Trauma and Rehabilitation Registry Merge

Introduction

The Centers for Disease Control and Prevention describes traumatic injuries as the leading cause of death for children and young adults. Globally, trauma accounts for more than 5.8 million deaths per year[1]. Trauma is a leading cause of lost years of life to an individual who has sustained multiple life-threatening injuries[2].

The inception of systematic trauma care in 1922 by the American College of Surgery did not come to fruition until 1966, with the release of the National Academy of Sciences report, that the need for a system of trauma care was needed[3]. This report paved the way for the development of the Emergency Medical Services (EMS) system (under the auspices of the Department of Transportation) in 1973. The EMS Systems Act identified trauma systems as one of 15 essential components of an EMS system and from thereon, concerted efforts were undertaken to ascertain that the delivery of trauma care is at its optimum.

In Ohio, the roots of the EMS system can be traced back to 1969, with the leadership of Dr. James Warren through the creation of the Heartmobile Program (mobile coronary care unit), heralding the provision of advanced pre-hospital care across the nation. It was not until 1992, when the Division of EMS was established within the Ohio Department of Public Safety (ODPS). In the same year, Senate Bill 98 was passed creating the State Board of EMS to development and implement prehospital systems of care in the state. In 1999 the Ohio Trauma Registry (OTR) was set up within the Division of EMS requiring hospitals to submit data on trauma victims to the state. The OTR was designed to address data collection issues and quality of trauma care delivery as well as monitoring trauma outcomes. House Bill 138 was passed in July of 2000 to establish a statewide trauma system, to create the Ohio Trauma Committee (OTC), to define the trauma patient, and to establish standards for trauma centers. The OTC was established to assist the State Board of EMS in its objectives to develop a quality trauma system of care for injured patients.

The existence of integrated Trauma Systems and trauma registries have proven to be essential in improving survival rates and diminishing the likelihood of sustaining life-long disabilities[4,5]. This can be attributed to improved and effective triage systems at the field and the evolution of care in highly specialized regional trauma centers that can provide necessary service in a timely and expeditious manner. A recent meta-analysis revealed a 15% reduction in mortality with the establishment of trauma systems, further justifying their importance[6].

Recognizing the need to identify and document long term outcomes from traumatic injuries, the Trauma Rehabilitation Registry was established in 2005 within the Division of EMS. This is considered a vital step at incorporating a reliable measure of patient disability via the Functional Independence Measure (FIM) into the Trauma Registry instead of the previously used outcome measure of mortality (2009 Ohio Trauma Registry Annual Report). The data gathered in the Rehabilitation Registry from inpatient rehabilitation facilities however, has not been available in trauma system evaluation reports, creating a shortcoming in the system. Currently, there is an absence of standardization of data reporting and data linkage between the Trauma and Rehabilitation Registries. Little is thus known about the functional outcomes of those who survive catastrophic injuries.

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The objective of the study is to enhance the ability of the MetroHealth Trauma Registry to assess quality of trauma care with the addition of functional outcome measures from the inpatient rehabilitation database.

Study aims:

1. To link the Trauma and Rehabilitation Registry Data

2. To identify variables from the Trauma Registry that are associated with long term functional outcomes for persons who sustained traumatic brain injury (TBI), spinal cord injury (SCI) and polytrauma (multiple injuries).

The proposed study moves toward the direction of the State's goals in having a comprehensive Trauma system. Outlined in the State EMS Trauma Committee proceedings last October 2010 is the creation of a well-integrated trauma program that incorporates rehabilitation services early in the course of the patients' hospitalization, as well as inclusion of rehabilitation data (i.e. functional outcome data) into the trauma system evaluation reports. Vital to this process too is the involvement of rehabilitation personnel into the performance improvement process.

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<u>**Narrative Progress Report**</u>

<u>**Fiscal Report**</u>

Executive Summary

Purpose: The main purpose of this project was to identify variables from the Trauma Registry that impact long-term outcomes for persons with traumatic injuries.

Methods: Retrospective data analyses using Administrative Data Sets

Participants / Methods: 879 patients with traumatic spinal cord injury, traumatic brain injury and polytrauma from 2005 to 2010, who were transported to a Level I Trauma system and subsequently admitted and discharged from the system's inpatient rehabilitation center. Trauma Registry patients were matched (by medical record number and birth date) to their data in the Rehabilitation Registry. Standard descriptive statistics were calculated to describe participants and outcome measures. Demographic measures included age, sex, race, marital status, trauma type, and health insurance. Trauma data points included ISS, Glasgow Coma Score (GCS), intubation at any time prior to acute rehabilitation, positive and negative drug test, number of comorbidities/complications, total time spent at the scene of the accident. Outcome measures were obtained through the Rehabilitation Registry. These outcomes included: total length of hospital stay (REHAB LOS), rehabilitation discharge disposition, total Functional Independence Measure (FIM) gain, motor FIM gain, and cognitive FIM gain. Chi-square tests for categorical demographic variables and Student's t test for continuous variables were performed to determine any statistically significant differences between the three trauma type groups (i.e. polytrauma, traumatic spinal cord injury (SCI) and traumatic brain injury (TBI).

Bivariate associations were analyzed utilizing Pearson Correlations with a significance level of less than or equal to .05.

Binary Logistic regression was used to analyze the outcome measure of rehabilitation discharge disposition (home or not to home) and two stage linear regression was used to analyze the functional outcomes as measured with the FIM.

Results: The mean age of the total sample was 42.75 (± 18.04), 71.9% were discharged to home, 42.1% were intubated at some time prior to rehabilitation admission, 27.2% had public health insurance, mean ISS was 25.53 (± 9.55), mean Glasgow Coma Score was 15.39 (± 7.58), average total FIM Motor Gain was 24.68 (±13.64), and mean number of comorbidies/complications was 7.57 (± 3.59).

Separating the sample by trauma type we did not find any statically significant differences in the demographics of the three groups. Statistical differences between the trauma types were found for GCS, ISS, REHAB LOS and cognitive FIM gain. The GCS for SCI (mean = 13.333) and TBI (mean = 12.769) groups were higher than the polytrauma group (mean = 10.748). The TBI group had the highest mean ISS (mean = 30.29) compared to the Polytrauma group (mean = 26.15) and SCI group (mean = 13.86). The Polytrauma group had the longest average REHAB LOS (mean = 43.451) compared to the SCI (mean =39.526) and TBI (mean = 21.611) groups. The SCI group (mean=2.48) had the lowest cognitive FIM gain than the Polytrauma group (mean = 5.53) and the TBI group (mean =3.25).

The bivariate analysis between trauma data and rehabilitation outcomes revealed that higher ISS scores were associated with longer length of stays, not going home after rehabilitation, less total FIM gain, and less total FIM motor gain. Higher GCS was associated

with longer length of stay, lower total FIM gain, lower FIM motor gain and lower total FIM cognitive gain. Total scene time was only found to have an association with total FIM cognitive gain, with longer total time at the scene associated with higher levels of total FIM cognitive gain. Interestingly, those who were not tested for drugs had lower total FIM gain and lower total FIM cognitive gain.

Length of hospital stay

Having government sponsored health insurance increased REHAB LOS by 22.086 days and being intubated at any time prior to rehabilitation increased hospital stay by 22.890 days. For every one point increase in ISS increased REHAB LOS by almost one day (.788 days).

Rehabilitation Discharge Disposition

Persons who are older, have more comorbidities/complications, were intubated pre-rehabilitation, and have higher ISS are less likely to be discharged to home after acute rehabilitation. Those persons who are married and have commercial health insurance compared to those without any health insurance are more likely to be discharged to home after acute rehabilitation.

Total FIM Gain

Older persons, persons with more comorbidities/complications, those with high ISS and high GCS decreased the amount of total FIM gain during acute rehabilitation. The strongest predictors in the regression model were GCS and number of comorbidities/complications with a significant level of $\leq .001$.

Total FIM Motor Gain

For total FIM motor gain, the regression analysis indicated that the older a person, the more comorbidities/complications, higher ISS, higher GCS, and longer scene time decreased the level of motor gain as measured by the FIM score. Testing negative for drugs compared to not being tested for drugs increased total FIM motor gain.

Total FIM Cognitive Gain

Having more comorbidities/complications, testing positive for drugs and higher GCS decreases the gain in cognitive function as measured by the FIM. Having been intubated at some time prior to rehabilitation increased a person's gain in cognitive function.

Conclusion, Recommendations and Future Course: Trauma data, especially ISS and GCS, should be included in research and quality projects when trying to determine and understand long-term outcomes of persons with traumatic injuries. Further standardization and utilization of the trauma and rehabilitation registries (i.e. criteria for inclusion and scoring methods) across institutions can define long term outcomes for those who survive SCI. Further improvements in medical informatics will allow for the creation of a repository of data within an institution and across collaborating Trauma systems.

Our continued research with this combined database will be to look at the three trauma groups (Poly, SCI and TBI) separately to determine if different trauma variables affect outcomes of the three groups. In addition, we plan to look at the GCS components (verbal, eye and motor) and their independent effects on outcomes. Further finetuning of the databases will hopefully yield a larger merged study population from which trends and outcomes can be sufficiently derived.

Biosketch, Principal Investigator, M Mejia

Melvin Samson Mejia, M.D.

Department of Physical Medicine and Rehabilitation
2500 MetroHealth Drive, Cleveland, OH 44109
Office: 216-778-2929
Fax: 216-778-5560
email: mmejia@metrohealth.org

EDUCATION

2003-2004		Spinal Cord Injury Medicine Fellowship	University of Texas Southwestern Medical Center at Dallas, TX
2000-2003		PM&R Residency	Case Western Reserve University MetroHealth Rehabilitation Inst of Ohio, Cleveland, OH
1999-2000		Medical Internship	Case Western Reserve University MetroHealth Rehabilitation Inst of Ohio, Cleveland, OH
1995		Post-Graduate Internship	Veterans Memorial Med Center, Philippines
1990-1994	M.D.	Doctor of Medicine	University of the East Memorial Med Center, Philippines
1986-1990	B.S.	Biology	Ateneo de Manila University, Philippines

STAFF APPOINTMENTS

2006-Present	Assistant Professor, Department of Physical Medicine and Rehabilitation / Spinal Cord Injury Service	Case Western Reserve University MetroHealth Rehabilitation Inst of Ohio, Cleveland, OH
2004-2006	Assistant Professor, Department of Physical Medicine and Rehabilitation / Spinal Cord Injury Service	University of Texas Southwestern Medical Center at Dallas, Dallas, TX Veterans Affairs North Texas Health Care System, Dallas, TX

LICENSURE AND CERTIFICATIONS

Medical Licensure

- State Medical Board of Ohio, 2003

Board Certification

- American Board of Physical Medicine and Rehabilitation, 2004
- American Board of Physical Medicine and Rehabilitation, Subspecialty Certification in Spinal Cord Injury Medicine, 2004
- Educational Commission for Foreign Medical Graduates 1997

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SELECTED PRESENTATIONS

"Merging of Trauma and Rehabilitation Registries to Further Define Long Term Outcomes in Traumatic Spinal Cord Injuries", Mejia M, Roach MJ, Nemunaitis G, Nowak M, Claridge J. To be presented at the Academy of Spinal Cord Injury Professionals, Las Vegas, NV. September 2012.

"Impact of Roho Cushion Inflation on Pushrim Kinetics During Advanced Wheelchair Skills in Persons with Spinal Cord Injury", Mejia M, Nagy J, Nemunaitis G, Roach MJ. 2012 ASIA Conference, Denver, CO. May 2012.

"Impact of Pneumatic vs Airless Wheelchair Tires on Pushrim Kinetics During Advanced Wheelchair Skills in Persons with Spinal Cord Injury", Mejia M, Nagy J, Nemunaitis G, Roach MJ. 2012 ASIA Conference, Denver, CO. May 2012.

"Association of Body Weight and Height on Pushrim Forces During Advanced Wheelchair Skills in Persons with Spinal Cord Injury", Mejia M, Nagy J, Nemunaitis G, Roach MJ. 2012 ASIA Conference, Denver, CO. May 2012.

"Impact of Time Since Injury on Pushrim Kinetics During Advanced Wheelchair Skills in Manual Wheelchair Users with Spinal Cord Injury", Henzel M, Nagy J, Roach MJ, Nemunaitis G, Mejia M. 2012 ASIA Conference, Denver, CO. May 2012.

BOOK CHAPTERS

- Airway & Respiratory Interventions: Ventilator Management. Common Problems in Rehabilitation Medicine: Spinal Cord Injury. Mejia M. Edited by T Bryce. Demos; NY, NY, 2009

Biosketch Co-Investigator, GA Nemunaitis

NAME	POSITION TITLE
Nemunaitis, Gregory A. eRA COMMONS USER NAME	Associate Professor of Physical Medicine and Rehabilitation Director of the Spinal Cord Injury Medicine

EDUCATION/TRAINING (*Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
Case Western Reserve University, Cleveland, OH	BA, BA	1980	Anthropology/Medical Science
Case Western Reserve University School of Medicine, Cleveland, OH	MD	1985	Medical Doctor
Mt Sinai Medical Center, Cleveland, OH	Internship	1986	Internal Medicine
Thomas Jefferson University Hospital, Philadelphia Pennsylvania	Residency	1989	Physical Medicine and Rehabilitation
Medical College of Ohio, Toledo, Ohio	Certification #1623	1992	American Board of Electrodiagnostic Medicine
Medical College of Ohio, Toledo, Ohio	Certification #147	1999	Subspecialty certification in Spinal Cord Injury Medicine
Rehabilitation Institute of Chicago, Chicago, Ill	Regional Classifier	2000	United Cerebral Palsy Athletic Association
MetroHealth Medical Center, Cleveland, Ohio	Recertification # 147	2009	Subspecialty certification in Spinal Cord Injury Medicine
Emergency Management Institute, FEMA Independent Study Course	IS-00197.EM	2009	Special Needs Planning Considerations for Emergency Management

A. Positions and Honors.

Positions and Employment

1989 – 1996 Assistant Professor, Department of Physical Medicine and Rehabilitation, Medical College of Ohio, Toledo, OH

1992 – 2000 Residency Program Director, Department of Physical Medicine and Rehabilitation, Medical College of Ohio, Toledo Ohio

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1996 – 2002	Associate Professor, Department of Physical Medicine & Rehabilitation, Medical College of Ohio, Toledo, Ohio
2006 - 2012	WOC Physician at the Louis Stokes Cleveland Department of VAMC
2002 – present	Associate Professor, Department of Physical Medicine & Rehabilitation, MetroHealth Rehabilitation Institute of Ohio, Cleveland, Ohio
2002 - present	Director of Spinal Cord Injury Rehabilitation, MetroHealth Rehabilitation Institute of Ohio, Cleveland, Ohio
2004 - present	Program Director of the Spinal Cord Injury Medicine Fellowship, MetroHealth Rehabilitation Institute of Ohio, Cleveland, Ohio
2006 - present	Associate Professor at CWRU School of Medicine, Case Western Reserve University, Cleveland, Ohio
2006 – present	Consultant for Gradalis Corp. Muscle Assessment in HIBM2 following GNE Gene Therapy. Mary Crowley Research Center, Dallas, Texas
2011 – present	Professor, Department of Physical Medicine and Rehabilitation CWRU School of Medicine, Case Western Reserve University, Cleveland, Ohio

<u>Other Experience and Professional Memberships</u>

1986 -present	The American Academy of Physical Medicine and Rehabilitation
1990 –present	Member, American Spinal Injury Association
1992 –present	Association of Academic Physiatrists
1995 –1997	Education Committee, American Academy of Physical Medicine and Rehabilitation
2006 -2012	PI: Spinal Cord Injury Model System Grant. National Institute of Disability and Rehabilitation Research
2006 -2012	Dissemination and Knowledge Translation Committee. Spinal Cord Injury Model System. National Institute of Disability and Rehabilitation Research, US Department of Education
2006 -2012	Technology Module/SIG. Spinal Cord Injury Model Systems. National Institute of Disability and Rehabilitation Research, US Department of Education
2005 -present	Membership Committee Member, American Spinal Cord Injury Association
2001 -present	State of Ohio Emergency Medical Services Board, Trauma Committee Member
2002 -present	Member, American Trauma Society
2006 -present	Grant reviewer for the State of Ohio EMS/Trauma Research Grant Program Ohio Department of Public Safety, Division of EMS
2006-present	Peer Reviewer: Neurorehabilitation and Neural Repair

B. Selected peer-reviewed publications

<u>Abstracts</u>

1. Henzel K, Nagy J, Roach MJ, Nemunaitis G, Mejia M. Impact of Time since Injury on Pushrim Kinetics During Advanced Wheelchair Skills in Manual Wheelchair Users with Spinal Cord Injury (SCI). Topics in Spinal Cord Injury Rehabilitation 2012;18(1):243-244.
2. Mejia M, Nagy J, Nemunaitis G, Roach MJ. Impact of Roho Cushion Inflation on Pushrim Kinetics During Advanced Wheelchair Skills in Manual Wheelchair Users with SCI. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):243-244.
3. Mejia M, Nagy J, Roach MJ, Winslow A, Wilczewski C, Adams L, Nemunaitis G. Association of Body Weight and Height on Pushrim Forces during Advanced Wheelchair Skills in Persons with SCI. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):247.
4. Mejia M, Nagy J, Roach MJ, Winslow A, Wilczewski C, Adams L, Nemunaitis G. Impact of Pneumatic vs. Airless Wheelchair Tires on Pushrim Forces During Advanced Wheelchair Skills in Manual Wheelchair Users with SCI. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):248.
5. Nagy J, Winslow A, Wilczewski C, Adams, Kaplan D, Distler M, Roach MJ, Mejia M, Nemunaitis G. Observations of Community Manual Wheelchair Users with Spinal Cord Injury. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):245.
6. Nagy J, Winslow A, Wilczewski C, Adams, Kaplan D, Distler M, Roach MJ, Mejia M, Nemunaitis G. Impact of Axle Position on Pushrim Kinetics During Advanced Wheelchair Skills in Manual Wheelchair Users with Spinal Cord Injury. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):248.
7. Nagy J, Winslow A, Wilczewski C, Adams, Kaplan D, Distler M, Roach MJ, Mejia M, Nemunaitis G. Impact of Axle Position on Pushrim Kinetics During Advanced Wheelchair Skills in Able Bodied Subjects. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):249.
8. Mowery D, Nagy J, Winslow A, Wilczewski C, Adams L, Roach MJ, Mejia M, Nemunaitis G. Observations between Neurological Level of Injury and Manual Wheelchair Pushrim Force. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):247.
9. Distler M, Nagy J, Wilczewski C, Adams L, Nemunaitis G, Roach MJ, Impact of Caster Diameter on Pushrim Kinetics during Advanced Wheelchair Skills in Manual Wheelchair Users with SCI. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):246.
10. Winslow A, Nagy J, Mejia M, Nemunaitis G, Roach MJ. Variation in Pushrim Forces due to Alteration of Wheelchair Camber. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):244.
11. Winslow A, Nagy J, Mejia M, Nemunaitis G, Roach MJ. Pushrim Forces in a Rigid versus Folding Frame Wheelchair. Topics in Spinal Cord Injury Rehabilitation 2012;18(1):212.
12. Atluri K, Nagy J, Newcomb H, Roach MJ, Mejia M, Nemunaitis G, Wilson R. Effects of Backrest Elevation of Transport Stretcher/Gurney on Sacral Interface Pressure. [poster] Topics in Spinal Cord Rehabilitation 2011;16(1):62.
13. Dechter S, Roach MJ, Nemunaitis G, Mejia M. Nocturnal Home Turning Schedule for Pressure Relief among Persons with SCI Living in the Community. [Poster] Topics in Spinal Cord Rehabilitation 2011;16(1):64.

14. Nagy J, Roach MJ Mejia M, Boninger M, Nemunaitis G. Pushrim Kinetics During Advanced Wheelchair Skills in Manual Wheelchair Users With Spinal Cord Injury [oral] Topics in Spinal Cord Rehabilitation 2011;16(1):21.
15. Wu G, Mejia M, Nemunaitis G, Bogie K. Multifactorial tissue health assessment of at-risk users and effects of weight shifting with a dynamic cushion. [poster] Topics in Spinal Cord Rehabilitation 2011;16(1):29.
16. Michaluk M, Nemunaitis J, Roach MJ, Hefzy S, Nagy J, Mejia M, Nemunaitis G. Redesign of the Spine board for the Reduction of Pressure Ulcer Formation in Individuals with Spinal Cord Injury, Part II. J of Spinal Cord Med 2010;33(2):178.
17. Michaluk M, Nemunaitis J, Nagy J, Roach MJ, Tyler D, Hefzy S, Mejia M, Nemunaitis G. Redesign of the Spine board for the Reduction of Pressure Ulcer Formation in Individuals with Spinal Cord Injury. Am J PM&R 2010;89(4): S1-S87.
18. Nagy J, Nemunaitis G, Roach M, Winslow A, Marlow J, Boninger M, Oyster M. Wheelchair Breakdown Frequency for Wheelchair Users with SCI. J of Spinal Cord Med 2009;32(4):461.
19. DiMarco A, Kowalski K, Geertman R, Hornyak D, Frost F, Nemunaitis G. Spinal Cord Stimulation (SCS) Cough System: Clinical Inpact and Patient Satisfaction. J of Spinal Cord Med 2009;32(4):486
20. Nemunaitis G, Boninger M, Nagy J, Oyster M, Marlow J, Roach M, McClure L. Evacuation Readiness for Wheelchair Users. J of Spinal Cord Med 2009;32(4):462
21. Nemunaitis G, Triolo R, Boggs L, Murray L, Miller M, Roach M, Nagy J, Marlow J, Nicolacakis K, Mejia M. Physiologic Impact of Neuromuscular Electrical Stimulation on Trunk Stability. J of Spinal Cord Med 2009;32(4):468.
22. M. Tsarouhas, J. Chae, M. Mejia, G. Nemunaitis, M. Roach. Vitamin D Deficiency in Individuals With Orthopedic Injuries Admitted to the Rehabilitation Service: A Case Series [abstract] Arch of Phy Med Rehabil 2008;89(11):74
23. Boulet M, Nemunaitis G, Kaufman B. Nagy J, Clark G, Buzanowska K. The effect of a liner on the dispersion of backboard interface sacral skin pressures. J Spinal Cord Med 2008;31(2):224.

Publications

1.Staas W, Nemunaitis G, Management of Reflex Sweating in SCI patients", Arch Phys Med 1989;70(7):544-546.
2.Nemunaitis G, Herbison G. "Cosmetic, Functional, Independent: Self Help Aids" Arch Phys Med. 1991;72(5):334-335.
3.Hefzy M, Nemunaitis G, Hess M. Design and Development of a Pressure Relief Seating Apparatus for Individuals with Quadriplegics. Assistive Technol, 1996;8(1):14-22.
4.DiMarco AF, Kowalski KE, Geertman RT, Hromyak DR, Frost FS, Creasey GH, Nemunaitis GA. Lower thoracic spinal cord stimulation to restore cough in patients with spinal cord injury: results of an NIH sponsored clinical trial. Part II: clinical outcomes. Arch Phys Med Rehabil 2009;90:726-32.
5.Jay C, Nemunaitis G, Nemunaitis J, Senzer N, Hinderlich S, Darvish D, Ogden J, Eager J, Tong A, Maples P. Preclinical Assessment of wt GNE Gene Plasmid for Management of Hereditary Inclusion Body Myopathy 2 (HIBM2). Gene Regulation and Systems Biology, Jun 20, 2008, 2008(2):243-252.

6.Triolo R, Boggs L, Miller M, Nemunaitis G, Nagy J, Nogan-Bailey S. Implanted Electrical Stimulation of the Trunk for Seated Postural Stability and Function After Cervical Spinal Cord Injury: A Single Case Study. Arch Phys Med Rehabil 2009;90(2) 340-347.
7.Phadke A, Jay C, Chen S, Haddock C, Wang Z, Yu Y, Nemunaitis D, Nemunaitis G, Templeton N, Senzer N, Maples P, Tong A and Nemunaitis J. Safety and in vivo Expression of a GNE-Transgene: A Novel Treatment Approach for Hereditary Inclusion Body Myopathy-2. Gene Regulation and Systems Biology 2009:3 89–101.
8.Jay C, Levonyak N, Nemunaitis G, Maples P and Nemunaitis J. Hereditary inclusion body myopathy (HIBM2). Gene Regulation and Systems Biology 2009;3:181–190.
9.Nemunaitis G, Mejia M, Roach MJ, Nagy J, Wolf T. A descriptive study on vitamin D levels in individuals with spinal cord injury in an acute inpatient rehabilitation setting. PMR 2010;2(3):202-208.
10. Nemunaitis G, Maples P, Jay C, Gahl W, Huizing M, Tong A, Phadke A, Pappen B, Bedell C, Templeton N, Kuhn J, Senzer N, and Nemunaitis J. Hereditary Inclusion Body Myopathy (HIBM): Single Patient Response to GNE Gene Lipoplex Therapy. J Gene Med. 2010:12(5); 403-12.
11. Roach MJ, Nemunaitis G, Powell H, and Harrington A. Cell Phone Ownership and Social Interaction in Persons with Spinal Cord Injury. Special Issue of Arch. Phys. Med. 2010;92(3):472-6.
12. McClure L, Nemunaitis G, Boninger M, Nagy J, Oyster M, Marlow J, Roach MJ. Breakdown of Evacuation Readiness for Wheelchair Users. Arch. Phys. Med. 2010;92(3):491-8.
13. Chen Y, Deutsch A, DeVivo MJ, Johnson K, Kalpakjian C, Nemunaitis G, Tulsky D. Current research outcomes from the spinal cord injury model systems. Arch Phys Med Rehabil 2011;92(3):329-31.
14. Werman HA, Erskine T, Caterino J, Riebe JF, Valasek T, Members of the Trauma Committee of the State of Ohio EMS Board. Development of statewide geriatric patient's trauma triage criteria. Prehosp Disaster Med 2011;26(3):1–10.
15. Nemunaitis G, Jay CM, Maples PB, Gahl WA, Huizing M, Yardeni T, Tong AW, Phadke AP, Pappen BO, Bedell C, Allen H, Hernandez C, Templeton NS, Kuhn J, Senzer N, Nemunaitis J. Hereditary inclusion body myopathy: single patient response to intravenous dosing of GNE gene lipoplex. Hum Gene Ther. 2011 Nov;22(11):1331-41.
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17. Worobey L, Oyster M, Nemunaitis G, Cooper R, Boninger ML. Increases in Wheelchair Breakdowns, Repairs, and Adverse Consequences for People with Traumatic Spinal Cord Injury. Am J Phys Med Rehabil. 2012 Apr 30. [Epub ahead of print].

Book Chapters

1.Nemunaitis G. Cardiovascular interventions: Inferior vena cava filter placement and removal. In: Common Problems in Rehabilitation Medicine: Spinal Cord Injury. Edited by Thomas Bryce. Demos Medical Publishing; New York, NY, 2009.
2.Nemunaitis G, Triolo R, Kobetic R, Kilgore K, Creasey G, Anthony DiMarco A. (2008). Neuromuscular Elictrical Stimulation in Spinal Cord Injury. In: Spinal Cord Injury

Medicine. Edited by S Kirschblum, D Campagnolo, J Delisa, et al. Lippincott, Wiliams & Wilkins; Philadelphia, Pa, 2011.

3.Hefzy M, Nemunaitis G. The University of Toledo Projects, In: NSF 2005 Engineering Senior Design Projects to Aid the Disabled, Chapter 17, Edited by John Enderle and Brooke Hallowell, Copyright 2006 by Creative Learning Press, Inc., pp 285 – 306.

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Biosketch, Co-Investigator, J Claridge

Jeffrey Claridge, MS, MD
MetroHealth Medical System, Div. of Trauma
2500 MetroHealth Dr.
Cleveland, OH 44109

Current Professional Position

2008-present	Division Director of Trauma, Critical Care and Burns MetroHealth Medical Center

Education

2008	M.S., Clinical Investigation Case Western Reserve University School of Medicine Cleveland, Ohio
1996	M.D. with Honors University of Rochester Rochester, New York
1992	B.S. with High Honors Rochester Institute of Technology Rochester, New York

Faculty Appointments

June 2010 – Present	Division Director of Trauma, Critical Care and Burns MetroHealth Medical Center Cleveland, Ohio
January 2010 – Present	Medical Director of Northern Ohio Trauma System (NOTS) Cleveland, Ohio
December 2009 – Present	Director of Trauma, MetroHealth Medical Center Cleveland, Ohio
July 2005 – Present	Assistant Professor of Surgery General Surgery, Trauma, Surgical Critical Care Department of Surgery MetroHealth Medical Center Case Western Reserve University, School of Medicine Cleveland, Ohio
July 2004 – June 2005	Clinical Instructor Trauma/Critical Care/General Surgery Department of Surgery University of Tennessee Memphis, Tennessee

Licensure

USMLE: Passed both Step one and two.
Ohio, 2003 – present, #86505
Tennessee, 2003 -2005, #MD0000037815

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Certifications

American Board of Surgery, General Surgery; March, 2004 (#48947)
American Board of Surgery, Surgical Critical Care; October, 2004 (#2100)

Professional Organizations

Eastern Association for the Surgery of Trauma, 2006 - Present
The American Association for the Surgery of Trauma, 2008 - Present
Surgical Infection Society, 2006 - Present
Councilman, 2009 - Present
Member of Scientific Investigation Committee, 2006 - 2009
Part of Retreat "planning for organization", 2008
Cleveland Surgical Society, 2005 - Present
Secretary/Treasurer - Present
Society of Critical Care Medicine, 2003 - Present
American College of Surgeons, Fellow, 2006 - Present
Southeastern Surgical Congress, 2000 - Present
Association of Surgical Educators (ASE), 2002
Alpha Omega Alpha, 1995 - Present

Association for Academic Surgery, 2008 - Present

Muller Jones Society - University of Virginia Surgical Society, Member, 2003

Selected Publications

1. Como JJ, Leukhardt WH, Anderson JS, Wilczewski PA, Samia H, **Claridge JA.** Computed Tomography Alone May Clear the Cervical Spine in Obtunded Blunt Trauma Patients: A Prospective Evaluation of a Revised Protocol. Journal of Trauma. 2011 Feb:70(2):345-51.
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Review of the Literature/Historical Perspectives

Trauma Registries allow for trauma systems to collect the necessary data for understanding the nature, epidemiology and management of traumatic injuries. The addition of the Trauma Rehabilitation Registry in the state of Ohio strengthens the ability of the Ohio EMS and Trauma systems to assess outcomes along the continuum of care for victims of trauma. Since the implementation of the Trauma Rehabilitation Registry in 2005, the State has yet to merge the two registries or analyze the rehabilitation data in relation with the trauma data. The purpose of this study is to merge MetroHealth Medical Center's (MH) Trauma and Rehabilitation registry databases and analyze the effects of pre-hospital and trauma centered variables on rehabilitation outcomes. This project emphasizes the importance of merging the trauma and rehabilitation datasets to be able to effectively evaluate the quality of health care across all phases of care and determine which variables in both registries define and /or alter outcomes. Findings from this study can assist the State in the modification or implementation of policies and / or protocols that will improve current and future delivery of care and improve outcomes of trauma patients.

Injuries remain a major global public health problem. Worldwide, 5.8 million deaths are attributed to injury per year.[1] The National Trauma Data Bank's (NTDB) 2010 Annual Report reviewed the year 2009 admissions from 682 U.S. Hospitals, with 681,990 records having valid trauma diagnoses. Of these, 654,825 (96%) survived and 27,166 (4.0%) died.[2] In the state of Ohio, 151,244 individuals were entered in the Ohio Trauma Registry (OTR) from 2005 to 2009, of which 144,622 (95.6%) survived and 6,622 (4.4%) died.[3] Trauma is a well-known leading cause of lost years of life to an individual, especially in those who sustain multiple life-threatening injuries.[4] Injuries definitely impact not only the lives of affected persons and families, but also the society as a whole. Short- and long-term effects are associated with injuries; hence, positive outcomes greatly depend on the availability of an effective delivery of care by a trauma system.

The existence of integrated Trauma Systems and trauma registries have proven to be essential in improving survival rates and diminishing the likelihood of sustaining life-long disabilities.[5,6] This can be attributed to improved and effective triage systems at the field and the evolution of care in highly specialized regional trauma centers that can provide necessary service in a timely and expeditious manner. A recent meta-analysis revealed a 15% reduction in mortality with the establishment of trauma systems further justifying their importance.[7,8]

The inception of systematic trauma care in 1922 by the American College of Surgery did not come to fruition until 1966, with the release of the National Academy of Sciences - National Research Council report, *"Accidental Death and Disability – The Neglected Disease of Modern Society"*, that the need for a system of trauma care has been recognized.[9] This report paved the way for the development of the Emergency Medical Services (EMS) system (under the auspices of the Department of Transportation) in 1973. The EMS Systems Act identified trauma systems as one of 15 essential components of an EMS system and from thereon, concerted efforts were undertaken to ascertain that the delivery of trauma care is at its optimum.

In Ohio, the roots of the EMS system can be traced back to 1969, (through the leadership of Dr. James Warren) with the creation of the Heartmobile Program (mobile coronary care unit), heralding the provision of advanced pre-hospital care across the nation. It was not until 1992, when the Division of EMS was established within the Ohio Department of Public Safety (ODPS). In the same year, Senate Bill 98 was passed creating the State Board of EMS to development and implement prehospital systems of care in the state. In 1999 the Ohio Trauma Registry was set up within the Division of EMS requiring hospitals to submit data on trauma victims to the state. The Ohio Trauma Registry was designed to address data collection issues, to ensure quality of trauma care delivery and to monitor trauma outcomes. House Bill (HB) 138 was passed in July of 2000 which aims to establish a statewide trauma system, to create the Ohio Trauma Committee, to define the trauma patient and, to establish standards for trauma centers. The Ohio Trauma Committee was established to assist the State Board of EMS in its objectives to develop a quality trauma system of care for injured patients. The trauma patient was defined as:

Patient's first or initial admission for at least 48 hours or transfer into the hospital for at least one injury ICD-9 diagnosis code in the range of 800-959.9 including burns, hypothermia, smoke inhalation, hanging, drowning, abuse, DOAs, patients that die after receiving any evaluation or treatment while on hospital premises, and patients who transfer out of the hospital.

HB 138 also provided for two commissions to study injury prevention and post-critical trauma care. It mandated seven special studies to examine trauma care in the State at the time. In November of 2003 the Post Critical Trauma Commission was completed "to determine how to improve the accessibility, affordability, quality, and cost effectiveness of post-critical adult and pediatric trauma care."[10] After intense review of Ohio's trauma system, 7 recommendations were made to address identified shortcomings in the current delivery system. The recommendations for improving the rehabilitation component focused on:

- Recognizing the needs of those undergoing rehabilitation and recovery
- Identification of rehabilitation services
- Establishing a resource system to facilitate access to information and services
- Developing educational re-entry programs
- Identification of opportunities for substance use prevention and treatment
- Establishing a registry for the follow-up of long-term complications and outcomes

Trauma and Rehabilitation Registry Merge

Recognizing the serious impact of injury and the need to assess and document long term functional outcomes led to the establishment of the Trauma Rehabilitation Registry in 2005 as a component of the Ohio Trauma Registry. In November 2007, at the request of the Ohio Trauma Committee, the Ohio Society of Trauma, Nurse Leaders (OSTNL) met to design an assessment process for Ohio utilizing the Model Trauma Systems Planning and Evaluation (MTSPE) document.[11] In March, 2008, the Ohio Trauma Committee convened to assess Ohio's statewide trauma system. A general assessment was conducted on the system's current strengths and weaknesses, as well as potential opportunities and threats to future development. In 2009, a task force was formed by the Ohio Trauma Committee to develop a strategic plan for Ohio's trauma system. In October of 2010, a final report, "A Framework for Improving Ohio's Trauma System" was completed and approved by the Ohio State Board of EMS.[12] The document focused on 113 indicators by which a state trauma system may be evaluated and the gaps that existed within the current trauma system. The final product was to use as a reference guide for the development of Ohio's statewide trauma system to advance the care of trauma victims. The document focused on eight major areas including:

- Leadership
- Injury Prevention
- Emergency/Disaster Preparedness Plan
- Prehospital Care
- Definitive Care – Acute Care Hospitals and Trauma Centers
- Definitive Care – Rehabilitation
- Evaluation, Quality Management & Performance Improvement
- Trauma System Registry Infrastructure
- Professional Education and Public Information and People with Functional Needs

The creation of a Trauma Rehabilitation Registry is an important step towards an integrated Trauma system that has the ability to examine outcomes through the continuum of care from the pre-hospital to rehabilitation settings.

Trauma and Rehabilitation Registry Merge

A query of the Ohio Trauma Registry (OTR) data from January 2005 through December 2009 showed that 151,244 individuals sustained traumatic injuries. Of those, 144,622 (95.6%) individuals survived, with 2,249 spinal cord injuries (SCI), 63,019 traumatic brain injury (TBI) and 23,090 polytrauma (ISS $\geq$ 17). Out of those, 8,213 were discharged from a hospital trauma service into an acute rehabilitation center.[3] A review of the MetroHealth Trauma Registry (MTR) data from 2005 to 2009 showed that 339 individuals with SCI, 3,195 individuals with TBI, and 2,803 individuals with Polytrauma were admitted to MetroHealth Medical Center. Of those 31% were discharged to MetroHealth's rehabilitation center, MetroHealth Rehabilitation Institute of Ohio (MRIO). A review of the MetroHealth Rehabilitation Registry (MRR) data from 2005 to 2009 documented that 158 individuals with SCI, 182 individuals with TBI, and 703 individuals with Polytrauma (ISS $\geq$ 17) were admitted to MRIO.

The data gathered in the Rehabilitation Registry from inpatient rehabilitation facilities however, have not been used in Trauma system evaluation reports, creating a shortcoming in the system, as identified by several prior reports.[10,12] Currently, there has been an absence of data reporting and data linkage between the Trauma and Rehabilitation registries. Thus, while the Trauma registry can gauge success of the delivery of trauma care, little is known about outcomes and quality of life in the 95% of persons who survive a traumatic injury. Minimal outcome data are available to assess pre-hospital and hospital care other than victim survival.

This project used MH's Trauma Registry and Rehabilitation Registry data sent to the State, the methods of this study can be replicated in the State Trauma and Rehabilitation Registries. The evaluation of functional outcomes over time will allow further investigation into the fine tuning of pre-hospital and hospital care to better assess impact on outcomes other than life or death.

Conceptual Framework

As stated in the American College of Surgeons *Systems Consultation Guide for Regional Trauma Systems*, the events of September 11, 2001 has led to an increased awareness of the need for collaboration between emergency care and public health systems.[13] It became evident that an effective trauma system should be able to interface very well with public health services as reflected in the Health Resources and Services Administration's (HRSA) Model Trauma System Planning and Evaluation (MTSPE) document released in 2006.[11] Thus, the concept that traumatic injury is a disease that can be prevented or its deleterious effects reduced forms the basis for the application of the public health model to trauma systems. Rehabilitation is an intrinsic component of the trauma system, and is facilitatory in promoting better outcomes and reduction of disability whenever possible. Rehabilitation services and specialists are integrated into the multidisciplinary advisory committee to ensure that pertinent issues to the delivery of care will be addressed appropriately.

Effective trauma systems therefore, invoke cohesive partnerships among varied trauma systems, health care providers and public health agencies, with the goal of reducing the burden of injury and improving the provision of care to those who sustained catastrophic injuries. While trauma registries provide a better understanding of the underlying injury and management, they contain minimal information on how interactions with other phases of care (ie. prehospital, hospital and rehabilitation) influence outcomes of the injured patient. Foremost in addressing this limitation is in emphasizing the role of linkage of data between the Trauma and Rehabilitation registries to evaluate the quality of service rendered across all phases of care and determine which variables inherent in both registries define and / or alter outcomes.

This project was conceptualized to address the need to enhance the ability of the combined Trauma and Rehabilitation registries to ascertain any inherent associations between key data variables that can define outcomes for trauma patients. The initial steps in achieving this goal will include merging of the datasets from the Trauma and Rehabilitation Registries. This will be followed by determining which variables from the registries affect long-term outcomes in persons who sustained catastrophic injuries.

Methods

This was an administrative data management and analysis project with the purpose of illuminating the importance of a combined longitudinal database for trauma victims that encompasses the scene of the injury through acute rehabilitation. The study sample consisted of all traumatic spinal cord injury, traumatic brain injury and polytrauma victims from 2005 through 2010 who came to came to MH's ED and subsequently were admitted and discharged from MH's inpatient rehabilitation facility. To accomplish this goal, we partnered with the data managers from the MH Trauma Registry and the MH Rehabilitation Registry to merge the data sets.

The project began by matching the MH Trauma Registry patients with their individual data located in the MH Rehabilitation Registry using the patients' unique Medical Record Numbers (MRN). To verify the matches, date of birth and gender were used. Discrepancies were resolved by direct review of the patient's electronic medical record. The merged dataset provided an account of trauma victims' clinical records from time of injury in the pre-hospital setting through acute rehabilitation. The merged dataset was analyzed to investigate the relationships between the key data points from the trauma registry and key data points found in the rehabilitation registry (i.e. length of stay, function, discharge disposition and survival).

Table 1 describes the variables used in the analysis, and which database contained the variables prior to the merge. The data fields from the MH Trauma Registry and MH

Rehabilitation Registry were organized in terms of key data including: demographics, co-morbidity, scene data, injury type, injury mechanism, anatomic site of injury, physiologic data, injury score, and outcome in terms of length of stay, Functional Independence Measure (FIM), discharge disposition, and survival. Key data from the time of injury with pre-hospital management to the Emergency Room, through the Trauma hospital and ultimately to the Rehabilitation Hospital were followed to assess the factors affecting functional outcomes for persons with SCI, TBI and Polytrauma.

Table 1. List of variables for analysis and original database location

Variables	**Database Location**			
	Trauma Data Registry			Rehab Registry
Demographics	**Pre-Hospital**	**Emergency Room**	**Inpatient Trauma**	**Inpatient Rehabilitation**
MR#		X		X
DOB	X	X	X	X
Sex	X	X	X	X
Race	X	X	X	X
Payment Source		X	X	X
Co-Morbidity				
Alcohol/Drug Use	X	X		
Scene of Accident				
Incident Zip Code	X			
Trauma Scene Time	X			
Total Time: from Time Unit Notified to Time Unit en Route	X			
Endotracheal Tube Intubation	X			
Injury Type				
Blunt	X	X		
Penetrating		X		
Mechanism of Injury				
Motor Vehicle Accident	X	X		
Fall	X	X		
Violence (Assault/Fight/GSW/Stab)	X	X		
Motor Cycle Collision	X	X		
Pedestrian	X	X		
Anatomic Site of Injury				
Traumatic Spinal Cord Injury		X	X	X
Traumatic Brain Injury		X	X	X
Polytrauma (ISS $\geq$ 17)		X	X	
Physiologic Data				
Glasgow Coma Score	X	X	X	X

Trauma and Rehabilitation Registry Merge

Systolic Blood Pressure	X	X	X	X
Respiratory Rate	X	X	X	X
Pulse Rate	X	X	X	X
Injury Score				
Abbreviated Injury Scale (AIS)		X		
Injury Severity Score (ISS)		X		
Revised Trauma Score (RTS)		X		
Outcomes				
Length of Stay		X	X	X
FIM				X
Discharge Disposition		X	X	X
Survival	X	X	X	X

Ohio Trauma Registry and Rehabilitation Registry Data Fields Description

Demographics:

The Ohio Registry Annual Data Report of 2003 identified that ninety-five percent (95.4%) of patients treated at a hospital for an injury severe enough to be reported to the OTR survived to be discharged.[14] Persons who are older, males, Black have higher mortality rates, more comorbid conditions, longer lengths of stay and higher health care utilization and health care costs.[15]

1. ***Age*** is recognized as a significant factor that affects the occurrence and severity of injury and outcomes.[16-18] Age was included as a continuous variable. And to look at differences among age groups, the analysis will group individuals into three age categories: pediatric (0-16 years old), adult (17-69 years old), and elderly ($\geq$ 70 years old).[19]
2. ***Sex*** is a binary variable coded as male or female. It has been shown that males who have a blunt trauma have a significantly increased risk of death compared to females.[16]
3. ***Racial*** differences exist, and in the 2003 report, Blacks have the highest overall injury rate of all other racial groups.[14] Race has been shown to be a significant determinant of rehabilitation outcomes, with Blacks having more comorbid conditions, poorer functional outcomes, and higher rates of secondary conditions after injury than any other racial group.[20] Race was a race categorical variable defined as White (not of Hispanic origin),

Black (not of Hispanic origin), Hispanic, American Indian or Alaskan Native, Asian or Pacific Islander, Other and Not documented (ND).

4. ***Payment Source*** has been shown to be a predominant predictor of health outcomes and health disparities even after controlling for other socioeconomic variables, such as race, age and sex.[21-23] The source of payment during hospitalization gave an estimate of how health care is reimbursed, which affects access to care post-injury, and ultimately long-term health outcomes. The primary payment source responsible for the incurred charges was categorized as: Commercial, Medicare Non-MCO, Medicare MCO, Medicaid Non-MCO, Medicaid MCO, Other Government (e.g. TRICARE, Developmental Disabilities Services and State Vocational Rehabilitation), Workers' Compensation, Self-pay, Uninsured and Not documented (ND).

Pre-existing co-morbidity factors

Alcohol or Drug abuse / misuse is a known contributor to traumatic injury. A recent review of records from the National Trauma Data Bank (NTDB) showed that pre-injury alcohol and drug use, while not associated with worse outcomes, do contribute to increased complications, thereby impacting length of stay and higher hospitalization costs.[24,25] De Guise and colleagues also found that pre-injury alcohol abuse was related to longer length of stays and longer duration of post-traumatic amnesia in traumatic brain injury.[26] Testing positive for alcohol was coded as 'yes or no' and testing positive for non-prescription drugs was coded as 'yes or no'.

Scene Data

There were several types of places where injuries occurred and were assigned values from 0-9. The site of injury either occurred at home, farm, mine/quarry, industrial, recreation/sport place, street/highway, public building, residential institution, other specified place, and unknown/unspecified/not documented. Scene data variables included incident zip code, trauma scene time, total time from notification to time unit en route and endotracheal intubation.

1. ***Incident Zip Code*** was used to geocode. The geocodes were linked to US Census data and then those codes were used to map the distance from the scene location to a Level I trauma center. The geocoding was also used to describe urban vs. rural make-up of the scene location. It is possible that limitations in access to a trauma center can potentially lead to worse outcomes.[27]
2. ***Trauma scene time, Total Time from Notification to time unit enroute*** was coded as exact time and used as continuous variables in the analysis. Time data has been shown to affect trauma outcomes, such as survival.[28]
3. ***Endotracheal Intubation*** was coded as a binomial variable (yes/no). A review of field resuscitation techniques and application of advanced life-support protocols (e.g. establishing airway access via intubation or cricothyrotomy) can help assess long term outcomes in trauma patients.[29-32] Intubation was coded as 'yes/no'.

Injury Type

Traumatic injury is categorized as either "blunt" or "penetrating". ***Penetrating injuries*** are a direct result of penetration into a body cavity (e.g. knife and bullet wounds), whereas ***blunt injuries*** are generally from non-penetrating causes (e.g. motor vehicle crash or a fall). Most injuries reported in 2003 are from blunt injuries (89.2%). The mortality rate related to penetrating injuries is significantly higher than those who sustained blunt trauma.[33]

Mechanism of Injury

The ***injury mechanism*** is reported as the External Cause of Injury code or E-code. Standard ICD-9 E-code groupings are presented in the form of a matrix (Table 2) and are depicted as mechanism vs. intent of injury. All cells in the matrix are mutually exclusive. The Centers for Disease Control and Prevention in collaboration with members of the American Public Health Association's Injury Control and Emergency Health Services Section (ICEHS) placed E-codes into groupings reflective of similar causes of injury.[34]

It has been recognized that injuries sustained from a ***fall, motor vehicle crash, assault / fight, motorcycle crash and pedestrian-related accidents*** comprise the majority of the known injury mechanisms which can impact the quality of life and outcomes in trauma patients.[14]

Table 2. E-Code Grouping Matrix table with assignment of E codes for injury mortality data MMWR August 29, 1997

	Manner/ intent				
Mechanism/ cause	**Unintentional**	**Suicide**	**Homicide**	**Undetermined**	**Other**
Cut/pierce	E920.0–.9	E956	E966	E986	E974
Drowning/ submersion	E830.0–.9,E832.0.9, E910.0–.9	E954	E964	E984	
Fall	E880.0–E886.9, E888	E957.0–.9	E968.1	E987.0–.9	
Fire/burn	E890.0–E899, E924.0–.9	E958.1,.2,.7	E961; E968.0,.3	E988.1,.2,.7	
Firearm	E922.0–.9	E955.0–.4	E965.0–.4	E985.0–.4	E970
Machinery	E919 .0–.9				
MV traffic	E810–E819 (.0–.9)	E958.5		E988.5	
Pedal cyclist, other	E800–E807 (.3); E820–E825 (.6);E826.1,.9; E827–E829 (.1)				
Pedestrian, other	E800–E807 (.2), E820–E825 (.7), E826–E829 (.0)				
Transport, other	E800–E807 (.0,.1,.8,.9), E820–E825 (.0–.5,.8,.9),E826.2–.8, E827–E829 (.2–.9),831.0–.9, E833.0–E845.9	E958.6		E988.6	
Natural/ environmental	E900.0–E909, E928.0–.2	E958.3		E988.3	
Overexertion	E927				
Poisoning	E850.0–E869.9	E950.0–E952.9	E962.0–.9	E980.0–E982.9	E972
Struck by, against	E916–E917.9		E960.0, E968.2		E973, E975
Suffocation	E911–E913.9	E953.0–.9	E963	E983.0–.9	
Other specified, Classifiable	E846–E848, E914–E915, E918, E921.0–.9, E923.0–.9, E925.0–E926.9, E929.0–.5	E955.5,.9; E958.0,.4	E960.1, E965.5–.9, E967.0–.9, E968.4	E985.5; E988.0,.4	E971, E978, E990–E994, E996, E997.0–.2
Other specified, not elsewhere classifiable	E928.8, E929.8	E958.8, E959	E968.8, E969	E988.8, E989	E977, E995, E997.8, E998, E999
Unspecified	E887, E928.9, E929.9	E958.9	E968.9	E988.9	E976, E997.9
All injury	**E800–E869, E880–E929**	**E950–E959**	**E960–E969**	**E980–E989**	**E970–E978, E990–E999**

Anatomic Site of Injury

Anatomic site of injury is determined by the same standards of the Ohio Trauma Registry. Site of injury is based on the *International Classification of Disease, 9th Revision, with*

Clinical Modification (ICD-9-CM) described in The Barell Injury Diagnosis Matrix.[35] Table 3 outlines the ICD-9 codes associated with type of injury and severity of injury.

Table 3. Anatomic Site of Injury based on ICD-9-CM Code

Type of Injury	Severity	ICD-9 Codes
Traumatic Spinal Cord Injury	Cervical	806(.0-.1), 952.0
	Thoracic	806(.2-.3), 952.1
	Lumbar	806(.4-.5), 952.2
	Sacrum/Coccyx	806(.6-.7), 952(.3-.4)
	Spine and Back Unspecified	806(.8-.9), 952(.8-.9)
	Cervical	806(.0-.1), 952.0
Traumatic Brain Injury	Type 1	800,801,803, 804 (.1-.4,.6-.9), (.03-.05,.53-.55), 850 (.2-.4), 851-854, 950 (.1-.3), 995.55
	Type 2	800,801,803, 804 (.00,.02,.06,.09) (.50,.52,.56,.59), 850 (.0,.1,.5,.9)
	Type 3	800,801,803,804(.01, .51)
Polytrauma	Injury Severity Score (ISS) ≥ 17	

Classification by body region includes head and neck, spine and back, torso, extremities, and unclassifiable by site. There is lack of a validated or consensus definition of polytrauma, leading to multiple descriptions over the years.[36] For this study, we adapted the polytrauma definition proposed by Keel to be that of an Injury Severity Score ≥ 17. [37]

Physiologic Data

1. The ***Glasgow coma scale (GCS), systolic blood pressure and respiratory rate*** are part of the physiologic data reported. GCS provides an index of coma depth by documenting the patient's verbal, eye opening and motor responses on a scale of 3 to 15, with higher scores indicating increased level of functioning.[38] The GCS has been used to correlate early injury severity measures and outcome after injury (Table 4).

Table 4. Glasgow Coma Score

	Response	Score
Eye Opening (E)	Spontaneous	4
	To voice	3
	To pain	2
	None	1

Verbal Response (V)	Normal conversation	5
	Disoriented conversation	4
	Words, but not coherent	3
	No words......only sounds	2
	None	1
Motor Response (M)	Normal	6
	Localizes to pain	5
	Withdraws to pain	4
	Decorticate posture	3
	Decerebrate	2
	None	1
Total = E+V+M		46

2. Hypotension, defined as ***systolic blood pressure (SBP)*** less than 90 mm Hg, is a well-recognized sign of hemorrhagic shock and is a validated prognostic indicator. A recent study showed that optimization of blood pressure portends to improved mortality and outcomes in those who present with hemorrhagic shock at the scene.[39,40] The ***respiratory rate (RR)*** is an important parameter measured in the field. It has been demonstrated that increased mortality and worsened disability is associated with patients who sustained hypoxic insults (pulse oximetry <92%).[41,42] Along with ***GCS and SBP, the Respiratory Rate*** define the Revised Trauma Score (described below) which is a physiologic score that can predict outcomes.

3. ***Heart rate (HR)*** measurements can aid in the determination of the shock index, which is a ratio of the HR and the SBP. It has been suggested that optimizing HR in trauma patients can improve outcomes.[43]

Injury Score

The Anatomic measures (i.e. AIS, ISS, and RTS) are standard measures used at MH to assess injury severity and as a tool to triage patients. The Ohio Trauma Registry also collects AIS and ISS data to measure injury acuity.

Abbreviated Injury Scale (AIS)

The Abbreviated Injury Scale (AIS, first introduced in 1969) outlined in Table 5 is a simple method for grading and comparing injuries by severity[44,45]. It is a consensus-derived, anatomically based system of grading injuries on an ordinal scale ranging from 1 (minor injury) to 6 (lethal injury). The AIS does not reflect the combined effects of multiple injuries; however, it forms the foundation of the Injury Severity Score (ISS). The most recent revision is from 1998. The AIS is monitored by a scaling committee of the Association for the advancement of Automotive Medicine.

Table 5. Abbreviated Injury Scale

Injury	AIS Score
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable

A recent study by Clark and colleagues found that an AIS for head and other body regions of 3, 4 or 5 to be strongly associated with mortality.[46]

Injury Severity Score (ISS)

The Injury Severity Score (ISS) was also determined from the Trauma database. This is an anatomical scoring system introduced in 1974 as a means of providing an overall score for patients with multiple injuries.[47] Each injury is assigned an AIS score and is allocated to one of six body regions (head, face, chest, abdomen, extremities and bony pelvis and external structures). Only the highest AIS score in each body region is used. The ISS is thus defined as the sum of the squares of the highest AIS grade in the most severely injured body regions. Only one injury per body region is allowed. The ISS ranges from 1-75, and an ISS of 75 is assigned to anyone with an AIS score of 6.

The ISS is the only anatomical scoring system in use and correlates linearly with mortality, morbidity, hospital stay and other measures of severity. It has also been a consistent risk factor predictor for post-injury multiple-organ failure (MOF). However, any error in the AIS scoring increases the ISS error, so accuracy is imperative. Also, many different injury patterns can yield the same ISS score and injuries to different body regions are not weighted. The AIS limits the total number of contributing injures to 3, which impairs its use in penetrating injuries. The AIS is not recommended as a triage tool, but as a predictor of mortality.

Revised Trauma Score (RTS)

The Revised Trauma Score (RTS) uses 3 specific physiologic parameters: GCS, SBP and RR. The scoring system is outlined below in Table 6. The RTS has two purposes: 1) field triage and 2) quality assurance and outcome prediction. Depending on the purpose, the formula for calculating the score varies. When used for field triage, the RTS is determined by adding each of the coded values together. Thus, the RTS ranges from 0-12 (as above). When used for quality assurance or outcome prediction, the GCS, SBP and RR are added together.

Table 6 Revised Trauma Score

Glasgow Coma Scale (GCS)	Systolic Blood Pressure (SBP in mm Hg)	Respiratory Rate (RR breaths/min)	Coded Value
13-15	>89	10-29	**4**
9-12	76-89	>29	**3**
6-8	50-75	6-9	**2**
4-5	1-49	1-5	**1**
3	0	0	**0**

The RTS has a high inter-rater reliability and accuracy in predicting death than the Trauma Score.[48,49] However, it can be very difficult to calculate in the field. This is especially true for the GCS, which is difficult to employ in patients who are intubated and mechanically ventilated. In addition, it is hard to score patients who are pharmacologically paralyzed or who are under the influence of alcohol of drugs. To combat these difficulties, best motor response and the eye-opening responses have been used to predict the verbal response. Substitution of the best motor response for the GCS can predict trauma mortality as well as or better than other trauma severity score.

Outcomes

Outcome measures for analyses consist of the length of stay, Functional Independence Measure (FIM), discharge disposition (e.g. home, nursing home, sub-acute nursing facility) and survival.

Length of Stay (REHAB LOS)

Length of stay can be used as a gauge of the utilization of healthcare resources and severity of the injury. In the years 2005 to 2009 the OTR reported an average REHAB LOS for trauma victims of 5.97 days. Data reported for REHAB LOS are for those that occurred in inpatient trauma, and do not include data from inpatient rehabilitation. The OTR was queried for REHAB LOS of trauma victims with SCI, TBI, and Polytrauma from 2005 to 2009. REHAB LOS for individuals with a diagnosis of SCI was 11.2 days, for TBI, 6.65 days and for polytrauma, 9.84 days.[3] The Metro Trauma Registry (MTR) from the years 2006 to 2010 reported an average REHAB LOS of 11.6 days for individuals with a diagnosis of SCI and 6.4 days for individuals with a diagnosis of TBI and 9.8 days for individuals with a diagnosis of Polytrauma.

Functional Independence Measure (FIM)

The ***FIM*** is the primary assessment tool used for measuring rehabilitation outcomes. The FIM was developed to create a minimal data set that could be uniformly applied as a valid measure of patient disability.[50] This allows health care providers and researchers to have a reliable method of tracing disability from rehabilitation admission through discharge, and follow-up. The FIM assesses physical functioning in 6 domains (self-care, sphincter control, mobility, locomotion, communication and social cognition) using an 18-item, 7 point Likert Scale with 7 being able to do an activity totally independently to 1 needing total assistance with an activity (Table 7).[51,52] FIM data will be collected during admission to inpatient rehabilitation and at discharge to provide functional detail on the outcome of trauma victim survivors.

Table 7. Functional Independence Measure (FIM)

FUNCTION DOMAINS		CODING SCHEME
Self-Care		No Helper
1. Grooming		7 Complete Independence
2. Bathing		6 Modified Independence
3. Dressing-Upper Body		
4. Dressing-Lower Body		Helper-Modified Dependence
5. Toileting		5 Supervision
Sphincter Control		4 Minimal Assistance
1. Bladder		3 Moderate Assistance
2. Bowel		
Transfers		Helper-Complete Dependence
1. Bed, chair, wheelchair		2 Maximal Assistance
3 Toilet		1 Total Assistance
2 Tub Shower		
Locomotion		
1. Walking or Wheelchair		
2. Mode of Locomotion		
3. Stairs		
Communication		
1. Comprehension		
2. Expression		
Social Cognition		
1. Social Interaction		
2. Problem Solving		
3. Memory		

The FIM has good inter-rater reliability, [53] but while it has broad domain coverage, FIM does not measure specific functional skills, i.e. fine motor ability, speed, ease and quality of task execution. Nevertheless, the FIM remains valuable in measuring burden of care and activity restrictions and serves as an important tool in outcomes research and in assessing the quality of a rehabilitation program.[54]

Discharge Disposition

Discharge disposition from Trauma Service was coded into categories: home, died, MetroHealth System, and outside MetroHealth System (i.e. AMA, other hospital system, jail/prison, homeless/shelter, protective services, and hospice). Those discharged to the MetroHealth System were further categorized into admitted to MetroHealth Acute Rehabilitation, admitted another MetroHealth System service, or left AMA. The population for analyses consists of only those persons discharged from the Trauma Service to Acute Rehabilitation. **Discharge *disposition*** from Acute Rehabilitation was coded as Home or Not discharged home. None of the patients admitted to Acute Rehabilitation had a discharge disposition as deceased.

The OTR reported discharge disposition for trauma survivors in 2005 to 2009 as: 55% home, 5.7% Rehabilitation, 20.3% ECF/NH/SNF and 13.8% other. A data query of the OTR also reported data on discharge disposition for SCI (25% home and 32% Rehab), for TBI (45 % home and 12% Rehab), and for Polytrauma (37 % home and 15% Rehab).[3] The Metro Trauma Registry (MTR) from the years 2006 to 2010 reported that of 339 individuals with a diagnosis of SCI, 158 (46.6 %) went to rehab; of 3,195 individuals with a diagnosis of TBI, 182 (5.7%) went to rehab; and of 2,803 individuals with a diagnosis of Polytrauma, 703 (30%) went to rehab.

Survival

Survival was reported and broken down by changes in survival by location including: prehospital, emergency department (ED), inpatient trauma and inpatient rehabilitation. In the years 2005 to 2009, the OTR reported 95.6% survival of the 151,244 trauma victims reported. Data reported for death are for those that occurred in the hospital setting (ED or inpatient trauma), and does not include those who die at the injury site or inpatient rehabilitation. The OTR was queried for survival of trauma victims with SCI, TBI, and Polytrauma from 2005 to 2009. Two thousand two hundred forty nine individuals were admitted with a diagnosis of SCI, and of those, 83.5% survived; 63,019 individuals were admitted with a diagnosis of TBI, and of those, 86.6% survived, and 23,090 individuals were admitted with a diagnosis of Polytrauma, and of those, 81.8% survived.[3] A review of the MTR data from 2006 to 2010 showed that 339 individuals were admitted with a diagnosis of SCI, and of those, 283 (83.5%) survived; 3,195 individuals were admitted with a diagnosis of TBI, and of those, 2,814 (88.1%) survived; 2,803 individuals were admitted with a diagnosis of Polytrauma, and of those, 2,317 (82.7%) survived.

Analysis

Analysis consists of standard descriptive statistics: frequencies, averages, t-test, and chi-square. For continuous outcome variables, such as the FIM, two staged l linear regression was used to investigate the relationship between trauma variables and functional outcomes. In the modeling, demographic and number of comorbidities/complications were controlled allowing for the direct effects of the trauma variables to be illuminated. For the binary outcome of rehabilitation discharge disposition (home/not home) a logistic regression technique was employed. Again, demographic and number of comorbidities/complications were controlled for in this analysis.

Trauma and Rehabilitation Registry Merge

In our original grant proposal, survival was noted as one of the outcomes to be investigated. None of the patients admitted to acute rehabilitation from the MetroHealth Trauma Service died; therefore, we did not include survival in our final analyses of the data. We did, however, look at Trauma Service discharge disposition, for which, survival was one of our outcomes.

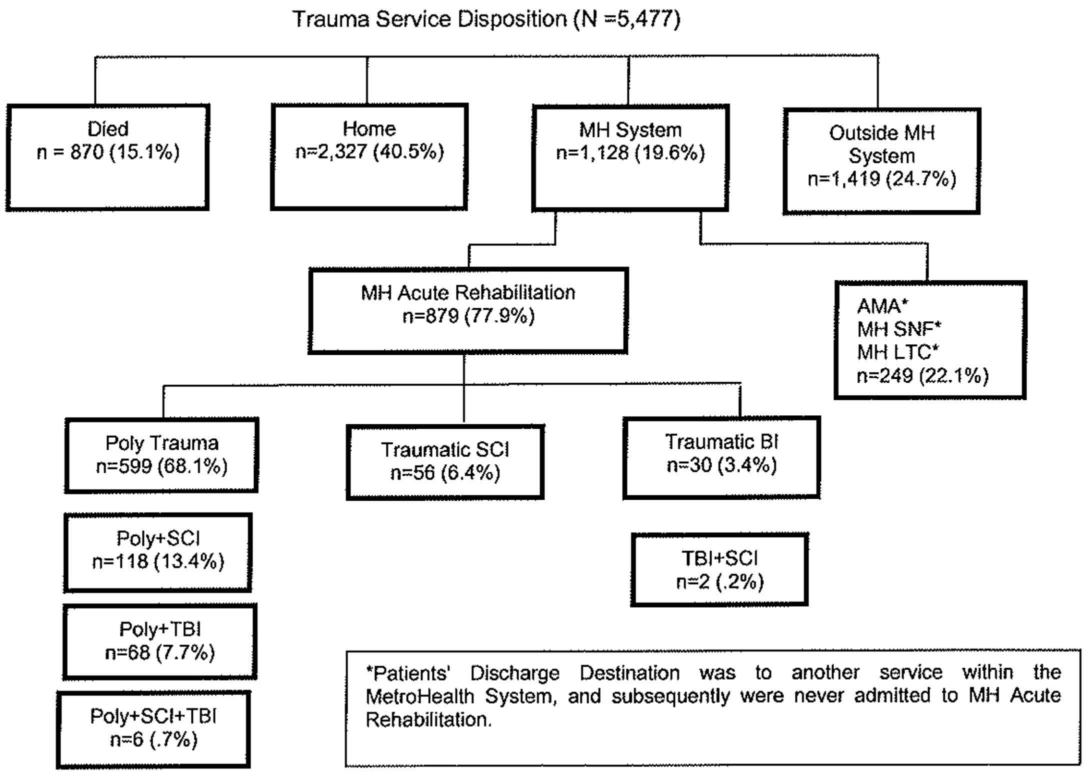
Results

Aim 1: To link the MetroHealth Trauma and MetroHealth Rehabilitation Registry Data.

We were able to link the Trauma and Rehabilitation Registries using patient medical record numbers (MR), birthdate and gender. The two databases linked and we did not have any patients in the Rehabilitation Registry not link back to their trauma data in the Trauma Registry.

Figure 1 displays the study sample generation from the Trauma Registry. Almost 15% of the trauma patients coming to the MH Emergency Department (ED) died prior to being discharged from the ED. Forty percent of patients were sent home from the ED and 24.7% were discharged to a health care facility outside of the MH System. Almost 20% were admitted to a MH service (i.e. acute care, SNF, LTC, or acute rehabilitation). Out of those admitted to a MH System service (1,128), 77.9% were admitted to acute rehabilitation. The total study samples consisted of 879 persons. Of those 879 trauma patients, 600 were Poly traumas, 116 had both Poly trauma and traumatic SCI, 58 SCI patients, 34 were TBI and 2 patients had a TBI and traumatic SCI.

Figure 1 Study Sample Inclusion Flow Chart



Sample Characteristics

Table 8 gives the descriptive statistics for the sample characteristics for the total sample and for the 3 traumatic injury groups. The traumatic SCI and TBI groups include patients who had a singular identification as having a SCI or TBI as documented by the appropriate ICD-9 code. The Poly trauma group includes persons with the ICD-9 code for poly trauma, which may include a SCI or TBI.

Looking at the Total Sample column in Table 8 below, the mean age of the study sample was 42.75 ($\pm$ 18.04), 71.9% were discharged to home from acute rehabilitation, 27.2% had government health insurance, mean number of complications and comorbidities was 7.57 ($\pm$ 3.59), mean Glasgow Coma Score was 15.39 ($\pm$ 7.58), mean ISS was 25.53 ($\pm$ 9.

55), average total FIM Gain was 29.91 (±17.21), 42.1% were intubated at some time prior to rehabilitation admission, and 27% tested positive for drug use.

Table 8 Descriptive Statistics for all Data Points

	Total Sample N = 879		Poly Traumas n=785		Traumatic SCI n=58		Traumatic BI n=36	
Demographics	**Percent**		**Percent**		**Percent**		**Percent**	
Gender								
Male	76.8		76.6		82.8		72.2	
Female	23.2		23.4		17.2		27.8	
Race								
White	73.2		73.6		66.7		75.0	
Black	23.2		22.7		33.3		22.2	
Other	3.1		3.3		0.0		0.0	
Marital Status								
Married	33.1		28.9		40.2		36.1	
Not married	66.5		71.1		59.8		63.9	
Health Insurance								
Commercial	47.4		47.4		48.3		47.2	
Government	27.2		27.3		25.9		27.8	
Uninsured	25.4		25.4		25.9		25.0	
	Mean	**±**	**Mean**	**±**	**Mean**	**±**	**Mean**	**±**
Age	42.75	18.04	42.27	17.91	45.36	19.26	48.83	11.99
Number of Comorbidities/Complications	7.57	3.59	7.62	3.60	7.84	3.67	6.19	2.90
Trauma Data Points								
ISS	25.53	9.55	26.15	9.11	26.34	14.54	25.75	9.805
Glasgow Coma	15.39	7.58	12.54	3.90	14.29	1.81	13.25	3.96
Total Scene Time	15.39	7.58	14.94	7.41	20.5	7.72	missing	----
	Percent		**Percent**		**Percent**		**Percent**	
Intubated pre-rehabilitation								
Yes	42.1		45.2		12.1		22.2	
Tested Positive for Drugs								
Yes	27.0		27.9		17.2		22.2	
No	24.9		25.0		31.0		13,9	
Not Tested	48.1		47.1		51.7		63.9	
Rehabilitation Outcomes	Mean	±	Mean	±	Mean	±	Mean	±
Total FIM Motor Gain	24.69	13.64	24.69	13.74	45.36	19.27	22.33	10.16
Total FIM Cognitive Gain	5.23	5.89	5.53	6.02	2.48	4.16	3.25	3.62
Total FIM Gain	29.91	17.21	30.22	17.54	28.41	15.12	25.58	11.94
Rehabilitation REHAB LOS	20.80	14.45	20.74	14.24	25.66	17.10	12.63	6.10
	Percent		**Percent**		**Percent**		**Percent**	
Rehab Discharge Disposition								
Home	71.9		71.2		72.4		86.1	

The columns representing the different trauma categories indicate that the 3 sub-samples are very similar on demographic characteristics. The SCI group is made up of less white (66.7%) than the Poly (73.6%) and TBI (75.0%) groups. The TBI group is slightly older (48.83 years old vs. 42.27 and 45.36). The largest difference is that the TBI group has a higher percentage of patients discharged home (86.1%) than the Poly (71.2%) and SCI (72.4%) groups. In terms of scene time, the SCI group had longer average minutes at the scene (20.5) than the Poly group (14.94). Scene time was missing on all 36 of the TBI patients.

When looking at health characteristics, the SCI group has higher Total FIM Motor Gain (45.36) than the Poly (24.69) and the TBI (22.33) groups. The SCI group had lower intubation rates (12.1%) than the other two groups (45.2% and 22.2%) and lower positive test for drug use (17.2% vs. 27.9% and 22.2%).

Aim 2: To identify variables from the Trauma Registry that are associated with long term outcomes for persons who sustained a poly trauma, traumatic SCI, or a traumatic brain injury.

Pearson correlations were conducted to first uncover which independent variables had an association with the outcome variables of interests (Length of Stay, FIM scores and Rehabilitation discharge disposition). Below in Table 9 are the results of the Pearson correlations and significance level.

Table 9 Pearson Correlations Between the Independent Variables and Outcomes

	ISS	GCS	Age	P/Drugs	N/Drugs	NT/Drugs	Sex	Married	Race	Intubated	G_Health	C_Health	U_Health	CCs	TST
REHAB LOS	.194**	-.090*	-.014	-.014	.000	.012	-.056	-.025	-.078*	.110*	.099*	-.029	-.068*	.178**	.037
Rehab Discharge Disposition	-.097**	-.059	-.261**	-.013	-.009	-.056	-.010	.038	.040	.031	-.198**	.183**	-.008	-.335**	.001
Total FIM Gain	-.055	-.304**	-.187**	.-.040	-.013	-.077*	-.059	-.048	.058	.254**	-.150**	.080*	.061	-.264**	.025
FIM Motor Gain	-.095**	-.199**	-.200	-.020	-.027	-.056	-.066*	-.036	.019	.154**	-.138**	.071*	.059	-.261**	.053
FIM Cognitive Gain	.058	-.425**	-.106**	-.070*	.024	-.094*	-.018	-.057	.125**	.383**	-.119**	.069*	.043	-.164**	.049*

*p≤.05 **p≤.001

ISS=Injury Severity Score
GCS=Glasgow Coma Score
P/Drugs=Tested Positive for Drugs
N/Drugs=Tested Negative for Drugs
NT/Drugs=Was Not Tested for Drugs
G_Health=Government health insurance
C_Health=Commercial health insurance
U_Health=Uninsured
CCs=Comorbidities/Complications
TST=Total Scene Time
FIM=Functional Independence Measure

ISS, intubation pre-rehabilitation, government health insurance have, and numbers of comorbidities/complications have statistically significant positive associations with REHAB LOS. Higher ISS, being intubated prior to rehabilitation, having government health insurance are associated, and more comorbidies/complications the longer lengths of hospital stay. Higher Glasgow Coma scores and having commercial health insurance are associated with shorter length of hospital stays.

Higher ISS, older persons, having government health insurance, and fewer comorbidities/complications are associated with not being discharged from rehabilitation to home. Having commercial insurance is associated with going home after acute rehabilitation.

Higher Total FIM Gain is associated with lower Glasgow Coma scores, being younger, being intubated pre-rehabilitation, not having government health insurance, having commercial insurance, and lower number of comorbidities/complications. Not having been tested for drugs is associated with lower Total FIM Gain.

FIM Motor Gain is negatively associated with ISS, Glasgow Coma score, age, sex, number of comorbidities/complications, and commercial health insurance. The higher the ISS, Glasgow Coma score, older persons, females, being female and having government health insurance the lower the FIM Motor Gain. Higher FIM Motor Gain is associated with having commercial health insurance and being intubated prior to rehabilitation.

Higher Glasgow Coma scores, older persons, more comorbidities/complications, those with government health insurance, testing positive for drugs, and not being tested for drugs were associated with lower FIM Cognitive Gain. On the other hand, higher FIM Cognitive gain was associated with being white, intubated prior to rehabilitation, and having commercial health insurance.

Total Length of Stay (REHAB LOS) from Trauma Service Admission through Acute Rehabilitation

Table 10 shows the results of the multiple linear regression analysis results. The full regression model explained 9.7% of the variance in REHAB LOS. In Stage I, race (B= -3.289; p =.040; blacks coded as '0' and whites coded as '1'), government health insurance (B =4.438; p=.020) and number of comorbidities/complications (B = .659; p = .000) had statistically significant effects on REHAB LOS. Whites had shorter REHAB LOS, having government health insurance increased a patient's REHAB LOS by 4.438 days and for every increase in comorbidities/complications, REHAB LOS increased by .757 days.

Table 10. Multiple Linear Regression for Rehabilitation Length of Stay (REHAB LOS) (N = 714)

STAGE I	Unstandardized Coefficients		Standardized Coefficients
Model	B	Std. Error	Beta
(Constant)	19.535**	2.2216	
Age	-.089*	.040	-.107
Sex	-.588	1.500	-.016
Race	-3.289*	1.594	-.091
Married	.701	1.524	.021
Commercial Health Insurance [a]	2.455	1.635	.081
Government Health Insurance [a]	4.438*	1.835	.130
Number of Comorbidities/Complications	.757**	.182	.190
STAGE II			
(Constant)	17.253**	4.188	
Age	-.044	.042	-.053
Sex	-.355	1.493	-.010
Race	-4.410*	1.618	-.122
Married	.79 8	1.511	.024
Commercial Health Insurance	1.753	1.644	.057
Government Health Insurance	4.328*	1.827	.127
Number of Comorbidities/Complications	.659**	.174	.166
Intubated at any time pre-rehab	.187	1.977	.006
Tested Positive for Drugs [b]	-1.661	1.578	-.049
Tested Negative for Drugs [b]	-1.031	1.579	-.029
ISS	.236**	.067	.151
Glasgow Comma Score	-.332	.187	-.113

Total Scene Time	.017	.045	.016
R^2 = .097**			

[a] Referent is Commercial Insurance [b] Referent is Tested Positive for Drugs
* *p≤.05* ** *p≤.001*

Looking at Stage II of the regression model, we find that race, having government health insurance and number of comorbidities/complications remain statistically significant indicating direct effects on REHAB LOS. ISS (B=.236; p=.000) had a statistically significant relationship with REHAB LOS in a positive direction. For every one unit increase in ISS, REHAB LOS is increased by .236 days. Looking at the standardized coefficients in Stage II, we find that being that number of comorbidities/complications (Beta=.166) is the strongest contributor to variation in REHAB LOS.

Acute Rehabilitation Discharge Disposition

Binary Logistic Regression was conducted to look at predictors of acute rehabilitation discharge disposition. Table 11 displays the results of the binary logistic multiple regression analysis for rhebailitation discharge disposition. Rehabilitation discharge disposition is affected by a patient's age, race, marital status, type of health insurance, number of comorbidities/complications and their ISS. Older persons are less likely to be discharge home (OR =-.961) after rehabilitation than younger persons. Persons with higher numbers of comorbidities/complications and having higher ISS are also less likely to go home after rehabilitation (OR= .812; OR=.979 respectively). Whites, married individuals and persons with commercial health insurance compared to those with no health insurancse are more likely to be discharged home. (OR=1.077; OR=1.731; OR=1.980 repectively).

Table 11. Binary Logistic Multiple Regression on Rehabilitation Discharge Disposition (N = 712)

Predictor	B	Std. Error	Odds Ratio (OR) Exp(B)	95% CI for EXP(B)	
				Lower	Upper
Age	-.040**	.007	.961	.948	.973
Sex	.118	.232	1.125	.714	1.773
Race	.074*	.239	1.077	.675	1.720
Married	.549*	.228	1.731	1.107	2.709
Commercial health insurance[a]	.683*	.251	1.980	1.210	3.241
Government health insurance[a]	.123	.267	1.131	.670	1.909
Number of Comorbidities/Complications	-.208**	.028	.812	.769	.859
Intubated pre-rehabilitation	-.203	.289	.817	.463	1.439
Tested Poisitve for Drugs[b]	.043	.240	1.044	.652	1.671
Teseted Negative for Drugs[b]	.086	.234	1.089	.689	1.722
ISS	-.021*	.009	.979	.961	.997
Glasgow Comma Score	.007	.028	1.007	.954	1.063
Total Scene Time	-.005	.006	.995	.984	1.007
(Constant)	4.470**	.641	87.323		

[a] Referent is Uninsured [b] Referent is Not Tested for Drugs
* $p \leq .05$ ** $p \leq .001$

Total FIM Gain

Table 12 gives the results of the multiple regression analysis for total FIM gain. The total regression model explains 17.6% of the variance in Total FIM Gain score. In Stage I of the regression model, for every one year of increase in age, Total FIM Gain score decreases by .119 points. For every unit increase in the number of comorbidities/complications there is a decrease of 1.085 points in a Total FIM Gain.

Table 12. Multiple Linear Regression of Total FIM Gain (N = 713)

STAGE I	Unstandardized Coefficients		Standardized Coefficients
Model	B	Std. Error	Beta
(Constant)	42.774**	2.271	
Age	-.119*	.040	-.124

Sex	-2.163	1.514	-.051
Race	2.365	1.597	.056
Married	-.650	1.529	-.017
Commercial Health Insurance [a]	.575	1.827	.016
Government Health Insurance [a]	-3.277	1.827	-.083
Number of Comorbidities/Complications	-1.085**	.569	-.226
STAGE II			
(Constant)	53.002**	4.002	
Age	-.069*	.041	-.072
Sex	-2.110	1.474	-.050
Race	.017	1.577	.000
Married	-.336	1.480	-.009
Commercial Health Insurance	.262	1.591	.007
Government Health Insurance	-2.838	1.779	-.072
Number of Comorbidities/Complications	-1.006**	.173	-.209
Intubated at any time pre-rehab	2.942	1.929	.083
ISS	-.165*	.065	-.091
Tested Positive for drugs [b]	-.571	1.537	-.014
Tested Negative for drugs [b]	.565	1.519	.014
Glasgow Comma Score	-.706**	.138	-.207
Total Scene Time	.042	.126	-.027
R^2 = .176**			

[a] Referent is Uninsured [b] Referent is Not Tested for Drugs
* $p \leq .05$ ** $p \leq .001$

Turning to Stage II of the regression analysis, we find that age and number of comorbidities/complications continue to have statistically significant direct relationships with Total FIM Gain in the negative direction. ISS and Glasgow Coma Score both have statistically significant direct effects on Total FIM Gain. For every unit increase in number of comorbidities/complications Total FIM Gain decreases by 1.006 points and for every unit increase in Glasgow Coma Score Total FIM Gain decreases by .706 points.

The Standardized Coefficients in Stage II indicate that number of comorbidities/complications (Beta=-.209) and Glasgow Coma Score (Beta=-.207) have the strongest contributions to the variance in Total FIM GAIN.

Total FIM Motor Gain

Table 13 gives the results of the multiple linear regression analysis for total FIM motor gain. The total model explains 13.8% of the variance in total FIM motor gain. Looking at Stage I of the regression model, we find that for every year added to age, there is a drop in total FIM motor gain by .104 points. With every unit gain in number of comorbidities/complications there is a decrease of .851 points in total FIM motor gain.

Table 13. Multiple Linear Regression for Total FIM Motor Gain (N = 713)

STAGE I	Unstandardized Coefficients		Standardized Coefficients
Model	B	Std. Error	
(Constant)	35.885**	1.799	
Age	-.104**	.032	-.138
Sex	-1.736	1.99	-.052
Race	.712	1.265	.021
Married	.125	1.211	.004
Commercial Health Insurance [a]	.350	1.279	.013
Government Health Insurance [a]	-2.260	1.447	-.073
Number of Comorbidities/Complications	-.851**	.140	-.224
STAGE II			
(Constant)	44.417**	3.235	
Age	-.094*	.033	-.124
Sex	-1.761	1.192	-.053
Race	-.395	1.274	-.012
Married	.199	1.196	.007
Commercial Health Insurance	.321	1.286	.012
Government Health Insurance	-1.947	1.438	-.063
Number of Comorbidities/Complications	-.767**	.140	-.202
Intubated at any time pre-rehab	-.021	.031	-.024
ISS	-.180**	.053	-.126
Tested Positive for drugs [b]	-.508	1.243	-.016
Tested Negative for drugs [b]	.055*	1.228	.002
Glasgow Coma Score	-.375*	.148	-.139
Total Scene Time	-.021*	.031	-.024
R^2 = .138**			

[a] Referent is Uninsured [b] Referent is Not Tested for Drugs
*$p \leq .05$ **$p \leq .001$

Trauma and Rehabilitation Registry Merge

After adding trauma registry variables into the model, Stage II shows that age and number of comorbidities/complications continue to have a statistically significant relationship with total FIM motor gain. This indicates that age and number of comorbidities/complications have direct relationships with total FIM motor gain. ISS, tested negative for drugs, Glasgow coma score and total scene time have statistically significant relationship with total FIM motor gain. Higher ISS, Glasgow Coma Score and total scene time reduce total FIM motor gain; while testing negative for drugs increases the motor gain score. The standardized coefficients in Stage II of the regression model indicate that ISS (Beta=-.126) and Glasgow Coma Score (Beta=-.139) are the strongest predictors of FIM Motor Gain in the model.

Total Cognitive FIM Gain

Table 14 gives the results of the multiple linear regression analysis for total cognitive FIM gain. The full model explains 22.1% of the variance in total FIM cognitive gain. Stage I of the model finds age, race and number of comorbidities/complications having statistically significant relationships with total FIM cognitive gain. For every added year in age, total cognitive gain is reduced by .015 points. Whites have an increase of 1.654 point in cognitive FIM gain compared to Blacks and for every increase in number of comorbidities/complications there is a decrease of .234 points in total FIM cognitive gain.

Table 14. Multiple Linear Regression for Total Cognitive FIM Gain (N = 713)

STAGE I	Unstandardized Coefficients		Standardized Coefficients
Model	B	Std. Error	Beta
(Constant)	6.889**	.804	
Age	-.015*	.014	-.045
Sex	-.427	.536	-.030
Race	1.654*	.565	.113

Married	-.775	.541	-.058
Commercial Health Insurance [a]	226	.571	.019
Government Health Insurance [a]	-1.017	.647	-.075
Number of Comorbidities/Complications	-.234**	.062	- .142
STAGE II			
(Constant)	8.585**	1.340	
Age	.025	.014	.077
Sex	-.349	.494	-.024
Race	.412	.528	.028
Married	-.535	.495	-.040
Commercial Health Insurance	-.058	.533	-.005
Government Health Insurance	-.890	.595	-.066
Number of Comorbidities/Complications	-.239**	.058	-.145
Intubation at any time pre-rehab	2.127**	.646	
ISS	.014	.022	.036
Tested Positive for drugs [b]	-.062	.515	-.005
Tested Negative for drugs [b]	.510	.508	.036
Glasgow Coma Score	-.331**	.061	-.282
Total Scene Time	-.009	.013	.023
R^2 = .221**			

[a] Referent is Uninsured [b] Referent is Not Tested for Drugs
*$p \leq .05$ **$p \leq .01$

In Stage II of the regression model, age and race are no longer statistically significant; indicating that age and race have an indirect effect on total FIM cognitive gain through the Trauma Registry variables. Number of comorbidities/complications continues to be significant, indicating a direct effect on total FIM cognitive gain. Intubation at any time pre-rehabilitation and Glasgow Coma Score are the Trauma Registry data points that have direct statistically significant effects on total FIM cognitive gain. Being intubated at any time pre-rehabilitation (B=2.127) increases total FIM cognitive gain. Higher Glascow Coma Scores (B = -.331) decreases total FIM cognitive gain. Glasgow Coma Score is the strongest predictor in the full regression model (Beta=-.282).

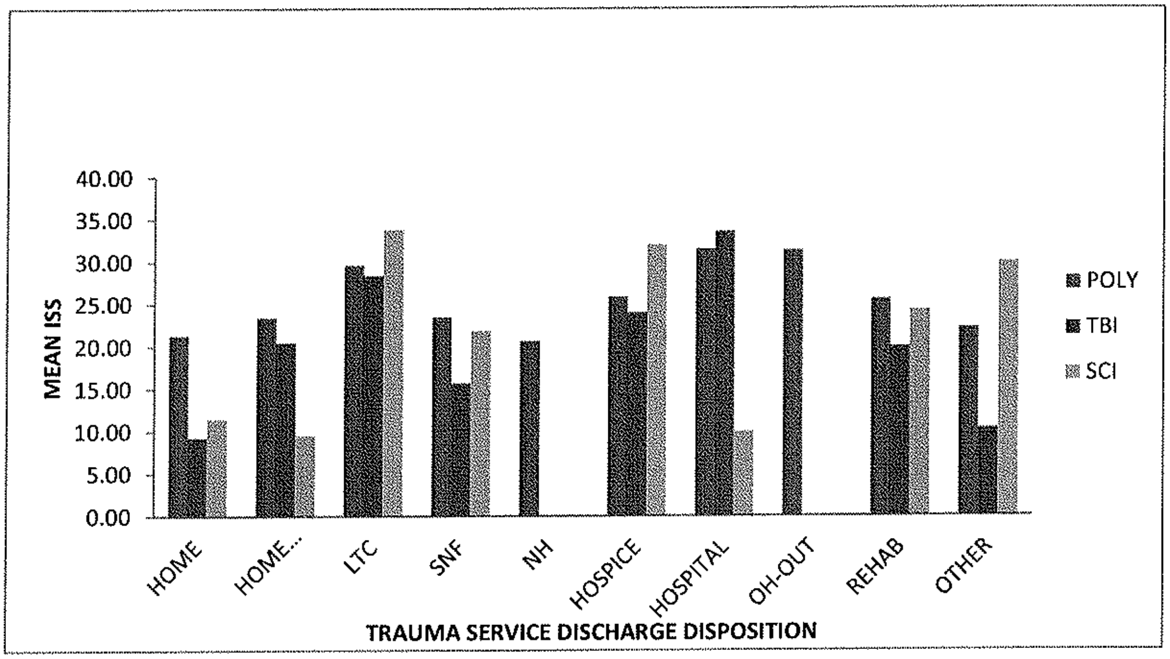
Trauma Service (TS) Discharge Disposition and Traumatic Injury

Although not specified in the grant application, we decided to look at ISS in relation to where patients were discharged to from the Trauma Service (TS). This was seen as a way of evaluating if ISS could be a useful in deciding where patients should be discharged to best serve their health care needs. Table 15 shows the mean ISS for each of the traumatic injury groups and their TS discharge disposition.

Table 15 Mean ISS for Trauma Service Discharge Disposition and Traumatic Injury (N = 5,754)

TRAUMA SERVICE DISCHARGE DISPOSITION	INJURY TYPE MEAN ISS					
	POLY		TBI		SCI	
	Mean	Stdv	Mean	Stdv	Mean	Stdv
Home	21.35	6.25	9.29	6.24	11.44	8.14
Home with Home Health	23.43	8.13	20.5	2.12	9.50	.71
LTC	29.61	11.44	28.43	14.65	33.83	18.36
SNF	23.48	7.05	15.69	7.01	21.84	16.04
NH	20.67	3.39	---	---	---	---
Hospice	25.87	6.35	24.00	NA	32.00	8.3
Hospital	31.54	15.61	33.60	25.99	10.00	NA
Outside Ohio Hospital Systems	31.33	5.60	---	---	---	---
Rehabilitation	25.61	8.64	19.96	8.15	24.29	13.58
Other	22.23	6.55	10.31	5.72	30.00	NA
Total Mean FIM Gain for MetroHealth Rehab patients	31.15	17.81	21.01	14.35	16.89	3.61

Chart 1. Mean ISS by Trauma Type and Trauma Services Discharge Disposition



Conclusions and Recommendations

Trauma data, especially ISS and GCS, should be included in research and quality projects when trying to determine and understand long-term outcomes of persons with traumatic injuries. The quality and effectiveness of trauma systems and care can be enhanced by merging of Trauma and Rehabilitation registries. Further standardization and utilization of the trauma and rehabilitation registries (i.e. criteria for inclusion and scoring methods) across institutions can define long term outcomes for those who survive SCI. Further improvements in medical informatics will allow for the creation of a repository of data within an institution and across collaborating Trauma systems. It is possible then to effectively link with ease databases from EMS, Trauma and Rehabilitation Services. This comprehensive Trauma system will then have the capability of fully assessing the quality of care being delivered through a continuum of services. This in turn can assist the State with its goals of establishing a well-integrated Trauma System that can define long-term outcomes in persons who sustain catastrophic injuries.

Future Research Directions

Our continued research with this combined database will be to look at the three trauma groups (Poly, SCI and TBI) separately to determine if different trauma variables affect outcomes of the three groups. In addition, we plan to look at the GCS components (verbal, eye and motor) and their independent effects on outcomes. It may be that the GCS for motor response is an important predictor of outcomes for the SCI group, but not for the TBI group. The GCS for verbal response maybe important for the TBI group, but not for the SCI group. A limitation of this study mainly revolve around the discovery of multiple data points for the other trauma variables (eg. GCS, BP) and incompleteness of other available records (especially for patients who have been transferred from outside trauma facilities), making it an arduous task for data extrapolation and analysis. It is the hope that further finetuning of the databases will yield a larger merged study population from which trends and outcomes can be sufficiently derived.

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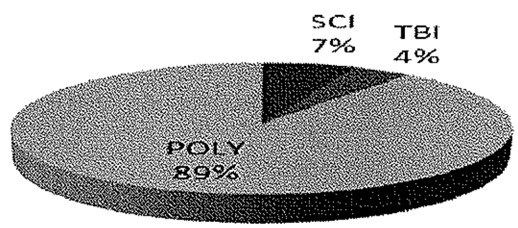
Appendix

Chart 1. Study Population Frequency of Trauma Type N = 879



Note: The SCI and TBI Trauma Types include only those with the one ICD9 Code related to SCI or TBI. The Poly Type includes those who may have had an ICD 9 code of traumatic SCI, TBI or both in addition to other ICD coded other injuries.

Chart 2. Number of Patients Discharged from Rehabilitation to Home

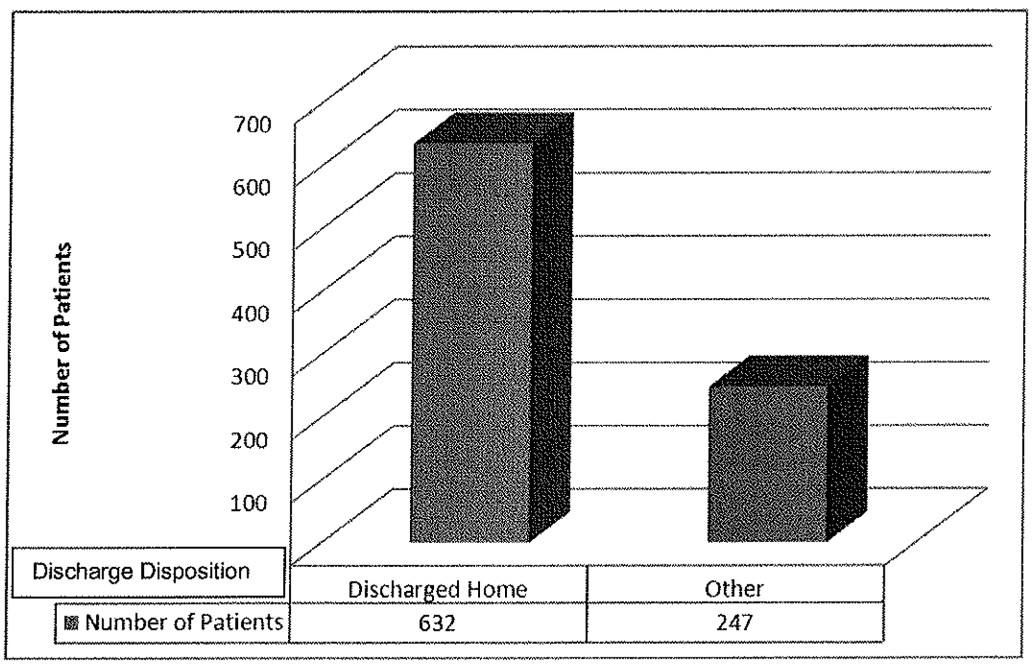
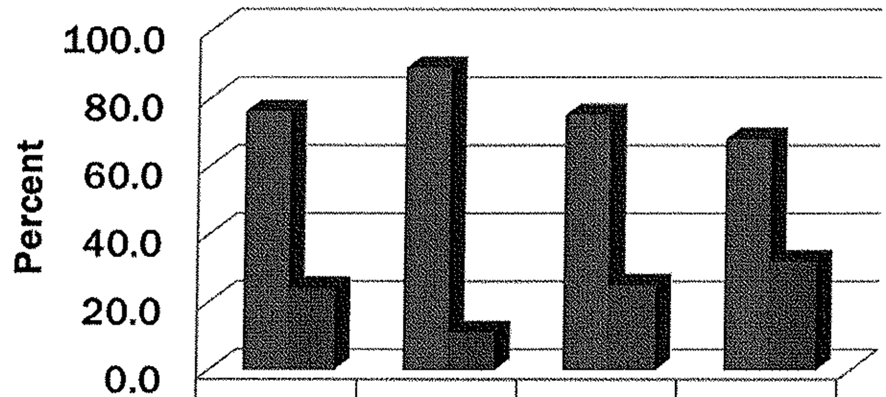
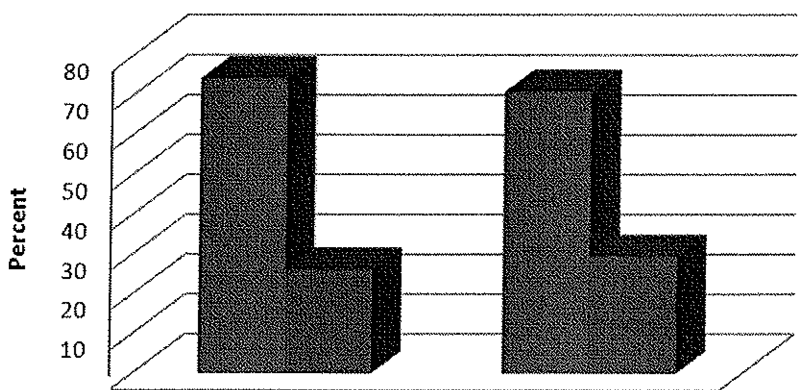


Chart 3. Percent of Patient Discharged Home from Rehabilitation by ISS Category



ISS	0-8	9-14	15-24	25+
Home	76.0	88.9	75.0	68.0
Other	24.0	11.1	25.0	32.0

Chart 4. Percent of Patients Discharged Home from Rehabilitation by GCS Category



GCS	<=13	>13
Home	73.9	70.7
Other	26.1	29.3