The impact of Medicaid expansion on trauma-related emergency department utilization: A national evaluation of policy implications

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BACKGROUND: The impact of the 2014 Affordable Care Act (ACA) upon national trauma-related emergency department (ED) utilization is unknown. We assessed ACA-related changes in ED use and payer mix, hypothesizing that post-ACA ED visits would decline and Medicaid coverage would increase disproportionately in regions of widespread policy adoption.

METHODS: We queried the National Emergency Department Sample (NEDS) for those with a primary trauma diagnosis, aged 18 to 64. Comparing pre-ACA (2012) to post-ACA (10/2014 to 09/2015), primary outcomes were change in ED visits and payer status; secondary outcomes were change in costs, discharge disposition and inpatient length of stay. Univariate and multivariate analyses were performed, including difference-in-differences analyses. We compared changes in ED trauma visits by payer in the West (91% in a Medicaid expansion state) versus the South (12%).

RESULTS: Among 21.2 million trauma-related ED visits, there was a 13.3% decrease post-ACA. Overall, there was a 7.2% decrease in uninsured ED visits (25.5% vs. 18.3%, $p < 0.001$) and a 6.6% increase in Medicaid coverage (17.6% vs. 24.2%, $p < 0.001$). Trauma patients had 40% increased odds of having Medicaid post-ACA (vs. pre-ACA: aOR 1.40, $p < 0.001$). Patients in the West had 31% greater odds of having Medicaid (vs. South: aOR 1.31, $p < 0.001$). The post-ACA increase in Medicaid was greater in the West (vs. South: aOR 1.60, $p < 0.001$). Post-ACA, inpatients were more likely to have Medicaid (vs. ED discharge: aOR 1.20, $p < 0.001$) and there was a 25% increase in inpatient discharge to rehabilitation (aOR 1.24, $p < 0.001$).

CONCLUSION: Post-ACA, there was a significant increase in insured trauma patients and a decrease in injury-related ED visits, possibly resulting from access to other outpatient services. Ensuring sustainability of expanded coverage will benefit injured patients and trauma systems. (*J Trauma Acute Care Surg.* 2020;88: 59–69. Copyright © 2019 American Association for the Surgery of Trauma.)

LEVEL OF EVIDENCE: Economic, level III.

KEY WORDS: Medicaid expansion; Affordable Care Act; emergency care; insurance status; healthcare utilization.

The Patient Protection and Affordable Care Act (ACA) was implemented in 2014 with the goal of expanding insurance coverage, increasing access to services and improving quality of patient care.[1,2] The impact of such legislation upon the trauma population is of particular relevance, as nearly one in five injured patients have historically been uninsured.[3] To date, trauma-specific studies of the impact of Medicaid expansion have centered on the evaluation of *inpatient* outcomes for injured patients, but little is known regarding the ACA's effect on all trauma-related emergency department (ED) utilization.

Injury-related visits comprise nearly 30% of the 146 million Emergency Department (ED) hospitalizations annually in the U.S.[4] The ED is a critical access point of care for trauma patients and serves as the primary site of patient triage based upon injury severity, with only a fraction of patients being admitted for subsequent observation or surgical intervention. Vulnerable underinsured trauma patients may be particularly reliant upon the ED post-discharge as their access to primary care, post-injury rehabilitation and other outpatient services has historically been limited.[3,5]

The Practice Management Guidelines Committee of the Eastern Association for the Surgery of Trauma (EAST) recently published a systematic review demonstrating that the ACA has not been associated with significant reductions in trauma inpatient mortality, but uninsured rates among trauma patients admitted to hospital have decreased.[6] Similarly, trauma patients now have improved access to post-discharge services following injury (e.g. rehabilitation, skilled-nursing facility, home health).[5,7] It is currently unclear whether this increase in insurance coverage and access to post-acute care has been associated with a change in ED utilization among trauma patients.

Among the broader patient population, ED visit volume and proportions of uninsured ED visits have varied considerably post-ACA, likely due to patient demographics and individual states' decisions regarding whether or not to expand Medicaid.[8,9] In this study, we aimed to assess whether the ACA was associated with national changes in trauma patient ED use and payer mix. We hypothesized that post-ACA, ED visits would decline overall and that Medicaid covered-visits would increase disproportionately in regions of widespread policy adoption.

METHODS

We performed a retrospective cohort analysis of trauma patients using the 2012 and 2014–2015 Nationwide Emergency Department Sample (NEDS) from the Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project (HCUP). The NEDS is the largest all-payer emergency department (ED) database in the United States, with 31 million ED visits per year. When weighted to represent national estimates, NEDS represents approximately 143 million ED visits annually. The database contains demographic and socioeconomic characteristics (e.g., age, sex, and household income), encounter data (i.e., ED visits, hospital admission and discharge), hospital characteristics (i.e., geographical region, urban rural designation, and trauma center level) and financial data (i.e., ED charges, and combined ED and inpatient charges). Injury Severity Score (ISS) was calculated for each patient using the ICDPIC version 3.0 within Stata/SE version 14.2 (StataCorp LLC, College Station, Texas).[10]

We identified patients aged 18 to 64 years with a primary diagnosis of trauma, as determined by International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) coding (ICD-9-CM 800.0 to 959.0, excluding 905 to 924). As most states implemented Medicaid expansion at the time of the ACA in January 2014, we compared patients who had a trauma-related visit in the 'pre-ACA' period (2012) with patients in the 'post-ACA'

Submitted: July 19 2019, Revised: October 22, 2019, Accepted: August 11, 2019, Published online: September 12, 2019.

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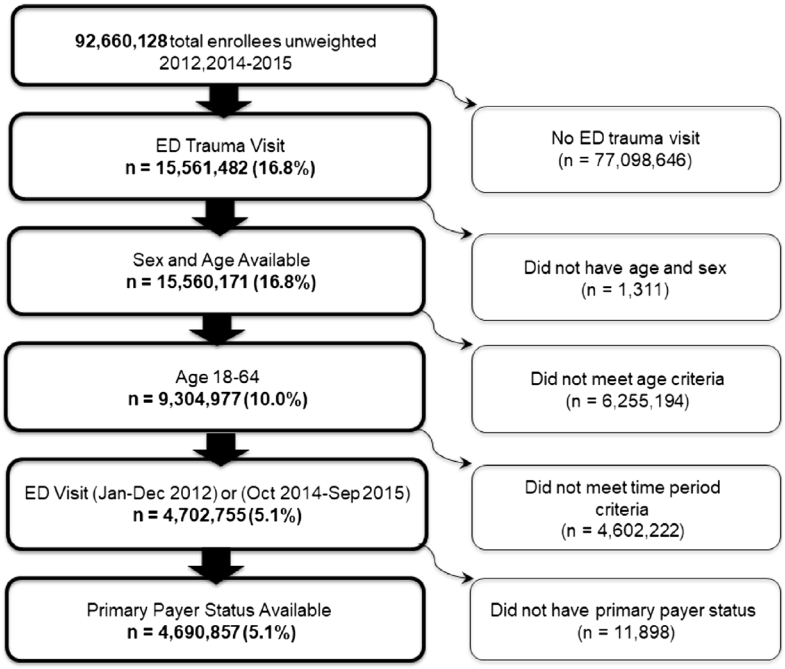
DOI: 10.1097/TA.0000000000002504



ED: Emergency Department

Figure 1. Flow diagram of inclusion and exclusion criteria.

period (October 1, 2014 to September 30, 2015). We selected October 2014 to September 2015 as our 'post-ACA' year to maintain consistency with ICD-9-CM codes, as the last three months of the 2015 database utilized ICD-10-CM coding.

Our primary outcomes of interest were the number of ED visits and payer status; secondary outcomes were total ED and inpatient charges and inpatient discharge disposition for patients admitted to the hospital. Our primary independent variable was time period ('pre-ACA' and 'post-ACA'). We assessed unadjusted differences among trauma ED visits in pre- and post-ACA periods using chi-square tests for categorical variables and Student's independent t-tests for continuous variables. Multivariable analysis of the payer status was restricted to Medicaid vs. self-pay and private, in order to account for the three main payer groups within our population. Mixed-effect logistic regression models with random intercepts for hospitals were used to assess the effect of the independent variables on Medicaid coverage, while controlling for hospital-level clusters and selected covariates. To achieve convergence we utilized multilevel mixed-effects logistic regression with QR decomposition of the variance-component matrix, which more efficiently approximates the likelihood function using adaptive Gaussian quadrature.[11]

We then employed a difference-in-differences technique to evaluate whether implementation of the ACA Medicaid expansion was associated with increased Medicaid coverage. The difference-in-differences analysis reduces potential bias from unmeasured variables by controlling for secular changes observed in the control group.[12] Primary independent variables in the payer status coverage logistic regression model included time period and hospital geographic region. To estimate the effect of Medicaid expansion on Medicaid coverage, we chose to compare the regions with the highest and lowest proportions of the population residing within Medicaid expansion states based upon 2012 estimates from the US Census Bureau: West 91% and South 12%.[13] An interaction term assessing the difference in differences was specified in the regression model as the time period (pre-ACA vs. post-ACA) by region (West vs. South). We chose the covariates for all regression models using a stepwise Akaike Information Criterion (AIC) method.[14] Covariates considered for multivariable analyses included: age group (18–44, 45–64), sex, injury severity score (ISS; minor 0–8, moderate 9–15, major 16–25, severe/unsurvivable 26–75, unspecified), median zip code household income (quartiles), trauma center level (non-trauma/level III vs. level I/level II), inpatient vs. ED visit and urban vs. rural hospital designation Within each variable, the category with the largest number of observations or highest rates of the outcome was chosen as the referent group (Southern region, pre-ACA period, age group 18–44, male sex, minor ISS, lowest quartile median household income, non-trauma/level III trauma center level, outpatient claim, and urban hospital designation). Missing or unknown was considered a separate category within each variable.

The secondary outcome of inpatient discharge disposition was defined as rehabilitation vs. home/home health. The analysis was restricted to patients who were admitted to inpatient care from the ED. To estimate the ACA effect on discharge to rehabilitation, we calculated a multilevel mixed-effects logistic regression model similar to the primary outcome model with random intercepts for hospitals and QR decomposition of the variance-component matrix. We applied the difference-in-differences methodology to the same independent variables and potential covariates were the same as in the primary model, selected using the stepwise AIC method.[14]

Finally, the ACA effect on combined inpatient and ED charges was analyzed using multilevel mixed-effects linear regression with random intercepts for hospitals. Charges, rather than costs, are represented with the NEDS and were adjusted for inflation using

TABLE 1. Patient and Healthcare Utilization Characteristics for All Trauma Patients (Ages 18–64) Presenting to the Emergency Department (ED) pre-ACA (2012) vs. Post-ACA (2014–2015), Unweighted

	Pre-ACA 2,597,425 (55.4%)	Post-ACA 2,093,432 (44.6%)	*p* value
Patient Characteristics			
Age, mean (SE), years	37.6 (13.2)	37.9 (13.3)	<0.001
Age by Category, number (%)			
18–24 years	547,904 (21.1)	424,861 (20.3)	<0.001
25–44 years	1,189,541 (45.8)	959,996 (45.8)	
45–54 years	504,294 (19.4)	396,523 (18.9)	
55–64 years	355,686 (13.7)	312,052 (14.9)	
Gender, number (%)			<0.001
Male	1,412,683 (54.4)	1,113,414 (54.1)	
Female	1,184,742 (45.6)	960,018 (45.9)	
Payer Status, number (%)			<0.001
Medicare	169,582 (6.5)	140,573 (6.7)	
Medicaid	457,517 (17.6)	505,729 (24.2)	
Private	977,033 (37.6)	813,690 (38.9)	
Self-Pay	661,121 (25.5)	382,472 (18.3)	
No Charge/Other	332,172 (12.8)	250,968 (12.0)	
Zip Income Quartile, number (%)			<0.001
0-25th Percentile	820,553 (31.6)	663,270 (31.7)	
25-50th Percentile	657,467 (25.3)	508,357 (24.3)	
50-75th Percentile	586,319 (22.6)	479,746 (22.9)	
75-100th Percentile	479,047 (18.4)	402,806 (19.2)	
Missing	54,039 (2.1)	39,253 (1.9)	
Injury Severity Score, number (%)			<0.001
Minor (ISS 0–8)	2,507,114 (96.5)	2,046,322 (97.7)	
Moderate (ISS 9–15)	67,169 (2.6)	37,123 (1.8)	
Major (ISS 16–25)	19,053 (0.7)	8,430 (0.4)	
Severe (ISS 26–74)	3,691 (0.1)	1,247 (0.1)	
Unsurvivable (ISS = 75)	356 (0.01)	270 (0.01)	
Unspecified	42 (0)	40 (0)	
Injury Mechanism, number (%)			
Cutting/Piercing	326,909 (12.6)	258,529 (12.4)	<0.001
Drowning	431 (0.02)	289 (0.01)	0.015
Falling	558,820 (21.5)	470,423 (22.5)	<0.001
Fire	1,188 (0.05)	907 (0.04)	0.219
Firearm	14,020 (0.5)	9,369 (0.5)	<0.001
Machinery	18,607 (0.7)	16,233 (0.8)	<0.001
Motorvehicle	371,692 (14.3)	308,554 (14.7)	<0.001
Nature	53,136 (2.1)	44,707 (2.1)	<0.001
Poison	1,081 (0.04)	773 (0.04)	0.011
Striking	319,719 (12.3)	253,012 (12.1)	0.219
Suffocation	679 (0.03)	577 (0.03)	0.35
Healthcare Utilization			
Died in the ED	1,410 (0.05)	1,185 (0.06)	<0.001
Inpatient Discharge Disposition, number (%)	110,649 (4.3)	22,797 (1.1)	<0.001
Home/home health	86,896 (78.5)	17,043 (74.8)	
Rehabilitation	17,105 (15.5)	4,341 (19.0)	
Died	1,936 (1.8)	447 (2.0)	
Other	4,712 (4.3)	966 (4.2)	
Length of Stay (LOS), mean (SE), days	5.3 (8.9)	5.7 (8.9)	<0.001
Median Charges (IQR), $			
ED charges only	1,357 (814, 2,421)	1,550 (915, 2,812)	<0.001
ED and Inpatient charges	39,765 (21,598, 75,834)	44,801 (23,973, 88,660)	<0.001

*ACA: Affordable Care Act; SE: Standard Error; LOS: Length of Stay; IQR: Interquartile Range.

TABLE 2. Patient and Healthcare Utilization Characteristics for Medicaid and Self-Pay Trauma Patients Presenting to the Emergency Department Pre-ACA (2012) vs. Post-ACA (2014–2015), Unweighted

	Medicaid			Self-Pay		
	Pre-ACA 457,517 (47.5)	Post-ACA 505,729 (52.5)	*p* value	Pre-ACA 661,121 (63.4)	Post-ACA 382,472 (36.7)	*p* value
Patient Characteristics						
Age, mean (SE), years	34.8 (12.2)	35.8 (12.5)	<0.001	34.8 (11.7)	34.6 (11.5)	<0.001
Age by Category, number (%)			<0.001			<0.001
18–24 years	110,636 (24.2)	112,653 (22.3)		153,214 (23.2)	85,629 (22.4)	
25–34 years	141,732 (31.0)	152,486 (30.2)		214,576 (32.5)	131,028 (34.3)	
35–44 years	95,760 (20.9)	105,488 (20.9)		138,708 (21.0)	81,773 (21.4)	
45–54 years	71,329 (15.6)	84,780 (16.8)		109,034 (16.5)	57,771 (15.1)	
55–64 years	38,060 (8.3)	50,322 (10.0)		45,589 (6.9)	26,271 (6.9)	
Gender, number (%)			<0.001			0.068
Male	187,408 (41.0)	238,144 (47.1)		423,392 (64.0)	245,621 (64.2)	
Female	270,109 (59.0)	267,585 (52.9)		237,729 (36.0)	136,851 (35.8)	
Zip Income Quartile, number (%)			<0.001			<0.001
0-25th Percentile	191,629 (41.9)	203,530 (40.2)		257,273 (38.9)	150,419 (39.3)	
25-50th Percentile	124,715 (27.3)	129,760 (25.7)		179,233 (27.1)	95,987 (25.1)	
50-75th Percentile	88,646 (19.4)	102,898 (20.4)		136,029 (20.6)	78,980 (20.7)	
75-100th Percentile	43,989 (9.6)	59,813 (11.8)		71,613 (10.8)	48,318 (12.6)	
Missing	8,538 (1.9)	9,728 (1.9)		16,973 (2.6)	8,768 (2.3)	
Injury Severity Score, number (%)			<0.001			<0.001
Minor (ISS 0–8)	444,114 (97.1)	495,595 (98.0)		641,689 (97.1)	374,264 (97.9)	
Moderate (ISS 9–15)	9,743 (2.1)	7,888 (1.6)		14,992 (2.3)	6,580 (1.7)	
Major (ISS 16–25)	2,976 (0.7)	1,897 (0.4)		3,654 (0.6)	1,353 (0.4)	
Severe (ISS 26–74)	611 (0.1)	274 (0.1)		668 (0.1)	194 (0.1)	
Unsurvivable (ISS = 75)	60 (0.01)	59 (0.01)		106 (0.02)	75 (0.02)	
Unspecified	13 (0)	16 (0)		12 (0)	6 (0)	
Cutting/Piercing	46,424 (10.2)	51,837 (10.3)	0.095	83,149 (12.6)	48,987 (12.8)	0.001
Drowning	39 (0.01)	39 (0.01)	0.658	88 (0.01)	40 (0.01)	0.205
Falling	109,114 (23.9)	119,905 (23.7)	0.107	125,038 (18.9)	71,142 (18.6)	<0.001
Fire	255 (0.1)	239 (0.1)	0.066	313 (0.1)	173 (0.1)	0.630
Firearm	2,688 (0.6)	2,689 (0.5)	<0.001	6,500 (1.0)	3,394 (0.9)	<0.001
Machinery	1,119 (0.2)	1,659 (0.3)	<0.001	3,429 (0.5)	2,592 (0.7)	<0.001
Motorvehicle	35,441 (7.8)	46,036 (9.1)	<0.001	88,488 (13.4)	66,164 (17.3)	<0.001
Nature	7,611 (1.7)	9,542 (1.9)	<0.001	12,927 (2.0)	7,549 (2.0)	0.513
Poison	226 (0.1)	253 (0.1)	0.890	312 (0.1)	144 (0.04)	0.025
Striking	57,734 (12.6)	65,338 (12.9)	<0.001	89,519 (13.5)	49,849(13.0)	<0.001
Suffocation	190 (0.04)	212 (0.04)	0.925	169 (0.03)	122 (0.03)	0.062
Healthcare Utilization						
Admitted as Inpatient						
Inpatient Discharge Disposition, number (%)	17,170 (3.8)	5,868 (1.2)	<0.001	20,599 (3.1)	2,723 (0.7)	<0.001
Home/home health	12,973 (75.6)	4,404 (75.1)	0.800	18,204 (88.6)	2,376 (87.3)	<0.001
Rehabilitation	2,966 (17.5)	1,057 (18.0)		959 (4.7)	178 (6.5)	
Died	355 (2.1)	118 (2.0)		471 (2.3)	68 (2.5)	
Other	846 (4.9)	289 (4.9)		925 (4.5)	101 (3.7)	
Length of Stay (LOS), mean (SE), days	7.3 (14.6)	6.6 (11.2)	<0.001	4.3 (6.6)	5.1 (7.8)	<0.001
Median Charges (IQR), $						
ED charges only	1,243 (741, 2,164)	1,457 (860, 2,527)	<0.001	1,357 (814, 2,452)	1,621 (951, 3,015)	<0.001
ED and Inpatient charges	40,617 (21,111, 82,663)	48,829 (24,457, 103,661)	<0.05	37,824 (20,960, 68,646)	42,536 (23,294, 83,496)	<0.001

*ACA: Affordable Care Act; SE: Standard Error; LOS: Length of Stay; IQR: Interquartile Range.

September 2015 estimates from the Bureau of Labor and Statistics. We applied a natural logarithm transformation to the total charges model outcome to conform to normality assumptions. We present percentage changes in the mean charges relative to each reference group. The difference-in-differences was assessed using the same variables and

methodology as previous models, and covariate selection was performed similarly.

All analyses were conducted using Stata SE v14.2 (StataCorp LLC, College Station, Texas). Use of the NEDS follows regulations within the data use agreement as defined by the Agency for Healthcare Research and Quality. The Stanford University Institutional Review Board (IRB) determined this study exempt from IRB review, as it does not meet the definition of human subject research as defined in federal regulations 45 CFR 46.102.

RESULTS

A total of 4,690,857 patients (unweighted) met the inclusion criteria for this study (Fig. 1). Among the 21.2 million weighted trauma-related ED visits analyzed, there were 13.3% fewer ED trauma visits post-ACA (pre-ACA vs. post-ACA: 11.3 million vs. 9.8 million). Overall, the proportion of ED visits for uninsured patients decreased following implementation of the ACA (pre- vs. post-ACA: 25.5% vs. 18.3%, $p < 0.001$) and the proportion of ED visits covered by Medicaid increased (pre- vs. post-ACA: 17.6% vs. 24.2%, $p < 0.001$) (Table 1). Among patients with Medicaid, self-pay and private insurance, there was a marked increase in the proportion of patients with Medicaid discharged from the ED (pre- vs. post-ACA: 18.0% vs. 31.6%, $p < 0.001$) and a decrease in self-pay patients (23.1% vs. 14.1%, $p < 0.001$) in the West. There was a lesser but still significant increase in Medicaid (pre- vs. post-ACA: 16.4% vs. 18.0%, $p < 0.001$) and a decrease in self-pay patients (32.5% vs. 28.0%, $p < 0.001$) in the South.

Certain patient demographic, clinical and utilization characteristics differed between pre-ACA and post-ACA study periods (Table 1, unweighted). On average, there was a small decrease in the injury severity of trauma patients presenting to the ED, with the majority of patients presenting due to minor injuries (ISS < 9: 96.5% vs. 97.7%). For patients with ISS < =15, in-hospital mortality remained stable for both trauma patients discharged from the ED (pre- vs. post-ACA: 0.04% vs. 0.04%, $p < 0.001$), and for those admitted to hospital (pre- vs. post-ACA: 0.7% vs. 0.8%, $p < 0.001$). Among patients with ISS > 15, mortality increased among those discharged from the ED (pre- vs. post-ACA: 1.7% vs. 3.0%, $p < 0.001$) and decreased among inpatients (pre- vs. post-ACA: 7.3% vs. 6.7%, $p < 0.001$). Among admitted trauma patients, mean length of stay (LOS) increased (pre- vs. post-ACA: 5.3 to 5.7 days, $p < 0.001$) and the percent of patients discharged to rehabilitation increased (pre- vs. post-ACA: 15.5% vs.19.1%, $p < 0.001$). On average, there was a small increase in the percentage of trauma patients presented to specialty level I and II trauma centers post-ACA (pre- vs. post-ACA: 26.4% vs. 27.6%, $p < 0.001$). During the study period, inflation-adjusted costs of care increased. Median combined ED and inpatient charges increased from $39,765 (IQR: $21,598, $75,834) to

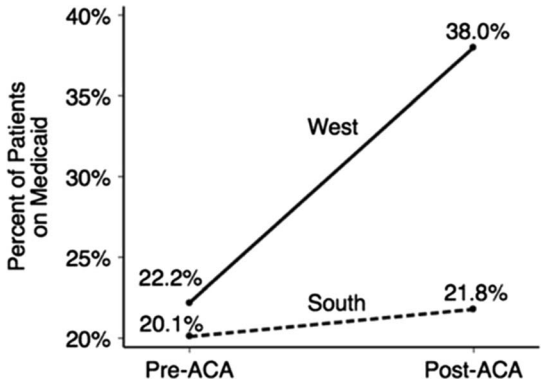


Figure 2. Proportion of patients with Medicaid coverage (among Medicaid, self-pay, and private insurance) in Western and Southern regions before and after implementation of the Patient Protection and Affordable Care Act (ACA).

TABLE 3. Mixed Effect Regression: Likelihood of Having Medicaid Coverage Among Trauma ED Utilizers

		Medicaid vs. Self-pay and Private		
Variable		Adjusted Odds Ratio	[95% CI]	*p*-Value
	Intercept	0.19	[0.18, 0.21]	<0.001
Time Period	Pre	Referent		
	Post	1.40	[1.38, 1.42]	<0.001
Region	South	Referent		
	West	1.30	[1.16, 1.46]	<0.001
Time*Region Interaction				
	Post*West	1.60	[1.56, 1.64]	<0.001
Zip Income Quartile (Percentile)	0-25th	Referent		
	26-50th	0.78	[0.77, 0.78]	<0.001
	51-75th	0.58	[0.58, 0.59]	<0.001
	76-100th	0.34	[0.34, 0.35]	<0.001
	Missing	0.69	[0.68. 0.70]	<0.001
Sex	Male	Referent		
	Female	1.96	[1.95, 1.97]	<0.001
Age Category	18–44	Referent		
	45–64	0.70	[0.70. 0.71]	<0.001
Inpatient	No	Referent		
	Yes	1.20	[1.18, 1.23]	<0.001

$44,801 (IQR: $23,973, $88,660). Median charges for ED services alone also increased from $1,357 (IQR: $814, $2,421) to $1,550 (IQR: $915, $2,812).

Given that the ACA expanded criteria for Medicaid enrollment, we performed a sub-analysis on Medicaid and uninsured/self-pay trauma patients presenting to the ED pre- and post-ACA in order to determine whether patient characteristics would differ significantly (Table 2). On average, there was a small increase in Medicaid patients presenting with minor injuries (ISS < 9, pre- vs. post-ACA: 97.1% vs. 98.0%, $p < 0.001$). While mortality in the ED remained stable for patients with ISS < =15 (pre- vs. post-ACA: 0.03% vs. 0.04%, $p < 0.001$), it increased among the ISS > 15 group (pre- vs. post-ACA: 1.1% vs. 2.2%, $p < 0.001$)]. For Medicaid trauma patients admitted to the hospital, mean LOS decreased (pre- vs. post-ACA: 7.3 vs. 6.5 days, $p < 0.001$), whereas uninsured patients had longer average hospital stays post-ACA (pre- vs. post-ACA: 4.3 vs. 5.1 days, $p < 0.001$). Discharge to rehabilitation increased for both groups [Medicaid (pre- vs. post-ACA: 17.5% vs. 18.0%, $p < 0.001$) and self-pay (pre- vs. post-ACA: 4.7% vs. 6.5%, $p < 0.001$)]. For those patients destined for rehabilitation, LOS awaiting discharge decreased among Medicaid patients (pre- vs. post-ACA: 15.8 days vs. 12.8 days, $p < 0.001$) and increased for uninsured trauma patients (pre- vs. post-ACA: 12.6 days vs. 14.0 days, $p < 0.001$). Medicaid combined ED and inpatient charges increased from a median of $40,617 (IQR: $21,111, $82,663) to $48,829 (IQR: $24,457, $103,661). Charges for ED services alone also increased from a median of $1,243 (IQR: $741, $2,164) to $1,457 (IQR: $860, $2,527). Self-pay combined ED and inpatient charges increased from $37,824 (IQR: $20,960, $68,646) to $42,536 (IQR: $23,294, $83,496). Self-pay charges for ED services alone also increased from $1,357 (IQR: $814, $2,452) to $1,621 (IQR: $951, $3,015).

Mixed-effect multivariable logistic regression models were calculated to estimate the difference in differences of pre- vs. post-ACA effects among regions of high and low uptake of ACA expansion (Western and Southern regions) (Table 3; Fig. 2). Trauma patients presenting to the ED had 40% increased odds of Medicaid coverage post-ACA compared to pre-ACA (aOR 1.40 [95% CI 1.38, 1.42], $p < 0.001$). Female gender (aOR 1.96 [1.95, 1.97], $p < 0.001$) and inpatient admission following an ED visit (aOR 1.20 [1.18, 1.23], $p < 0.001$) were significantly associated with Medicaid coverage in the multivariable model. Compared to patients presenting to hospitals in the South, patients presenting to hospitals in the West had significantly higher odds of Medicaid coverage (aOR 1.30 [1.16, 1.46], $p < 0.001$). Patients presenting to hospitals in the West represented a greater post-ACA increase in Medicaid-covered trauma ED visits than the patients in the South (post-ACA*West interaction: aOR 1.60 [1.56, 1.64], $p < 0.001$).

For patients admitted to hospital following an ED visit, the multivariable model demonstrated that the proportion of patients discharged to post-acute care (PAC) (rehabilitation, skilled nursing facility, or long-term care facility vs. home or home health) increased significantly from the pre-ACA to post-ACA time period (aOR 1.24 [1.14, 1.36], $p < 0.001$). Trauma patients who were female (aOR 1.57 [1.50, 1.64], $p < 0.001$), older (45–64 years vs. 18–44 years: aOR 3.02 [2.89, 3.16], $p < 0.001$), and had higher ISS ([ref: ISS < 9], ISS 9–14: aOR 2.25 [2.15, 2.36], ISS 15–25: aOR 3.30 [3.10, 3.51], $p < 0.001$) had significantly higher odds of being discharged to PAC. When comparing discharge to PAC for all patients attending hospitals in the West vs. the South, the interaction between time and region was not significant, indicating that the pre-to-post increase in the odds of discharge to PAC was similar between the regions.

Finally, multivariable analysis confirmed that total inflation-adjusted inpatient and ED charges increased significantly from the pre-ACA to post-ACA time period (adjusted percentage change: 18% [15%, 22%], $p < 0.001$). Compared to patients presenting to hospitals in the South, the total inpatient and ED charges were significantly higher for patients attending hospitals in the West (percentage difference: 38% [26%, 52%], $p < 0.001$). Post-ACA, the West experienced a lesser increase in total charges than the South ($p = 0.004$). Patients presenting to a level I or II trauma center experienced 31% higher charges than level III or non-trauma centers (95% CI 15%, 49%, $p < 0.001$). Conversely, hospitals in rural locations had lower charges than hospitals in urban locations (percentage difference: −41% [−48%, −33%], $p < 0.001$).

DISCUSSION

Our study revealed an overall 13% decrease in the number of ED trauma-related visits post-ACA implementation for patients ages 18–64 between the years 2012 and 2015. This decline in ED volume among injured patients is similar to trauma-specific trends observed in HCUP and in other studies over the last decade.[15,16] The reason for our observed decline in the rate of injury-related ED visits is likely multifactorial. The epidemiology of trauma is changing, with the number of older trauma patients on the rise. Many of these patients present to the ED as a result of falls and other injuries, however our study specifically excluded patients aged 65 and older to avoid confounding related to Medicare qualification at the age of 65.[15] Additionally, there has been a concurrent increase in the number of independent urgent care centers nationally, which may be absorbing some of the minor injury burden that traditionally presented to hospital EDs.[9,15,17]

Patient choices driving decisions to seek care at the ED vs. urgent care, particularly for minor injuries, are complex and include factors such as insurance coverage, costs, distance and local access within a particular community, as well as the estimate time to receiving treatment. The specific role of the ACA and its impact on ED volume remains debated in the literature. Initial administrative data from EDs in Maryland and the District of Columbia demonstrated a 3.7% decrease in all-comer ED visits immediately post-ACA.[18] Several studies, however, reported an increase in ED utilization, mostly within states that adopted Medicaid.[19,20] Policy experts hypothesized that insurance gains associated with the ACA would increase patient predilection to use of all types of care and subsequently place strain on existing healthcare infrastructure, such as Emergency Departments.[21] However, the trauma population is unique in that injury is unpredictable and most initial triage occurs emergently within the ED, independent of patient preference. Therefore, the post-ACA decline in trauma volume is likely to be at least in-part associated with fewer trauma-related return ED visits. Prior to ACA implementation, underinsured trauma patients may have been more

prone to 'frequent flyer' status in the ED due to poorer baseline health, drug disorders and mental health conditions, and coping with the sequelae of injury without appropriate follow-up.[22,23] With increases in insurance coverage post-ACA, these patients should theoretically have improved access to post-injury services, such as inpatient rehabilitation, home health care, urgent care and primary care providers, thereby off-setting the burden placed upon Emergency Departments to provide these services.[24–26] Our analysis confirmed findings from previous studies, demonstrating a post-ACA increase in discharge to post-acute care (PAC) of nearly 25% (aOR 1.24, $p < 0.001$).

In addition to an overall decrease in trauma-related ED visits, we observed a 7.2% decrease in uninsured ED visits and 6.6% increase in Medicaid-covered ED visits. These are consistent with previously reported patterns of insurance coverage change post-ACA among trauma inpatients within the National Trauma Data Bank (NTDB), where the uninsured rate fell by 5.9 percentage-points, with a corresponding 7.5% absolute increase in Medicaid coverage.[27] Similarly, among the young adult general ED population, there was a 9.4% decrease in uninsured ED visits, accompanied by a 6.3% increase in Medicaid covered visits.[28] The RAND Health Insurance Experiment previously hypothesized that low-income patients may have high unmet health needs that would prompt more frequent ED visits if they were previously uninsured and became enrolled in Medicaid.[8] We did in fact see an increase in the number of Medicaid patients presenting to the ED for minor injuries (ISS < 9). However, this hypothesis does not apply to the urgent nature of many more severe trauma-related ED visits. We postulate that the uptake in Medicaid visits, observed primarily in geographic regions of high-Medicaid expansion, reflect changes in overall payer mix post-ACA. In other words, with a larger proportion of the adult population under 65 now qualifying for Medicaid in these states, one would expect to see this increase in the proportion of Medicaid patients reflected across ED visits.

These findings were confirmed in our regression analyses, revealing that trauma patients presenting to the ED had 40% increased odds of Medicaid coverage post-ACA compared to pre-ACA. Patients in the West, which had higher Medicaid expansion uptake, experienced a disproportionately greater increase in Medicaid patient trauma ED visits than the patients attending hospitals in the South, which had lower uptake of Medicaid expansion, as well as a marked decrease in self-pay patients. A significant predictor of Medicaid status was inpatient admission following an ED visit (aOR 1.20 [1.18, 1.23], $p < 0.001$). We hypothesize that the mechanism by which admission to hospital is associated with an increased likelihood of Medicaid coverage at discharge is through Hospital Presumptive Eligibility (HPE). As of 2014 under the ACA, hospitals were given the option to screen patients for Medicaid eligibility at the time of hospitalization. The purpose of HPE is to provide rapid insurance coverage for hospitalized patients who appear to be eligible.[29] HPE enables hospitals to initiate temporary Medicaid enrollment for uninsured patients urgently requiring coverage and access to post-discharge services. HPE hospitals are typically government-owned, and our study found a particular increase in Medicaid patients within government-owned, level I and II trauma center teaching hospitals. However, while HPE Medicaid may be temporarily increasing rates of short-term coverage, HPE Medicaid expires within 60 days. It is currently unclear what percentage of patients eventually enroll and ultimately qualify for a full, long-term Medicaid plan to continue coverage. Similarly, because NEDS does not collect patient-level longitudinal data, we were unable to evaluate whether a particular patient had a return ED visit within the same year and if they subsequently became uninsured. While the HPE mechanism can certainly impact the proportion of Medicaid insured ED visits observed in the immediate post-injury period, failure to convert to full Medicaid risks leading to significant insurance churn without tangible improvement in access to care or patient outcomes.

When analyzing our secondary outcome of mortality, we observed no significant difference in ED or inpatient mortality pre- and post-ACA. A recently published meta-analysis concluded that Medicaid expansion policies were not associated with a change in the odds of inpatient mortality for trauma (OR 0.96; 95% CI, 0.88–1.05).[6] The previous literature did not describe the post-ACA impact on ED mortality for trauma patients, but our study confirms these rates did not change despite an overall decrease in ISS for trauma patients. Additional study is required to further explore the increase in ED mortality evidenced among ISS > 15 patients.

Finally, we analyzed the impact of the ACA on costs of ED and inpatient care. Although ED charges only comprise a fraction of total costs of care for subsequently admitted patients, only approximately 15% of trauma patients presenting to the ED are admitted to hospital. The majority of young trauma patients (97%) have minor injuries (ISS < 9) and are treated and discharged from the ED. The NEDS database limits our analysis to charges, rather than costs. Inflation-adjusted inpatient and ED charges increased significantly from the pre-ACA to post-ACA time period (percentage change: 18%). Compared to patients presenting to hospitals in the South, the inpatient and ED charges were significantly higher (independent of time) for patients attending hospitals in the West (percentage difference: 38%). From pre- to post-ACA implementation, charges rose less sharply in the West than they did in the South (percentage change: −6%). This suggests that the increase in ED and inpatient charges is related to the change in payer mix. Few studies have addressed changes in costs of care after implementation of Medicaid expansion among trauma patients, most of which also found increases in charges particularly across Medicaid payers.[25,30] Undurraga et. al. demonstrated that after ACA implementation, increases in median charges were accompanied by a corresponding increase in payments by insurers.[30] These reimbursements can be critical to the financial stability of trauma centers, particularly those within safety-net hospitals (SNHs) whose mission is to serve the indigent and underinsured.[31] Our previous work studying the financial impact of the ACA upon California trauma centers demonstrated SNHs with the most significant gain in Medicaid patients post-ACA (and corresponding decline in self-pay patients) were associated with the greatest improvement in net inpatient revenue and operating margin post-ACA. Further work is needed to assess the true impact of insurance expansion on trauma-related costs from all perspectives (the patient, payer, hospital and broader financial impact upon our trauma systems).

Limitations of this study are inherent to the retrospective database. Causal effects of the ACA are difficult to establish

retrospectively, but we have applied statistical analysis techniques to improve causal inference, including difference-in-differences analyses and multivariable regression modeling. The NEDS is a nationally representative administrative database meant to provide valuable demographic, cost and healthcare utilization data. However, it does not include granular clinical data, nor trauma-specific information such as mechanism of injury. All trauma-related information (injuries and injury severity) was derived from ICD-9-CM codes, converted using the ICDPIC tool. As well, the NEDS uniquely captures data associated with hospitalizations (either as discharges from the ED, or from an inpatient setting). Consequently, we were not able to extrapolate upon the outcomes of trauma patients post-discharge, the rate of return visits to the ED or hospital readmission, nor the out-of-hospital mortality rate (i.e. for patients who later died after discharge from the ED or the inpatient setting).

Additionally, we were limited by the granularity of geographic data within the NEDS. We did not have detailed geographic data regarding hospital location, therefore we were not able to determine whether patients were admitted in states that participated in Medicaid expansion. Therefore, we performed our difference-in-difference analyses based upon the geographic census regions with the highest and lowest population percentages residing within Medicaid expansion states as of 2015. Only 37 of 51 states (including the District of Columbia) have expanded Medicaid to date, and that the policy was implemented at varying time intervals across states.[32] Similarly, there were likely some differences in the contributions of states within each of the four census regions between 2012 and 2014–2015. Despite this, we designed our analysis to represent regions of Medicaid-expansion versus non-expansion given the limitations of the dataset.

Our hope is that the findings from this study will lead to follow-up analyses with more robust clinical data from trauma registries and state-level data that may elucidate significant differences in trauma ED utilization between Medicaid expansion and non-expansion states.

CONCLUSION

Medicaid expansion was associated with a significant increase in insurance coverage for trauma patients and an overall decrease in injury-related ED visits from 2012 to 2015. This may be the result of improved discharge to post-acute services for trauma patients, as well as better access to other outpatient and primary care services. Overall, increases in the proportion of insured patients utilizing the ED may also lead to additional reimbursements and improved financial stability of vulnerable county-owned trauma centers. Efforts to ensure future sustainability of expanded coverage are likely to benefit injured patients and trauma systems.

DISCLOSURE

There are no conflicts of interest to report for any of the authors.
Dr. Knowlton is currently receiving a grant from the American College of Surgeons (the C. James Carrico Faculty Research Fellowship for the Study of Trauma and Critical Care) until 2020.
This manuscript will be presented as a podium oral presentation at the 78th Annual Meeting of the American Association for the Surgery of Trauma; September 18–21, 2019 in Dallas, TX.

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DISCUSSION

JOSEPH P. MINEI, M.D., M.B.A. (Dallas, Texas): Drs. Bulger and May, members of the AAST, thank you for the opportunity to discuss this paper. And I thank Dr. Knowlton for her timely submission of a well-written manuscript.

Dr. Knowlton and the team from Stanford have continued to provide the lead when it comes to analyzing public policy in health care economics and acute care surgery.

The authors have looked at the NEDS database that provides a sampling of ED visits across the country. The sampling methodology, as I understand it, is meant to mimic the status of ED types across the country.

So, for instance, if there are 20 percent of EDs across the country that predominantly provide care in an inner-city, safety-net environment, then 20 percent of NEDS sampling will come from those hospital types.

Dr. Knowlton and her colleagues have examined the impact of Medicaid expansion on ED visits. The authors have shown us that areas of the country that have expanded Medicaid with the ACA expansion opportunity have associated decreased ED visits, higher proportion of patients with Medicaid, and decreased unfunded patients, as well as shorter lengths of stay and increased post-acute care discharge placement when compared to areas of the country where Medicaid expansion has not increased. This was associated with increased hospital charges.

The authors posit that this decreased ED utilization, while multifactorial, is in part due to less repeat ED use due to better post-discharge care and placement.

I have the following questions.

Can you tell us more about the NEDS sampling methodology? As I searched the data base and the rules for sampling I noted that, for instance, the State of Texas was not included in the 2002 sampling yet was included in the later time sampling.

It is well-known that Texas did not expand the Medicaid population. How does this impact your data analysis as the sampling between the two time points looked at different hospitals?

Second, I noticed that the proportion of patients that died in the ED did not change over time. Can you explain this?

If the total number of trauma visits decreased and that decrease was likely due to better post-acute care placement and patients not returning to the ED for sort of low-level concerns, it would seem to me that mortality should increase.

However, severely-injured patients that ultimately die did not change over the time periods. Does this give us further concern about the sampling technique used by NEDS and, thus, by extension, the validity of this study?

My final question centers around the increased charges associated with increased Medicaid coverage. Should we be concerned going forward that there will be increased charges and, by extension, costs in a government-run health system?

I recognize that charges, costs, and reimbursement are related but not necessarily connected. That is, just because there were increased charges did the hospitals receive increased reimbursement on a per-capita basis for Medicaid patients?

I applaud the authors of the Stanford group for continuing to push the boundary of our understanding of how public policy impacts trauma center financial viability.

I thank the Association for the privilege of the floor.

LISA M. KNOWLTON, M.D., M.P.H., F.R.C.S.C. (Stanford, California): Thank you, Dr. Minei, for your insightful comments and questions. First, I will start by addressing the NEDS sampling methodology.

The advantage and rationale for using NEDS for this type of study is that it's the largest all-payer emergency department database available to us in the U.S, with data extracted from approximately 950 hospitals annually, including 36 states and DC. This amounts to a roughly 20 percent stratified sample, as Dr. Minei pointed out, of U.S. ED patients.

The main objective of providing a stratified sample is to ensure that it is representative of the national ED landscape by applying HCUP weighting calculations.

Each year NEDS stratifies on various hospital characteristics so that one particular type of hospital is not over-sampled. Those include geographic region, trauma center designation, urban/rural location, teaching hospital status, as well as hospital ownership.

For example, if you're sampling on trauma center designation, NEDS wants to ensure that it has the same annual percentage of trauma hospitals as actually exist in the entire U.S.

Similarly, there should be roughly the same percent of ED discharges from year-to-year in a given geographic area, even though the contribution from individual states might vary, as was the case in Texas.

This is why we were limited in this particular study to providing only regional findings; however, in order to provide a more detailed picture by individual state we will be conducting similar future analyses using state-specific data bases.

In terms of our ED mortality findings, you are completely correct that one would expect mortality to increase.

Because we shared your hypothesis and also suspected that the large sample of ED trauma visits with minor injuries was skewing our sample and results, in our manuscript we performed a sub-analysis based on injury severity score.

So although mortality remained relatively stable for patients with minor injuries, among the ISS>15 group, mortality actually increased pre- to post-ACA, from 1.7 to 3 percent.

Finally, that is an excellent question regarding charges and costs and reimbursements. It really emphasizes the point that we continue to struggle to understand, particularly when using administrative databases such as this, the complex interplay between all three terms.

We have seen from other studies post-ACA implementation that increased charges, particularly among Medicaid payers, were accompanied by a corresponding increase in payment by insurers.

In fact, in our own previous work looking at the financial impact of the ACA among trauma centers in California, we found that the gain in Medicaid patients across safety-net hospitals corresponded with an improved net revenue for the hospital as well as operating margins.

This suggests that greater proportions of insured payers do, in fact, translate to improved county hospital reimbursements. There is an article published by the Commonwealth Fund entitled *The Fiscal Case for Medicaid Expansion* that provides some additional details justifying that point.

I do agree, however, that there is still much work to be done to assess the impact of insurance expansion on trauma-related costs from all perspectives, which include the patient, provider, payer, hospital, as well as the broader financial impact on our trauma and health care systems.

Thank you.

