Original Article

The Impact of Interdisciplinary Care on Cost Reduction in a Geriatric Trauma Population

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Abstract

The current growth of the geriatric population and increased burden on trauma services throughout the United States (US) has created a need for systems that can improve patient care and reduce hospital costs. We hypothesize that the multidisciplinary services provided through the Geriatric Injury Institute (GII) can reduce hospital costs, improve patient triage throughput, and decrease hospital length of stay (LOS).

Methods and Material: We performed a single-center, retrospective chart review of our Level II trauma center registry and electronic medical records of patients ages 65 and older who satisfied trauma activation/code criteria between July 1, 2014, to June 30, 2016 (N = 663). Patients presenting from July 1, 2014, to June 30, 2015, were grouped as Pre-GII, while those presenting from July 1, 2015, to June 30, 2016, were grouped as Post-GII. Primary outcomes were emergency department (ED) triage time, overall LOS, and hospital costs. Secondary outcomes included patient disposition, mortality, and health assessments. Statistical comparisons were made using a one-way analysis of variance and Mann-Whitney U test. Results: Pre-GII vs. Post-GII average ages and the Injury Severity Score (ISS) were not statistically different (p>0.05). The average LOS was similar between the Pre-GII and Post-GII groups (4.64 ± 4.42 days vs. 4.26 ± 5.58 days, p = 0.48). More patients were discharged earlier (≤4 days; 64% vs. 73%) as well as discharged to home (37% vs. 45%) in the Post-GII group. The total cost savings were $53,000 with a median savings of $1061 per patient ($8808 vs. $7747, p = 0.04). Savings were highest during the first two days of admission (p = 0.03). The reduction in ED triage time was not significant (310.7 minutes vs 219.8 minutes, p > 0.05). Conclusion: With the increase in geriatric trauma, innovative models of care are needed. Our study suggests that the GII multidisciplinary approach to trauma services can lower overall hospital costs.

Keywords: Cost reduction, geriatric trauma, health systems, multidisciplinary care

Introduction

The aging of the “baby boom” generation and their increased life expectancy has led to a rapidly expanding geriatric population within the United States (US). Approximately 15% of the US population is 65 years of age and older, and this population is estimated to grow to over 20% by 2050.[1] Trauma in older adults has risen in concert with the size of the geriatric population. According to the National Trauma Data Bank (NTDB), there has been nearly a 50% increase in geriatric trauma cases over the last decade. This population now accounts for one-third of all trauma cases.[2]

The growth of geriatric trauma has resulted in increased health-care expenditure. Geriatric trauma constitutes approximately 40% of both fatal and nonfatal hospital expenditure, with unintentional falls alone accounting for annual costs of up to $28 billion.[3] The Center for Medicare and Medicaid Services projects that the overall national health expenditure for geriatric patients will increase 30% by 2025.[4] Geriatric care following trauma is complex and may be attributed to high rates of polypharmacy, comorbid conditions, and decreased physiologic reserve compared to younger patients, which has led to higher case-fatality rates, an injury severity score (ISS), length of stay (LOS), and resource utilization, irrespective of the mechanism of injury.[2,5,6] Even a single fall may yield devastating consequences, such as...

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traumatic brain injuries, hip and rib fractures, prolonged functional disability, and even death.

Preliminary data from our own Level II trauma center corroborate national trends, showing a significant increase in trauma volume of persons over 60 years of age as well as similar increases in blunt and fall-related injuries. Thus, there is a need for comprehensive geriatric care that is dedicated to reducing the overall incidence of injury, improve care efficiency, decrease length of hospital stays, and allow for a safe transition to independence following hospitalization. In July 2015, our institution responded to this growing concern by establishing the Geriatric Injury Institute (GII), a multidisciplinary approach to geriatric trauma care that focuses on the following three main areas: (1) prehospital prevention and education, (2) inpatient care, and (3) safe reintegration and recovery following hospitalization.

Multidisciplinary care of geriatric trauma patients either through dedicated geriatric units or hospital pathways has been reported to improve inpatient outcomes. Although these data are promising, the cost-effectiveness of such programs remains to be elucidated. To date, there are few studies that have focused on the sustainability/cost-effectiveness of a specialized geriatric trauma program.

As such, the aim of this study is to determine whether the GII’s inpatient multidisciplinary geriatric services were able to reduce hospital costs, improve patient triage throughput in the emergency department (ED), and decrease hospital LOS in its first year.

Methods

Description of the Geriatric Injury Institute

Bridgeport Hospital is a 384-bed tertiary care hospital within the Yale New Haven Health System (YNHHS). It serves as an American College of Surgeons Committee on Trauma (ACS-COT)-verified Level II Trauma Center and an ACS-COT/American Burn Association-verified regional burn center. Hospital-based acute care surgeons cover the trauma service with the assistance of two community surgeons. Geriatric trauma patients (trauma patients that are 65 years of age or older) comprise approximately 30% of the total trauma admissions.

In July 2015, the GII originated from the needs of our community and was strictly funded through philanthropy. Now, over sixty hospitals, various health systems, and community members have participated in GII-related activities.

Prior to the GII, there were few pathways for the care of the geriatric population. As such, geriatric patients that did not meet previous trauma activation criteria were triaged by the ED, and often the trauma service as well as other medical services were consulted. Currently, the GII engages a multidisciplinary team (i.e., trauma surgeons, emergency physicians, specialty surgery services, hospitalists, family physicians, geriatricians, nutritionists, rehabilitation services, pharmacists, and research staff) that participates in community geriatric assessments, inpatient care, and outpatient follow-up rehabilitation efforts. Although all services were not activated simultaneously upon patient admission, the GII inpatient model tailors the appropriate services to the geriatric trauma patient. Since the inception of the GII, we have provided/utilized the following services:

1. Clinical pathways for specific common geriatric injury patterns including: falls on anticoagulation and rib fractures [Appendix 1, Additional File 1 and Appendix 2, Additional File 2]

2. Increased utilization of Geriatric Emergency Medical Services (GEMS): Bridgeport Hospital houses the only GEMS service in the state of Connecticut. A dedicated GEMS nurse practitioner oversees the ED care of geriatric patients. He/she interacts with patients and their families to determine the patient’s physical, medical, and cognitive ability as well as safety upon discharge

3. Social work and care coordination: Every geriatric patient is seen by social work and care coordination. Social workers and care coordinators work with the patient to assess home safety and ensure safe discharge disposition. They also contact the patient’s family members for similar purposes, ensuring that appropriate outpatient services are set up upon discharge

4. Observational unit: Upon the classification of a patient as “observation status” (i.e., expected LOS <2 days), resources are dedicated to them to ensure efficient diagnostic workup, treatment, and disposition.

Study design

Our study is a retrospective, single-center cohort study of patient data queried from our Level II trauma registry and electronic medical records (EPIC, Epic Systems Corporation, Verona, WI, USA). Data compilation was performed by trained, unblinded reviewers (one research associate and one resident) in accordance with retrospective review guidelines. All patients 65 years of age or older who were admitted to the trauma service between July 1, 2014, and June 30, 2016, were included in this study. The patients were triaged using the Trauma Response Protocol [Appendix 3, Additional File 3]. We excluded geriatric patients who (1) were admitted to surgical subspecialty services or internal medicine; (2) expired in the ED; (3) were trauma consultations with ED disposition; and (4) were downgraded from trauma activation level.

To evaluate the impact of the GII on the inpatient population, the patients were grouped into admissions occurring July 1, 2014, through June 30, 2015 (pre-GII) and those admitted from July 1, 2015, through June 30, 2016 (post-GII). To further evaluate any differences, the pre-GII and post-GII patients were stratified into groups based on LOS (≤2 days, 2–4 days, 4–6 days, and >6 days).

Our study was reviewed and approved by the Bridgeport Hospital Institutional Review Board in accordance with the guidelines.
Data collection
Demographic data such as gender, age, racial and ethnic categories from the National Institute of Health (NIH), insurance coverage, Charlson Comorbidity Index (CCI), anticoagulation and/or antiplatelet use, and prior living status were collected. Variables of interest included mechanism of injury, Glasgow Coma Scale (GCS) at presentation, ISS, ED admission LOS (time spent in ED prior to admission order), duration before initial physical therapy (PT) (time to PT) and geriatric medicine evaluation (GME) (time to GME), inpatient falls and mortality, LOS, patient discharge disposition, and hospital charges. Hospital charges were estimated by evaluating both direct and indirect (nonmedical) costs. Direct costs included health-care interventions, nursing care, and medical supplies, whereas indirect costs comprised overhead expenses including depreciation, administration, and marketing.

Statistical analysis
Categorical variables were expressed as mean and percentage, whereas noncost continuous variables were expressed as mean and standard deviation (SD). Cost was expressed as median with interquartile ranges (IQRs). Only patient age was expressed as median and mean with SD. Statistical comparisons were made with a one-way analysis of variance using SPSS statistical software (IBM Corp, Version 22.0. Armonk, NY, USA) and Mann–Whitney U-test (cost data) using Excel (Microsoft Corp, Redmond, WA, USA). P < 0.05 was considered statistically significant.

RESULTS

Demographic data
A total of 663 patients over the age of 65 presented as activated traumas, with 319 in the pre-GII and 344 in the post-GII groups. A total of 305 patients were eliminated based on the exclusion criteria, leaving a total of 358 patients in our analysis [Figure 1]. The excluded geriatric patients (146 pre-GII and 159 post-GII) were either admitted to surgical subspecialty services or internal medicine, expired in the ED, had trauma consultations with ED disposition, or were downgraded from trauma activation level. Data were not collected for those patients who were unqualified for inclusion into the study, so baseline comparisons could not be made. Demographic characteristics of the pre-GII and post-GII groups are shown in Table 1. Both groups were similar in age, racial/ethnic background, use of anticoagulation and antiplatelet therapy, prior functional status, insurance coverage, and in the extent of comorbid conditions. There was an 8% increase in trauma service admissions.

| Description                                | Pre-GII | Post-GII | P  |
|--------------------------------------------|---------|----------|----|
| Patient: sample size, n                    | 173     | 185      | 0.409 |
| Gender, n (%)                              |         |          |     |
| Female                                     | 94 (54.3) | 99 (53.5) | 0.876 |
| Males                                      | 79 (45.6) | 86 (46.5) |    |
| Age in years                                |         |          |     |
| Mean±SD                                    | 82.2±8.0 | 81.4±9.2 | 0.409 |
| Median                                     | 83      | 82       |    |
| Racial and ethnic categories, n (%)        |         |          |     |
| Caucasian                                  | 156 (90.2) | 150 (81.1) | 0.114 |
| African American                           | 7 (4.1) | 15 (8.1) |    |
| Hispanic or Latino                         | 9 (5.2) | 16 (8.7) |    |
| Other                                      | 1 (0.9) | 4 (2.2) |    |
| Insurance, n (%)                           |         |          |     |
| Medicare                                   | 131 (75.7) | 144 (77.8) | 0.636 |
| Medicaid                                   | 36 (20.8) | 51 (27.6) |    |
| Private                                    | 140 (80.9) | 118 (63.8) |    |
| Anticoagulation, n (%)                     |         |          |     |
| Total                                      | 73 (42.2) | 77 (41.6) | 0.937 |
| Warfarin                                   | 43 (24.9) | 43 (23.2) |    |
| Rivaroxaban                                 | 11 (6.4) | 9 (4.9) |    |
| Apixaban                                   | 10 (5.8) | 18 (9.7) |    |
| Dabigatran                                 | 7 (4.0) | 3 (1.6) |    |
| Enoxaparin                                 | 2 (1.2) | 4 (2.2) |    |
| Antiplatelet, n (%)                        |         |          |     |
| Total                                      | 37 (21.4) | 40 (21.6) | 0.909 |
| ASA/plavix                                 | 24 (13.9) | 27 (14.6) |    |
| Plavix                                     | 6 (3.5) | 6 (3.2) |    |
| CCI, n±SD                                  | 3.12±2.09 | 3.08±2.12 | 0.840 |

Values are represented as mean±SD or sum (%). Racial and ethnic categories (other) include American Indian or Alaska Native, Asians, and Native Hawaiian or Pacific Islander; prior living status (other) includes transfers from other hospitals and admissions from assisted living facilities. GII: Geriatric Injury Institute, SD: Standard deviation, ECF: Extended care facility, ASA: Aspirin, CCI: Charlson Comorbidity Index

Figure 1: Flow diagram of the patient selection process
Table 2: Comparison of admission and inpatient data for Pre-GII and Post-GII groups

| Description                  | Pre-GII | Post-GII | $P$  |
|------------------------------|---------|----------|------|
| Mechanism, n (%)             | Fall    | 149 (86.1) | 153 (82.7) | 0.672 |
|                              | MVC     | 21 (12.1)  | 28 (15.1)  |      |
|                              | Other   | 3 (1.7)    | 4 (2.2)    |      |
| GCS, mean±SD                 | 14.5±2.0 | 14.6±1.3  | 0.350 |
| ISS, mean±SD                 | 8.3±6.7 | 8.5±5.6   | 0.710 |
| ED triage time (min), mean±SD| 310.7±602.9 | 219.8±141.6 | 0.054 |
| PT evaluations, n (%)        | 151 (87.2) | 155 (83.7) |      |
| Time to PT (h), mean±SD      | 52.1±50  | 51.6±50.2 | 0.926 |
| GME, n (%)                   | 23 (13.3) | 45 (24.3) |      |
| Time to GME (h), mean±SD     | 5.1±5.82 | 4.5±3.83 | 0.594 |
| Inpatient falls, n (%)       | 2 (1.2)  | 1 (0.5)   | 0.523 |
| Inpatient mortality, n (%)   | 8 (4.6)  | 9 (4.9)   | 0.915 |
| LOS (days), mean±SD          | 4.6±4.4  | 4.3±5.6   | 0.482 |
| Disposition, n (%)           | Home/self-care | 37 (21.4) | 53 (28.7) | 0.646 |
|                              | Home with health-care services | 27 (15.6) | 30 (16.2) |      |
|                              | ECF and SNF for STR/LTR | 82 (47.4)  | 79 (42.7) |      |
|                              | Hospice | 4 (2.3)   | 2 (1.1)   |      |
|                              | Other   | 15 (8.7)  | 12 (6.5)  |      |
| Hospital cost                | Total cost | $2561700  | $2508700  |      |
|                              | Per patient, median (IQR) | $88808 | $7747  | 0.043*  |

Values are represented as mean±SD, sum (%), or median (IQR). *Statistical significance ($P<0.05$). Mechanism (other) included assault, suicide, gunshot wounds, and dog bites. Disposition (other) included transfers, discharge to intermediate care facilities, and inpatient rehabilitation. MVC: Motor vehicle collision, GCS: Glasgow Coma Scale, ED: Emergency department, PT: Physical therapy, GME: Geriatric medical evaluation, ISS: Injury Severity Scale, LOS: Length of stay, ECF: Extended care facility, SNF: Skilled nursing facility, STR: Short-term rehabilitation, LTR: Long-term rehabilitation, GII: Geriatric Injury Institute, SD: Standard deviation: IQR: Interquartile range

Pre-Geriatric Injury Institute versus Post-Geriatric Injury Institute

Patients from both pre-GII and post-GII groups suffered similar mechanisms of injury, with over 80% of geriatric trauma admissions due to falls. No significant differences were seen in GCS, ISS, time to initial evaluation by inpatient PT and GME, number of PT and GME evaluations, discharge disposition, or LOS [Table 2]. Although the value did not reach statistical significance ($P = 0.646$), there was a trend toward early discharge in the post-GII group, where an additional 8% of patients were discharged home either independently or with health-care services following admission. Although there were no changes in the time for initial GME evaluation, nearly double the number of patients were evaluated by our GME following the implementation of the GII (23 [13.3%] vs. 45 [24.3%], $P = 0.594$). The mean LOS was similar between the groups (4.64 ± 4.42 days vs. 4.26 ± 5.58 days, $P = 0.482$). After the GII was initiated, geriatric patients were triaged more efficiently, with an average 1.5 h decrease in ED triage time (310.7 ± 602.9 min versus 219.8 ± 141.63 min). Despite this decrease, this trend did not reach statistical significance ($P = 0.054$). Annual hospital costs similarly decreased after the implementation of GII, with a total cost savings of $53,000 and a $1,061 reduction in median hospital costs per patient after one year, as reflected in the IQR [Table 2]. The median per patient cost reduction reached statistical significance ($P = 0.0429$).

Analysis of groups stratified according to length of stay

There were no significant differences in age or GCS at presentation across groups [Table 3]. As expected, geriatric patients with worsening injuries had longer hospital courses and waited significantly longer periods of time before the initial PT evaluation. Interestingly, prior to the GII, patients with a high ISS spent more time on average in the ED before appropriate triage. This reduction in ED triage time under the GII model was most apparent among patients who stayed > 6 days ($P < 0.05$). Another observation is that more patients in the post-GII group had been discharged earlier in comparison to the pre-GII group. Discharges within 2 days and 4 days following admission increased by 6% and 8%, respectively, after the implementation of the GII, despite not reaching statistical significance. There was an $1100 median cost savings per patient between the pre- and post-GII groups stratified to LOS ≤2 days, and this decrease reached statistical significance ($P = 0.031$).

DISCUSSION

It is estimated that over 10,000 Americans become part of the growing geriatric population each day.[14] Geriatric trauma, as well as health-care expenditures, has paralleled these population trends. Data from the National Center for Injury Prevention and Control estimated that in 2010, the total annual cost of nonfatal injuries in the geriatric population totaled over 32 billion dollars.[15]

As such, the growing concern of this changing landscape demands for novel approaches that increase the quality of patient care while simultaneously decreasing health-care expenses. The need for innovation has been recognized by the American College of Surgeons, who in 2012 formulated the Trauma Quality Improvement Program (TQIP) with guidelines for the management of geriatric trauma patients. The TQIP guidelines highlight important considerations in (1) trauma team activation, (2) initial trauma evaluation, (3) inpatient care, and (4) discharge planning.[16] In response to these TQIP guidelines, the needs of our geriatric community, and the need for a cost-effective model of geriatric care, we created the GII.

The multidisciplinary care of geriatric trauma patients is a familiar concept. The idea of a “geriatric trauma center” was first introduced when Hempsall et al.[17] showed that...
orthopedic and geriatric co-management decreased LOS in geriatric patients with femoral neck fractures. Currently, there are several institutions that have created dedicated geriatric trauma units/protocols that are similar to the inpatient division of our GII, which have focused on patient care and outcomes. For example, Mangram et al.\textsuperscript{[9,10]} showed that multidisciplinary geriatric care at their Level II trauma center, the G-60 unit, decreased average hospital and ED LOS as well as improved patient outcomes. The G-60 unit was aggressive with multiple services recruited simultaneously and automatically during trauma activations, which included the following: trauma service, medical hospitalist, physical medicine and rehabilitation specialist, physical/occupational therapy, respiratory therapy, G-60 nurse supervisor, social work, nutritional, pharmacy, and palliative care. Similarly, Adam et al.\textsuperscript{[7]} and Karamanukyan et al.\textsuperscript{[8]} recently showed that the use of geriatric trauma care multidisciplinary protocols can improve patient care. It is evident that a multidisciplinary approach to geriatric trauma can improve patient outcomes, yet such comprehensive services may lead to increased health-care expenditures. Whether these programs are cost-effective remains to be elucidated.

With hospitals constantly challenged by lower reimbursements, the use of sustainable, innovative care models must constantly be sought in order to provide high-quality care to their communities. We have shown that GII multidisciplinary care can reduce health-care expenditures, as both direct and indirect hospital costs decreased by $53,000 with a median cost savings of $1061 per patient in its 1st year. To date, there are a limited amount of studies that have focused on the cost-effectiveness of a multidisciplinary care team for geriatric trauma patients. In a single-center, prospective, chart review of geriatric patients, DeLa’O et al. showed that in a 5-month period, a dedicated geriatric trauma program was able to generate significant charge reductions by 21.4%.\textsuperscript{[11]} Although our reductions are modest, DeLa’O et al.’s study extrapolates cost savings through expected daily estimates rather than individualized cost of care.

Reports indicate that the geriatric population experience longer delays in ED care and are more often undertriaged in spite of having severe injuries, which can lead to devastating results.\textsuperscript{[18,19]} Undertriage of the elderly is particularly detrimental when anticoagulant therapy is utilized. In response, recent ACS-COT guidelines recommend trauma team activation of geriatric patients who fall while on these medications.\textsuperscript{[20]} In a recent retrospective, single-center study, Manson et al.\textsuperscript{[21]} demonstrated reductions in ED triage duration when following the ACS-COT guidelines. Similarly, we also utilized evidence-based admission pathways for patients who fall while on anticoagulation as well as for geriatric patients who suffered isolated traumatic injuries (Additional file 1 and Additional file 2). We have shown a trend toward the reduction of ED triage times by 1.5 h. Given that a high number of patients in our cohorts presented as falls (84.4%) and over one-third of them take anticoagulants, it may be likely that utilizing our geriatric trauma fall on anticoagulation pathway.

### Table 3: Stratification of Pre-GII and Post-GII groups based on length of hospital stay

| Variable description | Pre-GII | Post-GII |
|-----------------------|---------|----------|
|                       | < or = 2 days | 2-4 days | 4-6 days | > 6 days |
| Sample size, n (%)    | 60 (34.7)  | 51 (29.5) | 28 (16.2) | 34 (19.7) |
| Age (years)           | 81.6±9.3  | 81.3±8.9  | 79.9±9.7  | 82.4±9.4  |
| Median hospital cost per patient, median (IQR) | $45000 ($35000-$72000) | $78000 ($66000-$106000) | $140000 ($104000-$176000) | $292000 ($212000-$434000) |
| Total hospital cost, sum (%) | $386100 (15.0) | $496400 (19.4) | $430200 (15.0) | $496400 (19.4) |
| GCS                   | 14.3±2.5  | 14.6±1.8  | 14.9±0.3  | 14.3±2.0  |
| ISS                   | 5.6±4.6   | 8.6±5.8   | 9.2±5.7   | 10.8±8.1  |
| Triage time (min)     | 211.7±118.7 | 271.2±272.6 | 323.4±432.0 | 517.8±1209.7 |
| Time to PT (h)        | 29.7±18.7 | 37.4±16.7 | 63.0±33.5 | 93.4±82.7 |

Values are represented as mean±SD. *Denotes P<0.05 between pre-GII versus post-GII with similar length of hospital stay. IQR: Interquartile range, GCS: Glasgow Coma Scale, ISS: Injury Severity Scale, PT: Physical therapy, SD: Standard deviation, GII: Geriatric Injury Institute.
contributed to the observed reductions in ED admission LOS. Moreover, there are a number of publications that support the use of tailored geriatric protocols and their ability to decrease average ED triage durations.[22]

The TQIP guidelines also endorse proactive geriatric consultation for a comprehensive geriatric assessment.[16] It must be recognized that the care of geriatric patients is complex, as patient’s age may not predict patient’s functional status or outcome.[23] There are various factors that alter a geriatric patient’s response to injury including polypharmacy and multiple comorbidities. Similarly, the 2016 annual report from the NTDB shows that geriatric patients have higher case-fatality rates irrespective of the mechanism of injury in comparison to their younger counterparts, in spite of having similar or lower ISS values.[24] Thus, a geriatric consult cannot be more important. Various authors have shown that coordinated management of geriatric patients between geriatricians and surgeons has yielded consistent reproducible improvements in patient outcome and functional status.[24,25] At our institution, the GEMS is a resource available in our ED that provides care to all presenting geriatric patients. Employing this unique resource in addition to geriatric inpatient consultation, we observed a 95% increase in the utilization of geriatric medicine services. Although the net benefits are difficult to discern, collaboration between geriatrics and the trauma service through the GII likely contributed to this observed increase.

The statistical power for each outcome (LOS, triage time, and hospital costs) was calculated using an alpha level of 0.05 and was higher in all pre-GII groups (n = 173), ranging from 13% to 41% compared to post-GII groups (n = 185) that ranged from 1% to 2%. Increasing alpha to 0.1, the statistical power for the pre-GII group ranges from 22% to 55% and for the post-GII group from 0.4% to 4%. Increasing the sample size in both groups would provide more information and likely influence a higher statistical power.

Finally, both early discharge and safe disposition to home are goals of the GII. After GII model implementation, more patients were discharged ≤ 4 days (101 [64%] pre-GII versus 135 [73%] post-GII). Similarly, more patients were safely discharged directly to home (64 [37%] pre-GII versus 83 [45%] post-GII), which has been shown to lead to better patient outcomes.[15,26] In addition, with population health and accountable care organizations becoming an important focus in the delivery of care and Medicare reimbursement, the GII approach has shown early efficacy in metrics shared by these other care models.

Despite very promising results, there are some limitations of this study. First, this is a single-center retrospective study of a Level II trauma center. We excluded patients that were not admitted to the trauma service, however, it is unlikely that it would have affected our overall outcome because GII services were not provided to them and so it avoided potential selection biases. Our experience with geriatric trauma has closely mirrored the national trends with respect to the mechanism of injury, mortality, and sex.[2,27] Although we believe that our multidisciplinary model can be implemented in multiple settings and communities, our experience may not translate to all trauma centers that may not have the resources for this multidisciplinary approach. Furthermore, novel scoring systems validated for use in geriatric patients were not utilized. For instance, the Fragility Index and the Trauma-Specific Frailty Index have shown to be more robust predictors of unfavorable patient disposition than the ISS.[23] We also did not evaluate the association between the CCI and the patient LOS. In a recent study, Nossaman et al. demonstrated that CCI has a positive correlation with hospital stay in a geriatric subset of patients, and they also showed that the Comorbidity-Polypharmacy Score could predict geriatric patient outcomes.[28] Finally, dedicated geriatric services have been shown to improve patient outcomes such as decreased rates of urinary tract infections, deep-venous thrombosis, pulmonary embolism, pneumonia, congestive heart failure, or acute renal failure, which has been reproduced in multiple studies.[30,39] Overall, the goal of the GII is to improve patient outcomes. However, this study is a systemic approach that aims to determine whether multidisciplinary care for a trauma subset of geriatric patients can decrease health-care expenditure, and further research will be needed to determine GII influence on patient outcomes.

Conclusions
Various authors have shown that a comprehensive, multidisciplinary approach to geriatric care leads to better outcomes for these patients. We have shown that a philanthropy-funded, multidisciplinary institute dedicated to injured geriatric patients can maximize the efficiency of care delivered to aged adults. This model has demonstrated value through our analysis and can meet the demands of a growing geriatric population while reducing their overall cost of care.

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Conflicts of interest
There are no conflicts of interest.
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Geriatric Falls on Anticoagulants:

1. Reverse Anticoagulation?
2. Neuro checks per level of care protocol
3. Case Management Consult
4. Geriatrics Consult
5. Physical Therapy Consult
6. Notification of PCP to discuss anticoagulation plan
7. +/- Hold anticoagulation

New Neuro changes or worsening of symptoms within 24

Repeat Head CT

ICH?

SICU vs. SDU level of care
NSG consult Anticoagulation reversal

Reassess the patient for missed injuries or other contributing factors
Call the appropriate consultants

Geriatric falls while on anticoagulation therapy is a common entity at trauma centers. With the incidence of delayed intracranial hemorrhage following a negative head CT at 1%-6%, the literature suggests to observe these patients for 24 hours in the hospital for evidence of delayed ICH. The above algorithm provides guidance on how to triage this growing patient population.

*DOAC: Direct oral anticoagulant (i.e., dabigatran, apixaban, rivaroxaban, enoxaparin, edoxaban)

Appendix 1: Geriatric falls on anticoagulation clinical pathway
Thoracic Trauma: Rib Fractures (Adult)

Multiple rib fractures (more than 4 ribs) in patients > 45 years of age have been associated with increased morbidity. Elderly patients (≥ 65 years) who sustain blunt chest trauma with 2 or more fractured ribs have twice the mortality and thoracic morbidity of younger patients with similar injuries. For each additional rib fracture in the elderly, mortality increases by 19% and the risk of pneumonia by 27%. Data suggests monitoring the respiratory function of both groups may improve patient outcome.

| Age 45 ≥ 4 Rib Fractures |
| Age 65 > 2 Rib Fractures |

Admit SICU vs. PCU
Early C-Spine / TLS Clearance
Elevate Head of Bed >30 degrees (With spine clearance)
Incentive Spirometry (IS) vs. Positive expiratory pressure therapy (PEP)
Out of bed ASAP (when medically cleared)
Pulm toilet (nasotracheal suctioning, cough deep breathing)
Physical Therapy Consult
Fall Risk Assessment
Pain control:
- Non-narcotic pain meds:
  - Acetaminophen (Assess for adequate liver function)
  - NSAIDS: Ibuprofen, Naproxen, Toradol (Creatinine Clearance >30)
- Adjunctive pain therapies:
  - Lidoderm Patch 4% (Local pain relief)
  - Cyclobenzaprine*
  - Diazepam (Muscles spasm pain)*
  - Gapapentin or pregabaline (Neuropathic pain)*
- PO Narcotics
  - Tramadol (Assess for adequate kidney function, seizure history)*
  - Tylenol with Codeine*
  - Oxycodone, Hydrocodone*
- Parenteral administered narcotic (Consider subcutaneous admin)
  - Morphine, Hydromorphone*
- Patient Controlled Analgesia
  - Morphine, Hydromorphone*

*Cautious use in those > age 65

| IS < 10-15 ml/kg |
| IS > 10-15 ml/kg |

Hold enoxaparin
Consider Epidural
Consider Rib Blocks
Consider CPAP/BIPAP
Continue analgesia
Reassess every six hours
Physical Therapy

Appendix 2: Adult rib fracture clinical pathway
Trauma Response Protocol

Trauma patients are categorized by the Emergency Department Triage Nurse based on either the pre-hospital data received via C-Med or by assessment at triage. Trauma patients can be categorized into one of three categories:

- **TRAUMA CODE** for immediate life threatening injuries
- **TRAUMA ALERT** for potentially life threatening injuries and significant mechanism of injury
- **TRAUMA CONSULTATION** for non-life threatening injuries in stable patients. The patient is evaluated initially by the ED Attending Physician and consultation may be requested.

**Criteria for Trauma Code / Trauma Alert Activation:**

**Trauma Code:**
- Respiratory distress / airway compromise / RR <10 or >29, or already intubated*
- Hypotension: **Age>65:** SBP<100mmHg; **Age 16-64:** SBP<90 mmHg; **Age<16:** SBP<(70+2 x Age)**
- Glasgow Coma Score ≤ 8 in Adults; Glasgow Coma Score ≤11 in Children**
- Gunshot wound to head, neck, chest, abdomen, buttocks or extremity proximal to elbow/knee
- Spinal cord injury with motor deficits (i.e. paraplegia, quadriplegia, lateralizing signs)
- Major burns (see Burn Code algorithm) including high voltage electrical injury
- Amputation of limb, excluding digits
- Patient receiving blood products
- Multiple casualty incidents where it is difficult to determine extent of all patients
- Patient, who in judgment of the provider, does not meet criteria but is deteriorating

**Trauma Alert:***
- Unrestrained occupant in a rollover
- Significant vehicle deformity (i.e. intrusion of passenger compartment, bent steering wheel) or prolonged extrication >20 minutes
- Death of same car occupant
- Ejection from a vehicle
- Pedestrian or bicyclist run over, thrown, or hit by automobile traveling >20mph
- Fall from height >20’ for adults; Fall from height >10’ for children**
- All stable stab wounds
- Extremity gunshot wound, excluding hands or feet
- More than one long bone fracture
- Glasgow Coma Score 9-13 in adults; Glasgow Coma Scale 12-13 in children**
- Spinal cord injury with sensory deficits (i.e. paresthesias or sensory changes)
- Hangings and Drownings
- Burns (See Burn Alert algorithm)
- Fall with head injury while on anticoagulation: Coumadin (Warfarin), Pradaxa (Dabigatran), Eliquis (Apixaban), Xarelto (Rivaroxaban), Lovenox (Enoxaparin) or Savaysa (Edoxaben)

*Trauma Patients intubated in the ER must be upgraded to a Trauma Code

**Children are defined as patients less than age 16. Those 16 and older are adults.

Appendix 3: Trauma response protocol with criteria for trauma code and alert activation