 (H1)	1.15 (0.66)	15.25% (97)	-0.0019	0.962
	Hospital 2 (H2)	8.60 (8.26)		0.2263	<0.0001
	Combined (H1+H2)	9.75 (8.26)		0.2275	<0.0001

6.4 Aim 3: Study secondary over-triage

Secondary over-triage (SO) was defined based on current literature [8,9]; patients transferred from another facility to a Level 1/2 trauma center and who did not require a surgical procedure, had an Injury Severity Score <15, and were discharged alive within 48 hours of admission from that facility. Our results show that that 20.22% (1,017 out of 5,030 transferred patients) experienced SO; the % of SO decreased steadily from 24.78% in 2008 to 18.78% in 2012 (Figure 9). When we analyzed the results to understand any regional differences in number of SO patients, we observed that rural areas (e.g., regions 7 and 8) had a high proportion of SO patients (Figures 10). Further exploration suggested that the primary clinical factor associated with SO was 'concussion' followed by 'fracture of face bones' and 'superficial injury' (Figure 11).

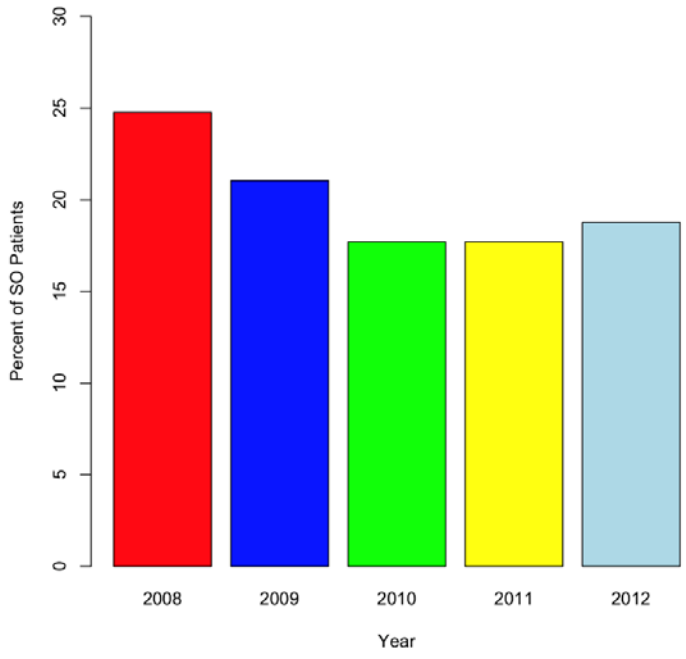


Figure 9: Secondary over-triage by year

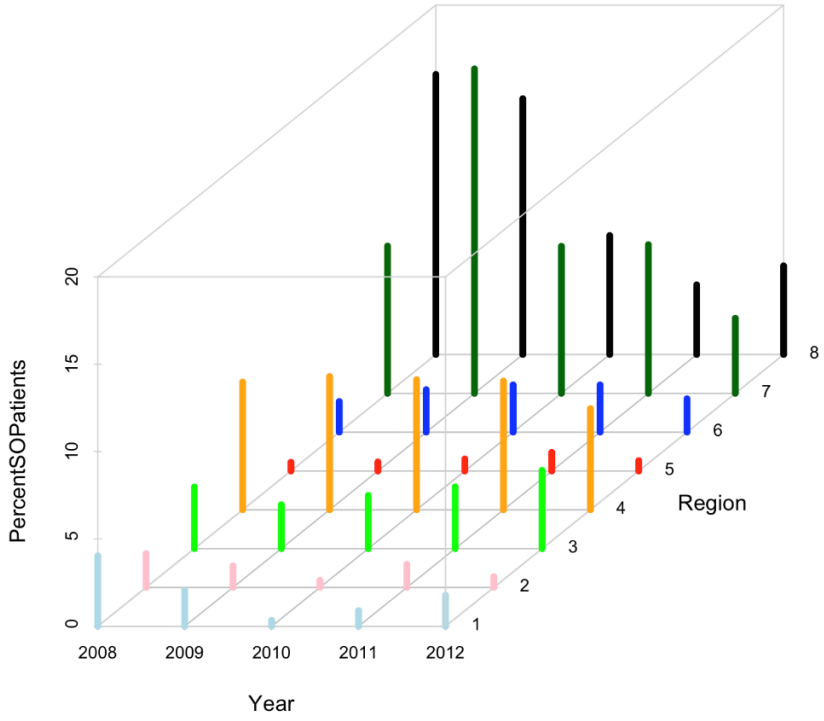


Figure 10: Secondary over-triage per year by homeland security regions

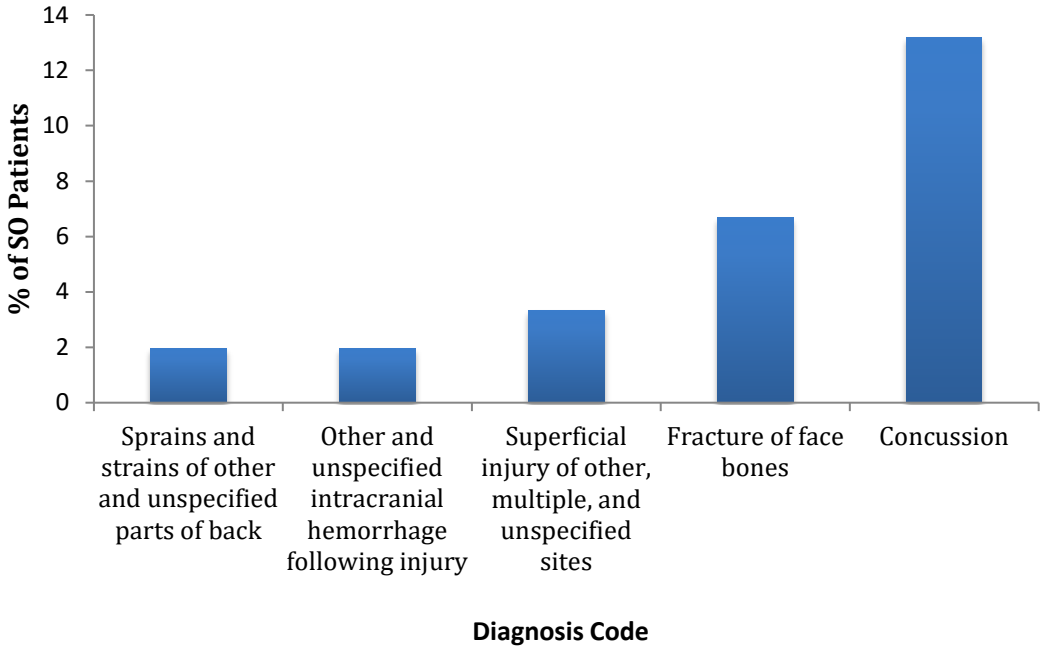


Figure 11: Secondary over-triage by clinical diagnosis

7. Discussion

The primary objective of this work was to analyze inter-facility transfers for the state of Ohio, identify underlying patterns and outcomes, and study secondary over-triage. Our analysis of 2008-2012 data indicated that 14.27% of all trauma patients in the state experienced inter-facility transfers, which is higher than one recent study by Newgard and others [10] who reported <4% transfer rates in several counties of Oregon and Washington. Further, the data indicated that transfer rates were higher in rural regions (i.e., regions 7 and 8 in the state of Ohio). We confirm these findings reported previously for the state of West Virginia [9] and some parts of Oregon and Washington [10]. This finding is intuitive since rural hospitals lack specialties and resources needed to provide trauma care. The data also indicated that over 20% of CT patients were transferred, reasons for which are unknown. We conjecture this may be due to insurance, vicinity to home, or due to other specific medical needs not available at H1. Studying this population further, however, will be useful since directly impacts resource management aspect of any trauma system.

The data showed that primary clinical reasons for patient transfers were injuries and poisoning. These injuries specifically included, fracture of different sites (skull, head, neck, and lower limb) and intracranial injuries along with open wound of head and neck. These injuries are usually perceived to be serious yielding the need for specialty care often available only at the L1/L2 centers.

The data related to the length of stay suggested that the LOS of second hospital (H2) of all the under-triaged patients was statistically significant and positively correlated with mortality. This may mean that either the injuries of such patients were so severe that the likelihood of their survival at the onset was low or, more importantly, that the condition of these patients may have deteriorated during the average 1.15 days of stay at the first hospital (H1) before being transferred to H2. Recent studies allude to the latter indicating that complications are higher in transferred patients than those directly admitted to care [11]. Our findings then raise a very important question

of whether to transport injured patients to closest NTC/L3 or transport them directly to L1/2 if the patient is still within "'golden hour' of receiving definitive care.

While transfer of injured patients is primarily for improved outcomes and patient care, often less severely injured patients (ISS≤15) are also transferred to Level 1 trauma centers resulting in secondary over-triage (SO) that present a resource-sensitive challenge to Level 1 trauma centers. It also delays definitive care, and can be expensive and inconvenient to patients. We observed that 20.22% (1,017 out of 5,030) of the patients experience SO in the state of Ohio, which is higher than a previous study by Osen and others, who reported 6.9% of SO on national data [7]. However, they defined SO as patients who were less injured and discharged alive from the hospital within 24 hours, and not 48 hours. Higher SO, however, are not uncommon and have been seen previously by Ciesla and others who reported 38% SO at a single institution [8]. Our study also confirms previous findings on higher SO in rural vs. urban areas, possibly due to limited resources hospitals have in the rural areas [12].

Our results show that the most common diagnosis for SO was concussion and fracture of face, which were probably considered as 'serious' issues to be seen by surgeons or other specialists that rural hospitals usually lack. We believe that telemedicine could help alleviate this problem and so the burden of secondary over-triage on the trauma systems. Since new practice of telemedicine have enabled rural practicing physicians to manage a wide range of acutely ill patients and improve care access [13], we believe this method could be used to make decisions on transfers for less injured patients (ISS≤15) as well.

8. Conclusions and Recommendations

The primary goal of the regionalization of trauma systems is to deliver the right care to the right patients at the right time. The American College of Surgeons (ACS) Advance Trauma Life Support (ATLS) algorithms recommend transferring patients to verified trauma centers when

appropriate. Previous studies suggest better outcomes for patients treated at the Level 1 trauma center, with up to 25% higher survival rate. However, more recent studies suggest that mortality does not change in transferred patients and there are many unnecessary transfers as well that put a lot of burden on the trauma system.

Our study findings suggest that inter-facility transfer rate for trauma patients in the state of Ohio were higher during 2008-12 than what has been recently reported in another study. Further, state-wide secondary over-triage was observed (20.2%) to be higher than some previous studies. This shows that inter-facility transfers and, thus, trauma care in the state of Ohio could further be improved by reducing unnecessary transfers. We believe that telemedicine could help alleviate this problem and subsequently the burden of secondary over-triage on the trauma systems. This approach, however, should be further evaluated and researched for the state.

9. Dissemination Plan

This work will be submitted at the Academic Surgical Congress Annual Meeting (August 2017). 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 2017-2018.

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