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How has the Affordable Care Act changed outcomes in emergency general surgery?

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INTRODUCTION: Lack of insurance coverage increases complications and mortality from surgical procedures. The 2014 Affordable Care Act (ACA) Open Enrollment (OE) insured more Americans, but it is unknown if this improved outcomes from emergency general surgery (EGS) procedures. This study seeks to determine how ACA OE coverage changes outcomes in EGS.

METHODS: This is a retrospective review using the Nationwide Inpatient Sample database from 2012 to 2014. Patients aged 18 to 64 years undergoing EGS procedures were identified by *International Classification of Diseases, Ninth Revision*, codes. Medicare patients were excluded. Patient demographics, hospital characteristics, and Charlson comorbidity index were obtained. Outcomes were measured by mortality, complications, and calculated costs. Univariate and difference-in-differences multivariate analyses were performed to determine the effect of the ACA OE on EGS outcomes.

RESULTS: A total of 304,110 EGS cases were identified. After Medicare patients were excluded, there were 275,425 cases. In 2014, Medicaid admissions increased 18.2% from 18,495 to 22,615 ($p < 0.001$) and self-pay admissions decreased 33% from 14,938 to 10,630 ($p < 0.001$). Mortality significantly increased for self-pay patients in 2014 from 0.81% to 1.22% ($p < 0.001$). Difference-in-differences analysis indicated that, after risk adjustment, the ACA OE was associated with a small reduction in mortality for insured patients (−0.12%, $p = 0.034$), increased complications (1.4%, $p = 0.009$), and increased wage-index adjusted mean costs (4.6%, $p < 0.001$). There was a significant increase in Medicare (+26.5%) and private (+12.2%, $p < 0.001$) insurance admissions in teaching hospitals, while nonteaching hospitals had fewer EGS admissions with a greater reduction in uninsured EGS admissions.

CONCLUSIONS: The ACA OE created a significant reduction in uninsured EGS admissions but did not reduce EGS mortality. Mortality decreased in insured patients but increased in uninsured patients, indicating that the ACA OE primarily insured lower-risk patients. The ACA OE did increase cost and complications in insured admissions. Teaching hospitals saw the majority of the increase in Medicaid and private insurance EGS admissions. A national registry would improve future study of insurance policy on EGS outcomes. (*J Trauma Acute Care Surg.* 2018;84: 693–701. Copyright © 2018 American Association for the Surgery of Trauma. All rights reserved.)

LEVEL OF EVIDENCE: Economic analysis, level IV.

KEY WORDS: Emergency general surgery; access; health policy; affordable care act; insurance disparities.

In January 2014, the Patient Protection and Affordable Care Act (ACA) Open Enrollment (OE) launched creating a Medicaid (MCD) expansion, which provided health insurance coverage to over 20 million previously uninsured individuals. As a result, MCD enrollment grew by 21% by the end of 2014.[1,2] The ACA and attempts at its repeal have created more controversy regarding the effects of health care insurance on mortality, health, health care quality, and costs.[3–7]

Prior studies indicate that lack of health care insurance is associated with worsened health care access, outcomes, and delays in care.[7–10] Effects on mortality in studies are mixed, but there is evidence for decreased mortality in conditions that are amenable to health insurance coverage.[7,11–13] For surgical conditions, lack of insurance is associated with delays in presentation and worsened outcomes.[14–16] Policies that increased health insurance coverage have improved access and outcomes in some areas. This includes a reduction in rates of perforated appendix at appendectomy for recipients of the ACA's Dependent Coverage Provision, which has mandated coverage of dependents 18 to 25 years old on parents' insurance since 2010.[17] The Massachusetts health insurance expansion in 2006 was associated with improved access to care for cholecystitis patients; increased rates of resection for pancreatic, thyroid, and colorectal cancer; and decreased need for emergent colorectal resection.[18–21]

Emergency general surgery (EGS) faces a challenge in maintaining access to high-quality emergency surgery care in the face of an aging population, overburdened emergency rooms, and a shortage of acute-care surgeons.[22–24] Need for an EGS procedure may represent a consequence of poor preventative, outpatient, or chronic health care, including those without health care insurance coverage.[25]

The purpose of this study is to assess changes in EGS insurance coverage, mortality, complications, and costs after the 2014 ACA OE expansion. Specifically, this study uses the quasiexperimental nature of the ACA OE by using a difference-in-differences (DID) analysis to: (1) assess changes in insurance coverage rates among EGS admissions after the ACA OE;

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(2) measure any changes in mortality, complications, or costs associated with the ACA OE; and (3) examine whether changes in insurance coverage rates, mortality, or complications varied across sociodemographic subgroups.

PATIENTS AND METHODS

Data Source

This is a retrospective analysis using the Healthcare Cost and Utilization Project's Nationwide Inpatient Sample (NIS) database from 2012 to 2014. The NIS is the largest public database of all-payer inpatient discharges in the United States.[26] The NIS is a stratified probability sample of inpatient hospital discharges that are weighted by region, hospital size, and teaching status to provide scaled national estimates. Notably, the sampling framework of the NIS changed in 2012.[27] Before 2012, the NIS represented all discharge data from a 20% stratified sample of United States hospitals. Beginning in 2012, the NIS changed its sampling method to sample 20% of discharges from all participating hospitals. Patients aged 18 to 64 years undergoing EGS procedures were identified by *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes. The NIS assigns each admission 1 to 15 diagnosis codes and 1 to 15 procedure codes based on *ICD-9-CM* codes. Patients aged 18 to 64 years undergoing EGS procedures were identified by these *ICD-9-CM* codes.

Patient Population

Emergency general surgery admissions were identified from the NIS database as nonelective emergency procedures with *ICD-9* procedure codes for appendectomy (47.01, 47.09, 47.11, 47.19, 47.20, 47.91, 47.92, 47.99), cholecystectomy (51.01, 51.02, 51.03, 51.04, 51.21, 51.22, 51.23, 51.24), hernia repair (17.11, 17.12, 17.13, 17.21, 17.22, 17.23, 53.00, 53.01, 53.02, 53.03, 53.04, 53.05, 53.10, 53.11, 53.12, 53.13, 53.14, 53.15, 53.16, 53.17, 53.21, 53.29, 53.31, 53.39, 53.41, 53.42, 53.43, 53.49, 53.51, 53.59, 53.61, 53.62, 53.63, 53.69, 53.90), bowel resections, ostomy creations (17.31, 17.32, 17.33, 17.34, 17.35, 17.36, 17.39, 45.02, 45.03, 45.33, 45.41, 45.61, 45.62, 45.63, 45.71, 45.72, 45.73, 45.74, 45.75, 45.76, 45.79, 45.81, 45.82, 45.83, 45.90, 45.91, 45.92, 45.93, 45.94, 45.95, 46.01, 46.02, 46.03, 46.04, 46.10, 46.11, 46.13, 46.14, 46.20, 46.21, 46.22, 46.23, 46.24, 46.31, 46.39, 46.40, 46.41, 46.42, 46.43, 46.93, 46.94), and incision of perirectal abscess (49.01).

Admissions with missing information on surgical procedures were excluded. Patients under 18 years or over 64 years were excluded, as were patients with Medicare, because they were either not directly affected by ACA expansion or were already covered by other programs.

Affordable Care Act OE expansion occurred in January 2014; admissions from 2012 and 2013 were defined as pre-ACA OE and post-ACA OE if they occurred in 2014 (Fig. 1).

Variables Collected

The following data points were collected from the database: patient demographics (age, race, and sex), date of admission, admission diagnosis, hospital length of stay (LOS), payer status, hospital charges, comorbidities, Charlson comorbidity index (CCI), in-hospital complications, median income quartile

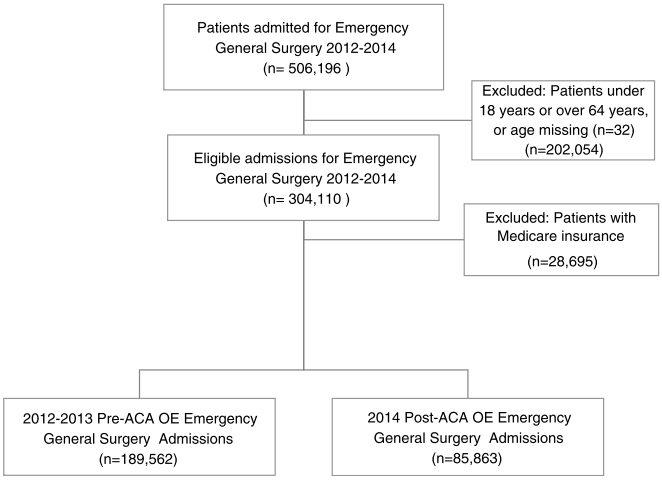

Figure 1. Flow diagram of study design. Widespread implementation of the ACA occurred in 2014.

by zip code, urban/rural status, hospital teaching status, and in-hospital mortality.[28]

In-hospital complications were defined as urinary tract infection, surgical site infection, pneumonia, sepsis, stroke cerebrovascular accident (CVA), pulmonary embolism, deep venous thrombosis, myocardial infarction, renal failure, respiratory failure, retained gallstone, ileus, postoperative shock, cardiac arrest, complications during procedure, acute posthemorrhagic anemia, central line infections, and reoperation. Hospital cost was analyzed using hospital charges data provided in NIS converted to wage-index adjusted cost using the hospitals' provided annual charge-cost ratios adjusted by the Centers for Medicare and Medicaid Services local wage index.[29]

Variables

The primary outcome measures were mortality, complications (defined as an admission with one or more complication codes), and wage-index adjusted costs. The secondary outcome measure was insurance payer, coded as either insured (private, MCD, or other [worker's compensation, TRICARE, Indian Health Service, other government insurance, and miscellaneous insurance]) or uninsured (self-pay).

The covariates included patient demographics of age, sex, and race/ethnicity (as non-Hispanic White vs non-White), comorbidities as defined below, and urban/rural status. Facility factors included teaching status and rural/urban geographic location. Also included was the ordinal ranking of community income provided by NIS in quartiles by ranking the patients' home zip code from 1 to 4 based on national zip code median income.

Comorbidities were measured via calculated CCI from the NIS provided comorbidities. Urban/rural status was based on the core-based statistical area as defined by the US Office of Management and Budget. Hospitals in "metropolitan" counties defined as urban and hospitals with a core-based statistical area type of "micropolitan" or "noncore" defined as rural. Since 2012, NIS does not disclose the state of the admitting hospital.

Statistical Analysis

The study exploited the implied experimental nature of the 2014 ACA OE expansion and used DID analyses to evaluate

differential changes in outcomes in the insured group (private, MCD, or other) with the uninsured (self-pay) group. Difference in differences was used to examine the difference in risk-adjusted mortality, risk-adjusted complications, and risk-adjusted calculated hospital costs.

All models were weighted to account for variations in sampling and clustering of patients within systems. Analyses were conducted using IBM SPSS Statistics 24 (IBM Corp., Armonk, NY). Two-sided p values less than 0.05 were considered significant. The study was exempted from further review by the University of California San Diego Human Research Protections Program and conducted in accordance with the data use agreement for the Nationwide Databases from the Healthcare Cost and Utilization Project Agency for Healthcare Research and Quality.

Risk Adjustment

Multivariate analyses were performed controlling for patient and hospital-level factors including patient age, sex, race/ethnicity, comorbidities using the CCI, hospital type, and median income quartile by zip code. Race/ethnicity was included as a covariate in analyses examining changes in outcomes. Cohorts were stratified as being either non-Hispanic White or non-White. Hospital type was classified as either rural, urban teaching, or urban nonteaching.

The primary independent variable of interest was the intervention group (insured) versus the control group (uninsured) before and after the 2014 ACA expansion.

Sensitivity Analyses

To determine the appropriateness of using the DID model, two separate analyses were performed. To ensure parallel trends in study outcomes before the pre-ACA OE period (2012 and 2013 only), a DID analysis of insured and uninsured groups was performed. To detect nonparallel trends in other payer groups, a second DID analysis was performed on Medicare patients 18 to 64 years was performed during the study period.

RESULTS

A total of 275,425 EGS admissions with ages between 18 and 64 years were included in the study, representing a weighted NIS sample from 1,377,125 EGS admissions, with a mean (SD) age of 43 (13) years. About 56.4% were female, and the median CCI was 2 (range, 1–16).

Table 1 demonstrates the demographics of the study population. There was a gradual decrease in EGS admissions, with 97,674 and 91,888 EGS admissions in pre-ACA OE years 2012 and 2013, respectively, and 85,863 in post-ACA OE 2014. In the post-ACA OE period, there was a significant increase in admissions with MCD (9.9% vs 26.3%, $p < 0.001$) and a significant reduction in self-pay (uninsured) patients (35.8% vs 12.3%, $p < 0.001$). Appendectomy (76,425) and cholecystectomy (105,557) were the two most commonly performed procedures over the entire study period.

The univariate analysis for the outcomes of the study population by payer before risk adjustment is shown in Table 2 and Figure 2. Overall mortality did not change significantly, from 0.9% (n = 895) in 2012, 0.9% (n = 810) in 2013, and 1.0% (n = 895) in 2014. Mortality did increase significantly in the self-pay groups but decreased significantly in the MCD group. Overall admissions with complications increased annually and also increased annually in each of the private, self-pay, and MCD groups. Overall mean LOS (SD) increased yearly, from 5.24 (8.7) days in 2012, 5.35 (8.5) days in 2013, to 5.68(9.1)

TABLE 1. Comparison of 18- to 64-Year-Old EGS Eligible Patient Demographics Before and After Implementation of the 2014 ACA OE

	Pre-ACA OE*		Post-ACA OE	
Calendar Year	**2012**	**2013**	**2014**	***p*****
Population	97,674	91,888	85,863	<0.001
Mean age (SD), y	42.74 (13.52)	43.12 (13.45)	43.61 (13.41)	<0.001
Sex, %				
Male	43.4	43.4	43.9	<0.001
Female	56.6	56.6	56.1	
Race/ethnicity				
White	56,923	52,532	48,386	<0.001
Black	10,519	10,423	9,952	<0.001
Hispanic	18,526	18,145	17,430	<0.001
Asian or Pacific Islander	2,501	2,422	2,375	<0.001
Native American	832	675	611	<0.001
Other	4,001	3,359	3,251	
Patient comorbidities (CCI)				
None	72,002	67,188	61,043	<0.001
≥1	25,672	24,700	24,820	
Insurance payor				
MCD	19,174	18,495	22,615	<0.001
Private insurance	51,441	47,213	44,180	<0.001
Self-pay	15,825	14,938	10,630	<0.001
No charge	1,286	1,830	1,163	<0.001
Other	5,576	5,080	3,417	<0.001
Type of surgery				
Appendectomy	28,877	25,517	22,031	<0.001
Cholecystectomy	37,000	35,365	33,192	0.044
Hernia repair	6,791	7,024	6,647	<0.001
Bowel resection	14,497	13,087	13,274	<0.001
Zip income quartile, %				
Upper half	46.7	46.1	43.2	<0.001
Lower half	53.3	53.9	56.8	
Facility characteristics				
Rural	9,490	8,561	6,682	<0.001
Urban nonteaching	42,424	38,987	25,746	<0.001
Urban teaching	45,760	44,340	53,435	<0.001
Facility census division				
New England	4,661	3,970	3,357	<0.001
Mid-Atlantic	15,038	13,792	12,722	<0.001
East North Central	12,278	11,711	10,851	<0.001
West North Central	5,319	4,899	4,538	<0.001
South Atlantic	18,726	17,836	16,973	<0.001
East South Central	5,075	4,969	4,753	<0.001
West South Central	11,954	11,693	10,915	<0.001
Mountain	6,961	6,412	5,824	<0.001
Pacific	17,662	16,606	15,930	<0.001

*Pre-ACA OE is years 2012 to 2013; post-ACA OE is year 2014.
**p Calculated for the combined pre-ACA OE years versus post-ACA OE year.

TABLE 2. Unadjusted Mortality, Complications, and Costs of 18 to 64-Year-Old EGS Patient Demographics Before and After Implementation of the 2014 ACA OE

	Pre-ACA OE*		Post-ACA OE	
	2012	2013	2014	*p***
Unadjusted mortality, %				
MCD	1.45	1.44	1.32	<0.001
Private insurance	0.78	0.70	0.85	<0.001
Self-pay	0.83	0.80	1.23	<0.001
Complications, %				
MCD	21.6	23.0	24.1	<0.001
Private insurance	20.0	20.8	23.2	<0.001
Self-pay	16.1	18.0	19.6	<0.001
Hospital length of stay, mean (SD), d				
MCD	6.5 (11.6)	6.6 (11.4)	6.5 (11.3)	0.477
Private insurance	4.92 (7.8)	5.0 (7.6)	5.4 (8.3)	<0.001
Self-pay	4.63 (7.0)	4.69 (7.2)	4.9 (7.2)	<0.001
Median wage-index adjusted costs, US $ (IQR)				
MCD	11,612 (6,668–21,321)	12,653 (7,233–22,997)	13,685 (7,995–24,824)	<0.001
Private insurance	10,285 (6,166–18,038)	11,115 (6,686–19,420)	12,088 (7,319–21,374)	<0.001
Self-pay	9,594 (5,880–16,488)	10,360 (6,314–17,589)	10,937 (6,708–18,705)	<0.001

*Pre-ACA OE is years 2012 to 2013; post-ACA OE is year 2014.
**p Calculated for the combined pre-ACA OE years and post-ACA OE year.
IQR, interquartile range.

days in 2014 ($p < 0.001$). Mean LOS (SD) also increased significantly every year in the private and self-pay group, but not in the MCD group. Median wage-index adjusted costs (interquartile range) increased overall and in all payer groups annually from US $10,469 (6,217–18,509) in 2012, US $11,344 (6,751–20,064) in 2013, and US $12,371 (7,384–22,043) in 2014.

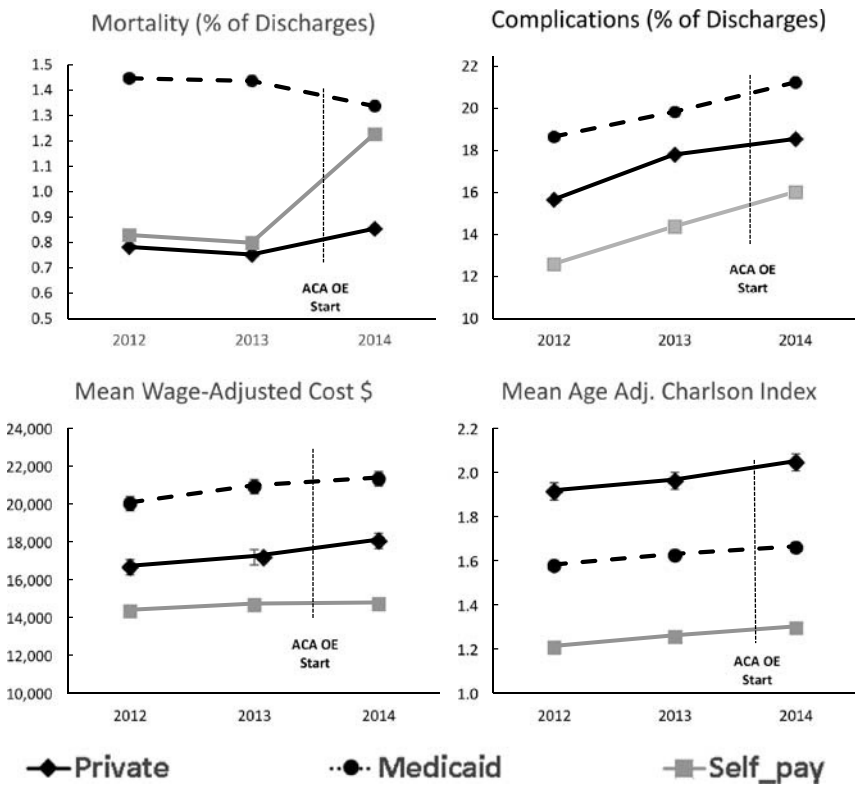

Figure 2. Unadjusted mortality, complications, mean wage-adjusted costs, and CCI of age 18 to 64 years EGS Discharges 2012 to 2014.

TABLE 3. Complication Rates by Procedure Pre-ACA OE Versus Post-ACA OE

	Pre-ACA OE†		Post-ACA OE		
	Complications	**No Complications**	**Complications**	**No Complications**	***p***
Appendectomy (%)	6,607 (7.1)	86,909 (92.9)	3,525 (9.0)	35,521 (91.0)	<0.001*
Cholecystectomy (%)	23,414 (17.1)	113,079 (82.9)	12,374 (19.6)	50,887 (80.4)	<0.001*
Bowel resection (%)	53,275 (40.1)	79,536 (59.9)	25,228 (40.3)	37,320 (59.7)	<0.001*
Hernia (%)	1,421 (18.1)	64,223 (81.9)	7,273 (19.2)	30,654 (80.8)	<0.001*

*$p < 0.001$ between pre-ACA OE and post-ACA OE.
†Pre-ACA OE is years 2012 to 2013; post-ACA OE is year 2014.

Complications by procedure type are shown in Table 3. There was a significant increase by univariate analysis in all pre-ACA OE and post-ACA OE admissions with complications for appendectomy (7.1% vs 9.0%, $p < 0.001$), cholecystectomy (17.1% vs 19.6%, $p < 0.001$), bowel resections (40.1% vs 40.3%, $p < 0.001$), and hernia repair (18.1% vs 19.2%, $p < 0.001$).

An analysis of subpopulation changes with risk-adjusted estimates for the pre-ACA and post-ACA periods is shown in Table 2 of Supplementary Material (see Supplemental Digital Content 1, http://links.lww.com/TA/B68). During the pre-ACA period, all age groups had higher rates of uninsured status, with age 18 to 44 years having the highest uninsured rates in the analysis (19.4%). In the post-ACA period, the largest reduction in lack of insurance coverage was in the 18 to 25 years age group (18.4–15.5%, $p < 0.001$), but there were significant reductions in uninsured rates in all age groups.

Males were more likely than females to be self-pay in the pre-ACA period (19.2% vs 14.8%), and both had a significant decrease in self-pay status in the post-ACA period (14.8% vs 11.1%, $p < 0.001$). Non-Hispanic Whites were more likely than non-Whites to be self-pay in the pre-ACA period (13.7% vs 20.9%, $p < 0.001$), with both groups seeing a significant decrease in self-pay rates in the post-ACA period (10.3% vs 15.8%, $p < 0.001$). Emergency general surgery admissions with comorbidities were more likely than those without comorbidities to be self-pay (13.5% vs 17.8%, $p < 0.001$). In both groups, there was a significant decrease in self-pay rates in the post-ACA period (15.8% vs 10.0%, $p < 0.001$). In the pre-ACA OE, admissions from the top half of median income quartiles (high-income) defined by zip code were much less likely to be self-pay than the low-income group (8.6% vs 20.6%, $p < 0.001$), but both groups had a significant decrease in self-pay rates (2.6% vs 15.6%, $p < 0.001$). There were also significant post-ACA decreases in self-pay patients for EGS admissions at urban and rural facilities and at teaching and nonteaching facilities.

Admissions with one or more complications significantly increased in both payer groups during the ACA implementation, with the largest increases observed in urban facilities (16.6% vs 19.3%, $p < 0.001$) and in males (20.0% vs 23.6%, $p < 0.001$).

Table 4 and Figure 3 show the changes in payer status of admissions at rural, urban nonteaching, and urban teaching facilities during the study period. There was a reduction in overall EGS admissions at rural and urban nonteaching facilities. Post-ACA OE EGS admissions decreased from mean pre-ACA OE admissions by 3,510 rural (25.0%, $p < 0.001$) and 14,053 urban nonteaching (27.6%, $p < 0.001$) admissions, respectively. Urban-teaching facilities had an increase of 14,746 (18.4%, $p < 0.001$) post-ACA OE EGS admissions. There was a reduction in overall self- pay admissions post-ACA OE at all hospital types. This was greater at rural and urban nonteaching facilities, with 999 (44.5%) and 3,741 (50.9%), respectively, fewer self-pay post-ACA OE admissions. A smaller reduction in self-pay post-ACA OE EGS admissions was observed at urban teaching facilities, which decreased by 988 (10.5%, $p < 0.001$) admissions. Medicaid EGS volume also decreased at private and urban nonteaching facilities in the post-ACA OE period, with 211 (6.6%) rural and 2,324 (19.5%) fewer urban nonteaching admissions. Meanwhile, MCD EGS admissions increased significantly at urban teaching facilities, by 6,985 (35%, $p < 0.001$) admissions in the post-ACA OE period.

Table 5 shows the impact of the ACA expansion on EGS admissions, mortality, complications, and mean wage-index adjusted costs. There was an overall 4.0% decrease in self-pay EGS admissions after the ACA expansion. Using risk-adjusted DID estimates, there was a small but significant attributable decrease in mortality in insured patients compared with self-pay patients (−0.12%, $p = 0.034$). Complications increased in both insured and self-pay groups, but more rapidly in the insured group, with the risk-adjusted DID increasing by +1.4 percentage points ($p = 0.009$). An increase in mean wage-index adjusted costs was observed in both insured and self-pay groups, but it was more rapid in the insured group. The risk-adjusted DID in

TABLE 4. Teaching Status and Payor Status of EGS Admissions 2012 to 2014

		Payor Status			
Year	**Teaching Status**	**Private**	**MCD**	**Self-pay**	***p***
2012	Rural	9,035	3,394	2,351	<0.001*†‡
	Urban, nonteaching	26,522	12,342	7,686	<0.001*†‡
	Urban teaching	52,242	19,938	9,489	<0.001*†‡
2013	Rural	8,077	3,017	2,130	<0.001*†‡
	Urban, nonteaching	36,686	11,444	7,002	<0.001*†‡
	Urban teaching	49,800	19,647	9,254	<0.001*†‡
2014	Rural	6,255	2,995	1,242	<0.001*†‡
	Urban, nonteaching	23,616	9,569	3,603	<0.001*†‡
	Urban teaching	59,769	26,778	8,384	<0.001*†‡

*$p < 0.001$ between teaching status.
†$p < 0.001$ between years.
‡$p < 0.001$ between payor status.

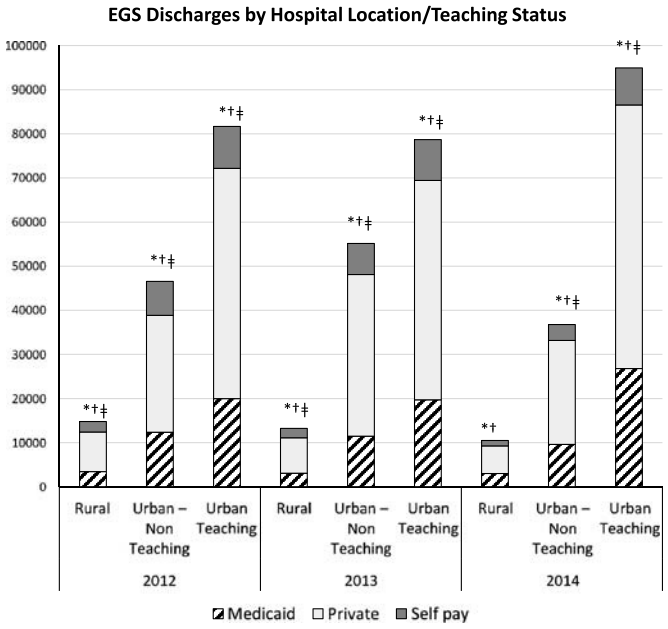

Figure 3. Age 18 to 64 years EGS discharges by payor status and hospital location/teaching status (*$p < 0.001$ between teaching status, †$p < 0.001$ between years, ‡$p < 0.001$ between payor status).

mean wage-index adjusted costs between the self-pay and insured groups was 4.6% ($p < 0.001$).

Sensitivity analysis demonstrated parallel trends in study outcomes only during the pre-ACA OE period. Parallel outcome trends on Medicare patients under 18 years and over 64 years old during the study period were also observed (see Table 1, Supplemental Digital Content 1, http://links.lww.com/TA/B68).

A number needed to treat calculation is possible using the risk-adjusted DID of −0.12% decreased mortality for the insured group and the pre-ACA mortality of 0.81% in the self-pay group in Table 5. The number of insured EGS admissions during the ACA OE expansion required to save one life is estimated to be 833.

DISCUSSION

Our analysis of the largest nationwide all-payer database demonstrates that, in the first full year of the ACA OE, there was a significant improvement in insurance coverage for EGS patients although about 1 in 10 still failed to gain insurance. Overall mortality was not affected by the ACA OE; however, subgroup analysis demonstrated a modest but significant reduction in mortality for the insured compared with a significant increase in mortality for the uninsured.

In addition, costs and complications increased for insured EGS admissions more than in uninsured admissions. Although overall admissions for EGS procedures decreased after the ACA OE, urban teaching hospitals had a significant increase in EGS admissions while these decreased at rural and urban nonteaching hospitals. Similarly, MCD admissions increased at urban teaching hospitals and decreased at rural and urban nonteaching hospitals.

The association between the expansion in insurance coverage and decreased mortality is consistent with prior studies of insurance policy changes.[7,10] Although the number needed to treat of 883 to save a life may seem like a modest effect, it is comparable with many accepted interventions in health care policy, including mortality reduction from state MCD expansion.[11] Although, without a change in overall mortality, this finding likely represents an altered risk profile among the subgroups, shifting low-risk patients from the uninsured to the insured group.

Citizens who did not enroll in ACA OE may have barriers such as poor health care knowledge, mistrust of authorities, behavioral or social issues, language or geographic isolation, and lack of internet access, literacy, or transportation.[30] Decreased mortality for insured patients may also be secondary to them presenting earlier, perhaps with less complex pathology.

Uninsured persons have previously been reported to have a longer duration of symptoms before presentation.[16,17,31] This factor may put these patients at a higher risk for adverse outcomes associated with their delayed presentation.[15,17,32] Nondocumented immigrants are excluded from most ACA coverage, are known to suffer issues with access, and may have a lack of trust of authority, resulting in a delay seeking EGS care.[15,33] Conversely, evidence exists that persons who enroll in the ACA may have healthier behaviors.[34]

Costs and complications are increasing in EGS. Costs increased for all patients, but more so for insured versus self-pay patients. Uninsured EGS patients may have lower costs because of inability to pay, shorter LOS or facility-imposed limits on care. There are multiple possible explanations for the increase

TABLE 5. Impact of the ACA OE on Rates of Admissions and Outcomes in EGS Patients

	Self-pay			Insured					
	Pre-ACA OE†	Post-ACA OE	Change	Pre-ACA OE	Post-ACA OE	Change	Unadjusted DID*	Adjusted DID**	*p* for Between-Group Differences
Admissions, %‡	16.7	12.7	−4.0	83.3	87.3	4.0	—	—	
Mortality, %	0.81	1.22	0.41	0.92	1.06	0.14	−0.27	−0.12	0.034
Complications, %	17.0	19.6	2.6	20.9	23.6	3.7	1.1	1.4	0.009
Wage-index adjusted costs, mean, US $	15,929	17,463	1,509 (9.4%)	19,834	22,649	2,815 (14.2%)	4.7	4.6	<0.001

*DID, calculated by subtracting the pre-ACA/post-ACA OE difference of the Uninsured Group from the Insured Group.

**Risk-adjusted for patient factors (age, sex, race, comorbidities, zip code income, urban/rural status) and hospital factors (teaching status, census region).

†Pre-ACA OE is mean of years 2012 to 2013; post-ACA OE is year 2014.

‡Using NIS-provided discharge weights, the discharge-weighted population represented is 79,170 pre-ACA OE self-pay patients, 54,600 post-ACA OE self-pay patients, 394,745 pre-ACA OE insured patients, and 374,715 post-ACA OE insured patients.

in complications. First, this may be because of increased attention on reporting complications as MCD admissions increase, with state-mandated complication reporting requirements. Second, EGS is often the only means to operate on the uninsured, whose higher risk of mortality likely also means increased complications. The newly insured population with improved access to elective surgery via a primary care doctor and specialty referral[35,36] may filter out less complex and lower-risk patients from EGS, increasing complications for the patients left undergoing EGS. Lastly, the overall increased complication rate may be related to EGS patients having more comorbidities, supported by our study findings of an increased incidence in admissions with a CCI ≥ 1 over the study period.

Urban teaching hospitals saw the largest increase in EGS admissions and MCD patients with the smallest decrease in uninsured patients compared with urban nonteaching and rural hospitals. This is not entirely unexpected since many teaching hospitals expanded ambulatory care in anticipation of the ACA OE to solicit these patients in anticipation of increased demand.[37–39] In addition, the insurance coverage available on the health insurance marketplaces has been criticized for leaving patients underinsured and with narrow networks. It may be that urban teaching centers are the only facilities that will accept this limited insurance coverage. The increased emergency department utilization and admissions after MCD and ACA OE have been identified in prior studies, so it is perhaps not surprising this effect exists for EGS patients as well.[22,23]

This study has some limitations. Healthcare Cost and Utilization Project's NIS is an administrative database that has potential for coding errors; however, our results are consistent with previous Healthcare Cost and Utilization Project's NIS studies looking at insurance and surgical outcomes.[11,12] In addition, the implied experimental design identifies an effect, but it is possible that there are other confounding factors that occurred in 2014 not identified by the study. We also identified 2014 as the start of the ACA OE, but the OE launch was not uniform across all states. Since 2012, NIS deliberately excluded state identifying data, making it impossible to select for states that implemented the ACA during the study period, which probably diluted the measured effects of the ACA OE. There are known differences in ACA OE implementation between states, many of which did not expand MCD in 2014 or already had expanded Medicare in previous years.[40,41] In addition, while January 1, 2014 was the date of a significant reduction in lack of insurance coverage, some reductions had started earlier, such as the 2010 Dependent Coverage Provision for those 18 to 25 years old. The health insurance marketplaces opened in October 2013 with some difficulties in consumer access at first and various state MCD expansions continued before, during, and after the study period.

In conclusion, the official launch of the ACA OE had an anticipated change on the landscape of health care by decreasing the number of uninsured Americans. We assert that this policy reduced EGS admissions by allowing patients with nonurgent or emergent pathology to be cared for electively, as reflected in increasing cost and complications for EGS. In addition, a "moving of the deck chairs on the Health Insurance Titanic" may have occurred. Younger and healthier citizens gained insurance and diluted the existing higher-risk insured group patients, decreasing mortality rates. Meanwhile, higher-risk patients were left behind in the uninsured group, increasing mortality rates. We recommend a national EGS outcomes database that can better define the effects of health care policy changes on EGS patient processes and outcomes. This would allow EGS investigators and surgeons to improve outcomes for our patients at the bedside and advocate for better EGS patient policy at our state and national Capitols.

AUTHORSHIP

M.H. performed the literature search, study design, data collection, data analysis, data interpretation, and writing. L.N.G. performed the writing and critical revision. R.C. performed the critical revision. J.D. performed the literature search, study design, data collection, data analysis, data interpretation, writing, and critical revision.

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DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Vistnes JP, Lipton BJ. The Uninsured in America: Estimates of the Percentage of Non-Elderly Adults Uninsured throughout Each Calendar Year, by Selected Population Subgroups and State Medicaid Expansion Status: 2013 and 2014. 2016 Jun. Statistical Brief (Medical Expenditure Panel Survey (US) [Internet]. Rockville, MD: Agency for Healthcare Research and Quality (US); 2001. Statistical Brief #488. Available at: http://www.ncbi.nlm.nih.gov/books/NBK447195/. Accessed February 2, 2017.
2. Obama B. United States health care reform: progress to date and next steps. *JAMA*. 2016;316(5):525–532.
3. Skinner J, Chandra A. The past and future of the Affordable Care Act. *JAMA*. 2016;316(5):497–499.
4. Butler SM. The future of the Affordable Care Act: reassessment and revision. *JAMA*. 2016;316(5):495–497.
5. Bauchner H. The Affordable Care Act and the future of US health care. *JAMA*. 2016;316(5):492–493.
6. Dalen JE, Waterbrook K, Alpert JS. Why do so many Americans oppose the Affordable Care Act? *Am J Med*. 2015;128(8):807–810.
7. Sommers BD, Gawande AA, Baicker K. Health insurance coverage and health — what the recent evidence tells us. *N Engl J Med*. 2017;377(6):586–593.
8. Ayanian JZ, Weissman JS, Schneider EC, Ginsburg JA, Zaslavsky AM. Unmet health needs of uninsured adults in the United States. *JAMA*. 2000;284(16):2061–2069.
9. Newton MF, Keirns CC, Cunningham R, Hayward RA, Stanley R. Uninsured adults presenting to us emergency departments: assumptions vs data. *JAMA*. 2008;300(16):1914–1924.
10. Finkelstein A, Taubman S, Wright B, Bernstein M, Gruber J, Newhouse JP, Allen H, Baicker K. Oregon Health Study Group. The Oregon health insurance experiment: evidence from the first year. *Q J Econ*. 2012;127(3):1057–1106.
11. Sommers BD. State Medicaid expansions and mortality, revisited: a cost-benefit analysis. *Am J Health Econ*. 2017;3(3):392–421.
12. Sommers BD, Long SK, Baicker K. Changes in mortality after Massachusetts health care reform: a quasi-experimental study. *Ann Intern Med*. 2014;160(9):585–593.
13. Advisers CoE. The Economic Record of The Obama Administration: Reforming The Health Care System [PDF]. Washington, DC. 2016. Available at: https://obamawhitehouse.archives.gov/sites/default/files/page/files/20161213_cea_record_healh_care_reform.pdf. Accessed February 2, 2017.
14. Ho VP, Nash GM, Feldman EN, Trencheva K, Milsom JW, Lee SW. Insurance but not race is associated with diverticulitis mortality in a statewide database. *Dis Colon Rectum*. 2011;54(5):559–565.
15. Bickell NA, Hwang U, Anderson RM, Rojas M, Barsky CL. What affects time to care in emergency room appendicitis patients? *Med Care*. 2008;46(4):417–422.

16. Shah AA, Haider AH, Zogg CK, Schwartz DA, Haut ER, Zafar SN, Schneider EB, Velopulos CG, Shafi S, Zafar H, et al. National estimates of predictors of outcomes for emergency general surgery. *J Trauma Acute Care Surg*. 2015;78(3):482–490. discussion 490–1.
17. Scott JW, Rose JA, Tsai TC, Zogg CK, Shrime MG, Sommers BD, Salim A, Haider AH. Impact of ACA insurance coverage expansion on perforated appendix rates among young adults. *Med Care*. 2016;54(9):818–826.
18. Loehrer AP, Chang DC, Hutter MM, Song Z, Lillemoe KD, Warshaw AL, Ferrone CR. Health insurance expansion and treatment of pancreatic cancer: does increased access lead to improved care? *J Am Coll Surg*. 2015;221(6): 1015–1022.
19. Loehrer AP, Song Z, Haynes AB, Chang DC, Hutter MM, Mullen JT. Impact of health insurance expansion on the treatment of colorectal cancer. *J Clin Oncol*. 2016;34(34):4110–4115.
20. Loehrer AP, Song Z, Auchincloss HG, Hutter MM. Influence of health insurance expansion on disparities in the treatment of acute cholecystitis. *Ann Surg*. 2015;262(1):139–145.
21. Loehrer AP, Murthy SS, Song Z, Lubitz CC, James BC. Association of insurance expansion with surgical management of thyroid cancer. *JAMA Surg*. 2017;152(8):734–740.
22. Barakat MT, Mithal A, Huang RJ, Mithal A, Sehgal A, Banerjee S, Singh G. Affordable Care Act and healthcare delivery: a comparison of California and Florida hospitals and emergency departments. *PLoS One*. 2017;12(8): e0182346.
23. Dresden SM, Powell ES, Kang R, McHugh M, Cooper AJ, Feinglass J. Increased emergency department use in Illinois after implementation of the patient protection and Affordable Care Act. *Ann Emerg Med*. 2017; 69(2):172–180.
24. Dall T, Chakrabarti R, Iacobucci W. The Complexities of Physician Supply and Demand: Projections 2014 through 2025. 2016 Update. Washington, DC. Association of American Medical Colleges. 2016. Available at: https:// www.aamc.org/download/458082/data/2016_complexities_of_supply_and_ demand_proje ctions.pdf. Accessed February 2, 2017.
25. Scott JW, Havens JM, Wolf LL, Zogg CK, Rose JA, Salim A, Haider AH. Insurance status is associated with complex presentation among emergency general surgery patients. *Surgery*. 2017;161(2):320–328.
26. Project HCUP. Overview of the National (Nationwide) Inpatient Sample (NIS). Rockville, MD. Agency for Healthcare Research and Quality. 2017. Available at: https://www.hcup-us.ahrq.gov/nisoverview.jsp. Accessed March 22, 2017.
27. Houchens RL, Elixhauser A, Jiang J. Nationwide Inpatient Sample Redesign Final Report Rockville, MD: U.S. Agency for Healthcare Research and Quality. 2014. Available at: http://www.hcupus.ahrq.gov/db/nation/nis/ nisrelatedreports.jsp. Accessed March 30, 2017.
28. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–383.
29. Project HCUP. Cost-to-Charge Ratio Files Rockville, MD: U.S. Agency for Healthcare Research and Quality. 2017. Available at: https://www.hcup-us. ahrq.gov/db/state/costtocharge.jsp. Accessed May 23, 2017.
30. Gordon PR, Gray L, Hollingsworth A, Shapiro EC, Dalen JE. Opposition to Obamacare: a closer look. *Acad Med*. 2017;92:1241–1247.
31. Lidor AO, Gearhart SL, Wu AW, Chang DC. Effect of race and insurance status on presentation, treatment, and mortality in patients undergoing surgery for diverticulitis. *Arch Surg*. 2008;143(12):1160–1165; discussion 1165.
32. Sabik LM, Dahman BA. Trends in care for uninsured adults and disparities in care by insurance status. *Med Care Res Rev*. 2012;69(2):215–230.
33. Joseph TD. What health care reform means for immigrants: comparing the Affordable Care Act and Massachusetts health reforms. *J Health Polit Policy Law*. 2016;41(1):101–116.
34. Breslau J, Stein BD, Han B, Shelton S, Yu H. Impact of the Affordable Care Act's dependent coverage expansion on the health care and health status of young adults: what do we know so far? *Med Care Res Rev*. 2016. doi: 10. 1177/1077558716682171.
35. Sommers BD, Simon K. Health insurance and emergency department use — a complex relationship. *N Engl J Med*. 2017;376(18):1708–1711.
36. Candon M, Polsky D, Saloner B, Wissoker D, Hempstead K, Kenney GM, Rhodes K. Primary care appointment availability and the ACA insurance expansions. *LDI Issue Brief*. 2017;21(5):1–4.
37. Zafar SN, Shah AA, Hashmi ZG, Efron DT, Haut ER, Schneider EB, Schwartz D, Velopulos CG, Cornwell EE 3rd, Haider AH. Outcomes after emergency general surgery at teaching versus nonteaching hospitals. *J Trauma Acute Care Surg*. 2015;78(1):69–76; discussion 76–7.
38. Chokshi DA, Chang JE, Wilson RM. Health reform and the changing safety net in the United States. *N Engl J Med*. 2016;375(18):1790–1796.
39. Coughlin TA, Long SK, Sheen E, Tolbert J. How five leading safety-net hospitals are preparing for the challenges and opportunities of health care reform. *Health Aff (Millwood)*. 2012;31(8):1690–1697.
40. McIntyre A, Joseph AM, Bagley N. Small change, big consequences — partial Medicaid expansions under the ACA. *N Engl J Med*. 2017;377(11):1004–1006.
41. Sommers BD, Epstein AM. Red-state medicaid expansions — Achilles' heel of ACA repeal? *N Engl J Med*. 2017;376(6):e7.

DISCUSSION

Dr. John A. Harvin (Houston, Texas): I would like to thank the AAST Program Committee for the opportunity to discuss this work.

Dr. Hamel and coauthors have undertaken a daunting task: to assess the effect of the 2014 implementation of the Affordable Care Act on mortality and morbidity in 2012 to 2014.

Using a large national database and elegant statistical methodology, the authors found an increase in insurance coverage for EGS patients. They found a significant reduction in mortality in insured patients and a significant increase in both costs and complications of self-pay in insured patients.

This is a very complex issue and I think quantifying the effect of the ACA and its magnitude is quite difficult. I have three comments and questions.

First, while you found significant changes in mortality within groups of payer status, the overall mortality was unaffected by the implementation of the ACA. If that is true, if the overall mortality is not affected but individual payer status mortality rates are affected, are we simply reshuffling chairs on the deck?

Second, one of the limitations of the Nationwide Inpatient Sample is that it does not contain information regarding the state in which the hospital is located. Disparities in health outcome exists both between states and within states. And this could lead to systematic differences in the health outcomes between states that expanded Medicaid and states that did not.

These differences cannot be accounted for in your model because the state data doesn't exist. Can you comment on how that lack of state data may affect or influence the results of your project?

And, lastly, any intervention can have both beneficial results and unintended consequences. While your analysis found a negative, a risk-adjusted difference in mortality of .12 percent, it also found an increase in complications in insured patients of 1.4 percent. If the number needed to treat for providing insurance is 833, then by my calculation the number needed to harm is 71.

I think one of the most significant findings of your work is this increasing rate of complications. Do you have any plans to delve more deeply into this disturbing trend?

Dr. Jose J. Diaz (Baltimore, Maryland): Jose Diaz, Baltimore. Very nice presentation. Reflects a lot of some of what we have looked at as well as our opinions.

A couple of questions. Why do you think that the NIS actually under-estimated the degree of age? Most of the other

statewide registries tends to put the average age of the EGS population almost 10 years older. That may actually reflect some of your outcomes.

The other is what we also have continued to see is increased costs of trauma centers and one of the things that I did not see in your presentation is transfers as that probably is what is reflecting the increased costs of care of this patient population in trauma centers.

Dr. Walter L. Biffl (Honolulu, Hawaii): That was a really nice presentation and I have one question and a couple of comments.

The question is you adjusted for Charlson Comorbidity Scores in the outcome analyses but were they different populations of patients who remain self-pay versus those who got insurance? For example, the homeless alcoholic might have been less likely to sign up for the ACA.

The comments are two. One, we have heard about half-a-dozen papers on the variability and outcomes of EGS and I think the EQIP concept is critical.

Regarding the costs, I think this is something that we really need to pay attention to. In my institution, just for the example of gallstone disease, there is tremendous variability in care and not everybody with a bilirubin 1.5 needs a GI consult and an MRCP and two extra days in the hospital. And I think it's up to us to standardize the care and try to control these costs, ourselves.

Dr. Michelle Hamel (San Diego, California): Thank you so much, Dr. Harvin, and the other questions. Thank you for your kind words and your insightful comments.

Dr. Harvin, I will address your questions first. In regards to your question about changes in mortality among insured versus uninsured patients without an overall change in mortality, first off, our initial hypothesis was that patients with insurance would present earlier without fear of financial repercussions of an uninsured hospital admission and, therefore, would have better outcomes and decreased mortality.

Of course it may be difficult to demonstrate decreased mortality since EGS mortality is fairly low to begin with.

In terms of the differences in mortality between insured versus uninsured patients and no change in overall mortality, yes, there is a concern that this may not be an effective insurance but, rather, perhaps, a shifting of patients between the groups.

Perhaps the self-pay group before the ACA was a heterogeneous mix of high-risk and low-risk patients. Of course, this is speculation.

In the uninsured group before the ACA there were likely young, healthy people that didn't get insurance because they don't use it. There were also probably low-income patients that didn't get insurance because they couldn't afford it which, obviously, the ACA intended to benefit those patients.

But perhaps there was an additional component of the self-pay group that's at high-risk for mortality for reasons unknown.

Are they not citizens and can't access health care or have a distrust of authorities? Do they lack internet access? Do they lack homes? Or do they lack literacy? Do they have a language barrier? Do they have behavioral or psychiatric issues?

Perhaps some of these patients represent a higher-risk group and when they young, healthy, low-risk patients are selected out this leaves a higher risk group behind, increasing percentage mortality in the self-pay group.

In this study we did adjust for age, race, income, comorbidities, et cetera. But we could not, obviously, control for behavioral factors. And that may be something that makes a difference in mortality for these patients.

Clearly, we need a better data source to really be able to fully elucidate the changes in mortality in EGS with insurance coverage.

In regards to your question about state-level data and the differences in the way the states implemented the Medicaid expansion, we, obviously, very much wanted to compare the state-level data but, unfortunately, could not since, as you pointed out, this information is not available in NIS.

This is definitely a limitation of this study. I think state-level data would be very interesting and, obviously, would be very useful in the political arena. But it may actually yield more accurate results. And, again, this is something that an EGS outcomes registry would be very helpful for.

In regards to your question about increased complications, we were very surprised by that finding. This is happening in all groups, regardless of insurance status.

Again, complications increased at a higher rate in insured patients. But complications in uninsured patients are increasing, as well. It's out hope that perhaps this is secondary to increased reporting rather than a true increase in complications in EGS.

There has been much more attention paid to reporting complications and, of course, Medicaid patients have state-mandated reporting requirements.

If the increased complication rate is secondary to increased reporting, the complication rate should level off at some point, when everyone is compliant with reporting.

But another possibility for the increase in complications is, perhaps, our EGS patients are higher-risk. EGS procedures are decreasing as a whole and maybe we're selecting out higher-risk patients.

There is more focus on non-operative management, such as antibiotic-only treatment of appendicitis or use of percutaneous cholecystostomy tubes to avoid emergency cholecystectomy in high-risk cases.

Then if surgery is needed, it can be done in an elective fashion so the patients that are being operated on may be actually at higher-risk for complications.

Additionally – I didn't show this data. There was also a question about Charleson Comorbidity Index, we did look at that. And EGS patients, indeed, do have a higher incidence of comorbidities. So specifically EGS patients may be at a higher risk for complications.

The increase in complications, indeed, is a disturbing trend and certainly has implications for pay-for-performance reimbursement.

So the time is up so I'll stop there. But thank you very much for your attention.

