Length of Stay, Cost, and Outcomes Related to Traumatic Subdural Hematoma in an Inpatient Setting in the United States

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Introduction

- In the United States, there are over 2 million traumatic brain injuries annually (TBI).[1,2]
- Most common type of TBIs is a traumatic (acute) subdural hematoma (TSDH).
- TSDH comprise up to 51.4% of all TBIs, and its prevalence continues to increase.[3,4]
- TSDH cases cause a significant financial burden to the healthcare industry.[5,6]
- Mortality rates in patients with TSDH remain high.[7,8]

Objectives: 1) *Primary objective*: Analyzing the trend in frequency of TSDH, inpatient cost, length of stay (LOS), surgical intervention, inpatient mortality, any complications from 2010 till 2017.

2) *Secondary objectives:*

a) Compare the rates of inpatient death and complications among surgical and non-surgical cases.

b) Identify the association between socio-demographic, clinical characteristics and hospital related factors on complications and inpatient death.

Methods and Materials

- **Inclusion criteria**: Discharge records with a primary diagnosis of TSDH were identified from Healthcare Cost and Utilization Project (HCUP)-NIS dataset between 2010 and 2017 by using ICD-9-CM (till Sept.2015) and ICD-10-CM codes (from October 2015 till December 2017)
- Records with missing data on LOS or cost were excluded
- **Independent variables**: Age, sex, race, Injury severity score (ISS), comorbid conditions requiring use of anticoagulant, hospital characteristics
- **Outcome variables**: Trend in monthly number of TSDH cases, quarterly trend in mean inpatient cost (in 2020 US $) , LOS, perioperative complications.
- **Statistical analysis**:
  - Trend in number of discharge records: Poisson regression
  - Trend in proportion of surgery, inpatient death and complications: Beta regression
  - Trend in inpatient cost and LOS: Log transformation with GLM
  - Multivariate logistic regression:

1) Compare the odds of inpatient death and complications during inpatient stay among surgical and non-surgical cases,

2) Find association between socio-demographic, clinical characteristics and hospital related factors on complications and inpatient death.

- *Missing data*: Ranged from 0.02% to 0.6%. Complete Case Analysis was used.

Impact of ICD-9 to ICD-10 coding change on trend analysis:

- Interrupted time series design after accounting for autocorrelation
- Optimal order of the autoregression model was determined by using a backward selection with an initial lag value of 12 months for monthly estimate or 4 quarters for quarterly estimate. p<0.05 was the criterion for retaining autoregressive parameters.

- Statistical software R (R foundation for Statistical Computing, Vienna, Austria) to calculate the ISS using ICD-9, ICD-10 and injury ("E") codes
- Type 1 error level = 0.05. SAS version 9.4 (Cary, NC) was used for analysis

Results

- Total of 113,966 discharge records – 56.8% male, 69.2% white, 51% is >= 75 yrs, 75.5% had ISS between 16 & 24, 29.4% used anticoagulants, 8.9% inpatient death, 23.4% had surgery
- Mean Cost ($): 23,182.4 (95% CI:22,983.5-23,381.3)
- Mean LOS: 6.4 days (95% CI:6.4-6.5)
- **Trend results:**
  - Significant **increase** in **number of TSDH** cases by 0.78% per month (p<0.0001)
  - Significant **decrease** in proportion of patients requiring **surgery** to not requiring surgery by 1.5% per quarter (p<0.0001)
  - Significant **decrease** in mean inpatient **cost** per quarter by 0.14% (p<0.0001)
  - Significant **increase** in mean **LOS** per quarter by 0.54% (p<0.0001)
  - Ratio of mean proportion of **death** to remained alive in inpatient condition **decreased** significantly by 0.52% (p<0.0001) per quarter.
  - Ratio of the mean proportion of patients having any **complication** to no complication significantly **increased** by 0.69% (p<0.0001) per quarter.

- Odds of inpatient death higher by 40% (OR: 1.40, 95% CI: 1.33-1.47, p < 0.0001) and having any complication was double (OR: 2.0, 95% CI: 1.93-2.07, p < 0.0001) among surgical cases compared to non-surgical cases.
- Pulmonary complications had highest frequency (16.77%)
- Odds of pulmonary, neurological, cardiac, thromboembolic complications and recurrent hematoma were significantly higher for surgical cases compared to non-surgical cases
- Odds of inpatient death and complications significantly increased with higher ISS, and for those who had comorbid conditions using anticoagulants.
- Odds of complications were higher for 18-44 years old and for males
- Odds of inpatient death and complications were highest in south region

Table 1. Trend analysis before and after ICD-9 to ICD-10 transition

		Estimate	95% CI	p-value
Monthly trend in number of cases	Before transition	*5.29*	4.61 – 5.97	*<0.0001*
	Level change	*314.1*	261.4 – 366.8	*<0.0001*
	After transition	*4.41*	1.47 – 7.34	*0.0037*
Quarterly trend in mean inpatient cost	Before transition	*– 196.5*	(– 245.0) -(-147.9)	*<0.0001*
	Level change	*3578.00*	(2293.8 – 4862.2)	*<0.0001*
	After transition	62.58	(– 142.7) – (267.9)	0.5386
Quarterly trend in Mean inpatient LOS	Before transition	*– 0.013*	(– 0.03) - (-0.001)	*0.0349*
	At transition	*1.33*	1.01 - 1.7	*<.0001*
	After transition	-0.026	(– 0.08) - (0.03)	0.3087
Quarterly trend in any complications	Before transition	*0.16*	0.12 – 0.20	*<.0001*
	Level change	0.26	(–0.8) – 1.3	0.6165
	After transition	*– 0.31*	(–0.48) – (– 0.14)	*0.0008*

Fig 1: Trend in number of cases, number of surgical cases and percentage of surgical cases across quarters

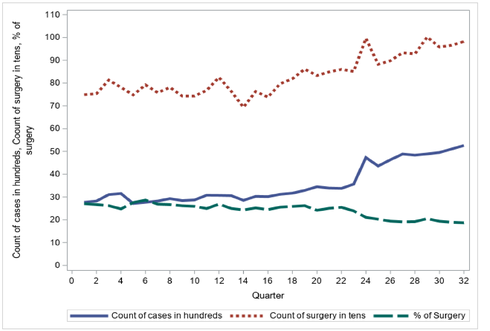


Fig 2: Trend in mean inpatient cost and mean LOS across quarters

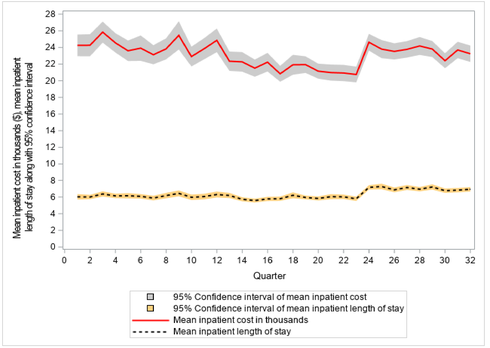
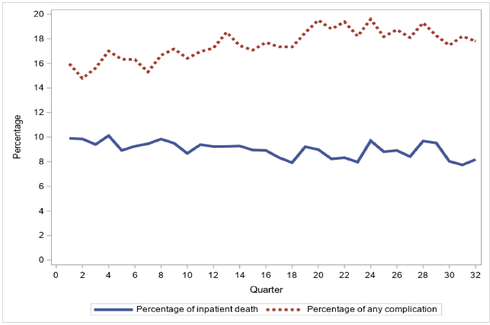


Fig 3: Trend in inpatient death and any complication across quarters



Discussion

- Increase in number of TSDH cases, highest increase among 75-84 yrs.
- Higher sensitivity of ICD-10 coding system might have caused a sharp increase in the number of cases after October 2015.[9]
- Decrease in proportion of patients who required surgery and mean cost of treatment. However, cost was significantly higher compared to a previous study using 2002-2011 NIS data.[8] Possible reasons include more costly diagnostic modalities, complex interventions using multidisciplinary teams, aggressive pharmaceutical interventions.[10, 11]
- Decrease in mean LOS between January 2010 and September 2015 and then increased at transition from ICD-9 to ICD-10 system.
- Decrease in inpatient mortality - might be a result of using advanced surgical and non-surgical techniques for treating TSDH patients.
- Increase in any complication rate - reasons might include use of sophisticated diagnostic tools to identify complications or aggressive screening strategies, use of complex surgical and non-surgical procedures to improve inpatient mortality.
- Inpatient mortality and complications were associated with the ISS, patients' comorbid conditions requiring use of anticoagulants and age.
- Pulmonary complications were most common during hospitalization.
- Highest level of inpatient mortality and complications in southern region needs further investigation.

Limitations:

- Individual patient is not the unit of analysis – no opportunity to follow up outcomes for a patient who had multiple admissions in hospitals.
- NIS database is susceptible to coding errors, which may lead to potential misclassifications and inaccurate diagnosis.
- Finally, the NIS database is unable to provide information about additional factors that may be driving up factors such as hospitalization costs and LOS, which might restrict the scope of the analysis.

Conclusions

Using a nationally representative sample of hospitalized patients, this study provided a more up-to-date estimate on occurrence, cost of treatment, LOS, surgical management, inpatient mortality rate and perioperative complications of treating patients with a primary diagnosis of TSDH in the US. The study also evaluated the impact of ICD-9 to ICD-10 coding change on the trend of those outcomes.

Increasing number of cases shows that TSDH still remains a prevalent injury in the US amongst all TBI, and additional resources and efforts should be allocated towards improving prognostic outcomes and controlling healthcare costs.

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