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Decreased Emergency Cholecystectomy and Case Fatality Rate, Not Explained by Expansion of Medicaid

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ABSTRACT

Introduction: Population data on longitudinal trends for cholecystectomies and their outcomes are scarce. We evaluated the incidence and case fatality rate of emergency and ambulatory cholecystectomies in New Jersey (NJ) and whether the Medicaid expansion changed trends.

Materials and methods: A retrospective population cohort design was used to study the incidence of cholecystectomies and their case fatality rate from 2009 to 2018. Using linear and logistic regression we explored the trends of incidence and the odds of case fatality after *versus* before the January 1, 2014 Medicaid expansion.

Results: Overall, 93,423 emergency cholecystectomies were performed, with 644 fatalities; 87,239 ambulatory cholecystectomies were performed, with fewer than 10 fatalities. The 2009 to 2018 annual incidence of emergency cholecystectomies dropped markedly from 114.8 to 77.5 per 100,000 NJ population ($P < 0.0001$); ambulatory cholecystectomies increased from 93.5 to 95.6 per 100,000 ($P = 0.053$). The incidence of emergency cholecystectomies dropped more after than before Medicaid expansion ($P < 0.0001$). The odds ratio for case fatality among those undergoing emergency cholecystectomies after *versus* before expansion was 0.85 (95% CI, 0.72-0.99). This decrease in case fatality, apparent only in those over age 65, was not explained by the addition of Medicaid.

Conclusions: A marked decrease in the incidence of emergency cholecystectomies occurred after Medicaid expansion, which was not accounted for by a minimal increase in the incidence of ambulatory cholecystectomies. Case fatality from emergency cholecystectomy decreased over time due to factors other than Medicaid. Further work is needed to reconcile these findings with the previously reported lack of decrease in overall gallstone disease mortality in NJ.

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Introduction

Cholecystectomy for diagnosed symptomatic gallstone disease is the most frequently performed abdominal surgery, totaling nearly 1 million cases in the United States (US) annually.[1,2] It has been previously defined as one of the three most burdensome emergency general surgery procedures because of its high frequency, serious complications, and preventable morbidity and mortality rates.[3,4] A study in one Midwest US state found the case fatality rate of *emergency* cholecystectomy was five times that of *elective* cholecystectomy.[5] This higher mortality of emergency cholecystectomy is very concerning, because 50 to 70% of cholecystectomies performed during acute hospitalization in the US are done as an emergency.[1-3,6-10]

Given the high frequency, the study of the trends of cholecystectomies over time may provide some clues into the epidemiology and prevention of mortality from gallstone disease.[11] A study in New Jersey (NJ) focusing on mortality associated with symptomatic gallstone disease, not specific to just cholecystectomy, found no improvement from 2009 to 2018.[12] The increases or decreases in cholecystectomies and whether trends in emergency cholecystectomies are responsible for this lack of improvement in mortality in the population with gallstone disease are not known. With the uninsured rate dropping by 42% over the second half of this time in NJ due to Medicaid expansion,[13,14] the associated increased access to healthcare could have also resulted in more timely intervention for clinical gallstone disease, with more ambulatory cholecystectomies contributing to a smaller number of emergency cholecystectomies and thus fewer deaths due to surgery.

Our aim was to identify the trends of emergency and ambulatory cholecystectomies and their case fatality rates in NJ. Our *a priori* hypotheses were that the incidence of emergency cholecystectomies would decrease, the incidence of ambulatory cholecystectomies would increase, and the cholecystectomy case fatality rate would not change, with the 2014 Medicaid expansion.

Methods

Study design, period, population, and data source(s)

A 10-y retrospective population cohort study from 2009 to 2018 was conducted to determine the trends in the incidence of emergency and ambulatory cholecystectomies and the rates of fatalities following these cholecystectomies in the state of NJ. The study years were chosen for two 5-y equal state times before and after the Medicaid expansion on January 1, 2014.[15] The 2009 to 2013 pre-expansion period served as a control segment of time and the 2014 to 2018 post-expansion period served as a quasi-experimental segment of time.

NJ inpatients and outpatients of all ages who had cholecystectomies after admission to a hospital by way of the emergency department (ED) or an ambulatory surgery center (ASC) served as our cohorts of interest (Fig. 1). These patients were expected to be at opposite ends of the spectrum of clinical gallstone disease (Fig. 2). Those who require cholecystectomy through the ED were expected to be a high-risk admission group, some of whom had a probable delay in time to diagnosis, presentation, or referral of a gallstone disease surgical condition.[16] Those undergoing cholecystectomy through an ASC, in contrast, were expected to be a low-risk group who had a referral for elective outpatient surgery. We excluded two other groups in the middle of this clinical spectrum of gallstone disease who were expected to be of moderate risk, that is, those who underwent cholecystectomy upon inpatient elective or direct hospital admission,[4,7] with much smaller numbers such that they could not substantively affect the trends we were observing. We also excluded patients with another indication other than gallstone disease for cholecystectomy, for example, trauma.

Counts of cholecystectomies and fatalities following these cholecystectomies came from the Agency for Healthcare Research and Quality - Healthcare Cost and Utilization Project (HCUP) Core files of the NJ State Inpatient Databases (SIDs) and State Ambulatory Surgery and Services Databases (SASDs).[17] The source of these data are hospitals in NJ reporting to the NJ Department of Health using uniform billing information, as required by hospital financing rules in N.J.A.C.8:31B.[18] After receiving these hospital data from the Department of Health, the HCUP initiates quality control procedures for each calendar year and assesses the values of codes as valid, internally consistent, and consistent with established norms.[19] These quality control procedures were in place during the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) era, as well as in the International Classification of Diseases, 10th Revision, procedure coding system (ICD-10-PCS) era. Invalid or inconsistent values and questionable values of the source data are set to special missing and inconsistent values, respectively, which provides the researcher an ability to investigate data anomalies. Systematic problems of the source data are never fixed and missing data are never imputed.

ICD-9 and ICD-10 cholecystectomy codes were used to extract all inpatient cholecystectomy records,[20] open or laparoscopic, complete or partial, and regardless of how many days after admission the cholecystectomy was done (see Supplemental Table 1). Current Procedural Terminology/Healthcare Common Procedure Coding System cholecystectomy codes were used to extract outpatient cholecystectomies.

We used the average of the 2010 and 2020 census according to the US Census Bureau in NJ as a population denominator in calculating incidence.[21] This approach was chosen since the overall population of NJ increased in the decade by only 5.6%, and the census data is a true state population count as opposed to yearly populations that are only estimated.[22,23]

Study measure(s)

Our independent variable was calendar time. Outcome variables were counts of emergency and ambulatory cholecystectomies, defined as any cholecystectomy following hospital

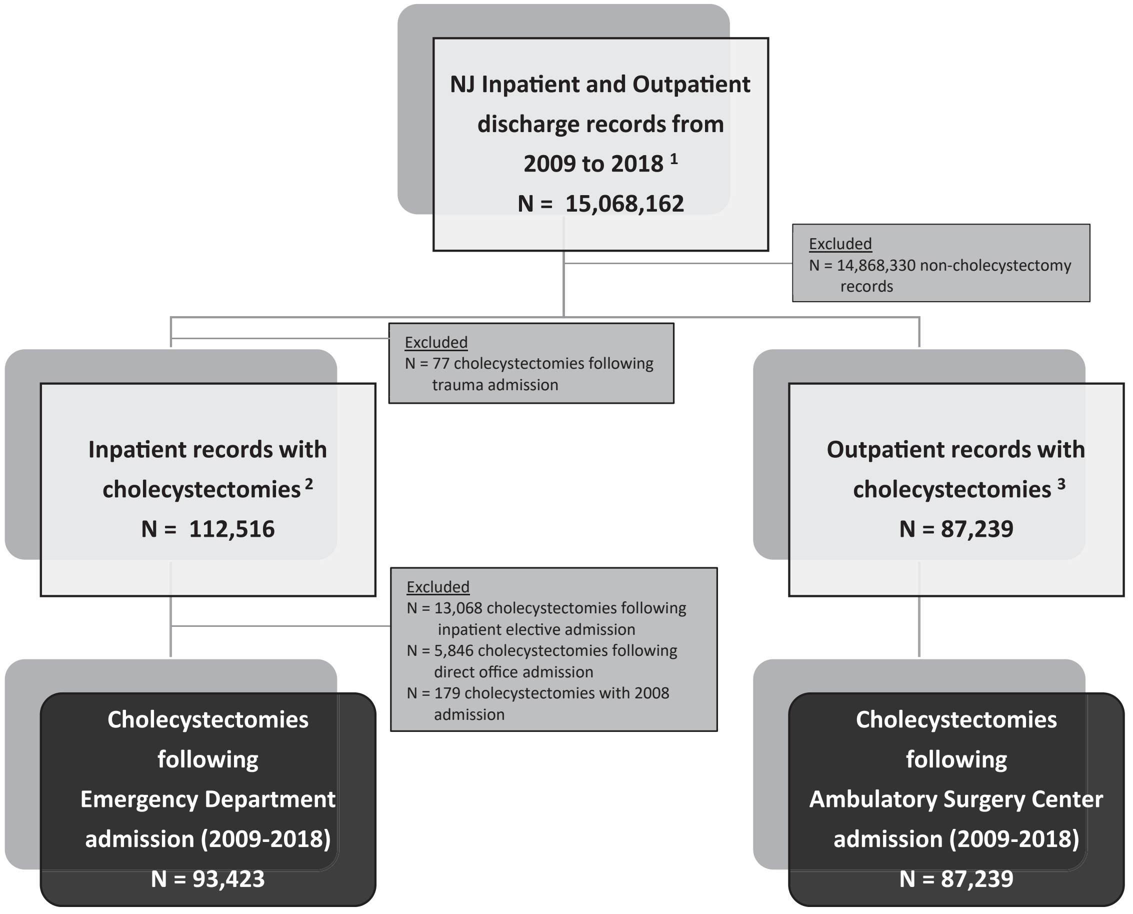

Fig. 1 – Cholecystectomies following Emergency Department and Ambulatory Surgery Center Admission. [1]Determined from the New Jersey (NJ) Agency for Healthcare Research and Quality (AHRQ) – Healthcare Cost and Utilization Project (HCUP) – State Inpatient Databases (SIDs), and State Ambulatory Surgery and Services Databases (SASDs), [2]Inpatient cholecystectomies determined from the NJ SIDs, [3]Outpatient cholecystectomies determined from the NJ SASDs.

admission from the ED and any cholecystectomy following admission to the ASC, respectively. Other outcome variables were counts of all-cause fatalities prior to facility discharge following these cholecystectomies. A fatality was defined as a record with death indicated as the patient's discharge disposition.

Study variable(s)

We collected demographic and clinical information for patients, including age, sex, race or ethnicity, income, insurance, days from admission to the operating room, and length of stay. We categorized age into less than 65 y and greater than

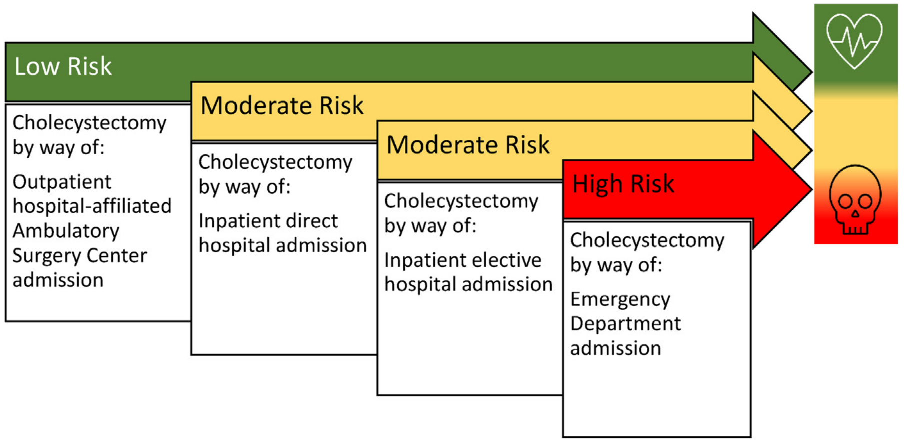

Fig. 2 – The spectrum of patients with clinical gallstone disease who require cholecystectomy.

or equal to 65 y, sex into female and male, race into Black and non-Black, ethnicity into Latino (white-Latino, Black-Latino, Asian-Latino, or other-Latino) and non-Latino, income into the lowest median household income quartile based on the patient's residence zip code and nonlowest income (the highest three quartiles), Medicaid and non-Medicaid, and uninsured and insured.

Analysis

Incidence of emergency and ambulatory cholecystectomies

Twelve monthly counts of emergency and ambulatory cholecystectomy cases were collected for each of the ten study years to create a total of 120 state-month observations of counts. An annual incidence of cholecystectomies per 100,000 NJ population was then determined by dividing the annual cholecystectomy case count by the average population denominator of 9,040,444.[21] Simple linear regression was used to model the slope of annual incidence over the entire 10-y time.

Trends of incidence of emergency and ambulatory cholecystectomies after versus *before expansion*

A time series of monthly incidences was used to test *a priori* hypotheses that the outcomes of interest, the trends of incidences of emergency, and ambulatory cholecystectomies, were different after as compared to before the January 1, 2014 Medicaid Expansion, that is, an intervention that interrupted the 'expected' 10-y trend. The interrupted time series was modelled using a segmented linear regression model[24-27] that included three time-based covariates, whose regression coefficients estimated the pre-expansion slope of incidence, the change in level of incidence January 1, 2014, and the change in the slopes of incidence from pre-expansion to post expansion time. Nonindependence of monthly data was adjusted for by use of autocorrelation variables in the segmented regression models.

Case fatality rate for emergency and ambulatory cholecystectomies

Twelve monthly counts of emergency and ambulatory cholecystectomy case fatalities were collected for each of the 10 y to create a total of 120 state-month observations of rates. An annual emergency and ambulatory cholecystectomy case fatality rate was then determined by dividing the annual fatality count following these emergency and ambulatory cholecystectomies by the total count of emergency and ambulatory cholecystectomies, respectively, separately in each year. This provides a percentage of emergency and ambulatory cholecystectomy fatalities prior to facility discharge for the emergency and ambulatory cholecystectomies performed each year. Simple linear regression was used to model the slope of annual case fatality rate over the entire 10-y time.

Case fatality for emergency and ambulatory cholecystectomies after versus *before expansion*

Because the population having cholecystectomies after as compared to before expansion was expected to be different, we used subgroup analyses and chi-square statistics to evaluate for potential confounding by demographic variables. We then used a multivariable logistic regression analysis to assess the likelihood (odds) of case fatality following cholecystectomies after *versus* before expansion, including in the multivariable models the potential effect modifiers and potential confounders.

A priori levels of significance were a *P*-value of < 0.05. SAS 9.4 statistical software package was used for all analysis. We obtained a 'nonhuman subjects research' exemption from our institutional review board for this study.

Results

Emergency cholecystectomies

Of the 180,662 total emergency and ambulatory cholecystectomies performed from 2009 to 2018 in NJ, 93,423 (51.7%) were emergency cholecystectomies (Table 1). The overall annual incidence of emergency cholecystectomies dropped from 114.8 to 77.5 per 100,000 NJ population during the years 2009 to 2018 (slope estimate, −4.51, standard error (SE) 0.57; *P* value < 0.0001; 95% confidence interval [CI], −5.83 to −3.19). Emergency cholecystectomies performed before expansion (2009 to 2013) compared to after expansion (2014 to 2018) decreased from 51,916 of 93,423 (55.6%, 95% CI: [55.3%-55.9%]) to 41,507 of 93,423 (44.4%, 95% CI: [44.1%-44.8%]) ($P < 0.0001$) (Table 1).

The segmented regression model found a difference in the slope of incidences in 2014 to 2018 compared to the slope of incidences in 2009 to 2013. This difference was consistent with a greater magnitude downward trend in monthly incidence after Medicaid expansion as compared to the lesser magnitude downward trend in monthly incidence before expansion (Fig. 3) [(estimate −0.0442, SE 0.0079; *P*-value < 0.0001), Supplemental Table 2]. In particular, the downward slope of incidence in the pre-expansion period (slope estimate, −0.0062) became a much bigger downward slope of incidence in the post-expansion period (slope estimate, −0.0504) [−0.0442 = (−0.0504)-(−0.0062)]. This downward slope overall was not explained by the increase in the Medicaid population. Emergency cholecystectomies performed in patients with Medicaid increased from 3385 of 51,916 (6.5%, 95% CI: [6.3%-6.7%]) before expansion to 6005 of 41,507 (14.5%, 95% CI: [14.1%-14.8%]) after expansion ($P < 0.0001$) (Table 1).

Ambulatory cholecystectomies

Of the 180,662 total emergency and ambulatory cholecystectomies performed from 2009 to 2018 in NJ, 87,239 (48.3%) were ambulatory cholecystectomies (Table 1). The overall annual incidence of ambulatory cholecystectomies increased from 93.5 to 95.6 per 100,000 NJ population in years 2009 to 2018 (slope estimate, 0.68, SE, 0.30; *P* value = 0.053; 95% CI −0.01 to 1.36). Ambulatory cholecystectomies performed before expansion compared to after expansion increased from 42,552 of 87,239 (48.8%, 95% CI: [48.4%-49.1%]) to 44,687 of 87,239 (51.2%, 95% CI: [50.9%-51.6%]) ($P < 0.0001$) (Table 1).

The segmented regression model found a small difference in the trends of incidence of ambulatory cholecystectomies after Medicaid expansion as compared to before expansion (Fig. 4) [(estimate −0.0142, SE 0.0068; *P*-value = 0.04), Supplemental Table 3]. In particular, the small upward slope

Table 1 – Demographics and clinical information of emergency and ambulatory cholecystectomies before and after the January 1, 2014, NJ Medicaid expansion.[*,†,‡,§]

	Pre-expansion 2009-2013	Postexpansion 2014-2018	P value
Emergency cholecystectomies[*]	51,916	41,507	<0.0001
Age, median [IQR]	51 [36, 67]	54 [38, 69]	<0.0001
<65 y old	37,117 (71.5%, 95% CI: [71.1%-71.9%])	28,016 (67.5%, 95% CI: [67.1%-68.0%])	<0.0001
Female	33,292 (64.1%, 95% CI: [63.7%-64.5%])	25,738 (62.0%, 95% CI: [61.6%-62.5%])	<0.0001
Black	5739 (11.2%, 95% CI: [10.9%-11.5%])	4717 (11.5%, 95% CI: [11.2%-11.8%])	0.12
Latino	10,269 (20.0%, 95% CI: [19.7%-20.4%])	9279 (22.7%, 95% CI: [22.3%-23.1%])	<0.0001
Lowest income[†]	6291 (12.2%, 95% CI: [12.0%-12.5%])	6751 (16.4%, 95% CI: [16.0%-16.7%])	<0.0001
Medicaid	3385 (6.5%, 95% CI: [6.3%-6.7%])	6005 (14.5%, 95% CI: [14.1%-14.8%])	<0.0001
Uninsured	9110 (17.6%, 95% CI: [17.2%-17.9%])	5305 (12.8%, 95% CI: [12.5%-13.1%])	<0.0001
ED to OR, d[‡]	1 [1, 3]	1 [1, 3]	<0.0001
LOS, d[‡]	3 [2, 6]	3 [2, 6]	<0.0001
Ambulatory cholecystectomies	42,552	44,687	<0.0001
Age, median [IQR]	48 [36, 60]	49 [36, 61]	<0.0001
<65 y old	35,167 (82.6%, 95% CI: [82.3%-83.0%])	35,978 (80.5%, 95% CI: [80.1%-80.9%])	<0.0001
Female	32,366 (76.1%, 95% CI: [75.7%-76.5%])	33,249 (74.4%, 95% CI: [74.0%-74.8%])	<0.0001
Black	3737 (8.9%, 95% CI: [8.6%-9.2%])	3900 (8.9%, 95% CI: [8.6%-9.1%])	0.87
Latino	7606 (18.1%, 95% CI: [17.7%-18.5%])	8600 (19.5%, 95% CI: [19.2%-19.9%])	<0.0001
Lowest income[†]	4018 (9.5%, 95% CI: [9.2%-9.8%])	4446 (10.0%, 95% CI: [9.7%-10.3%])	0.01
Medicaid	2797 (6.6%, 95% CI: [6.3%-6.8%])	4917 (11.0%, 95% CI: [10.7%-11.3%])	<0.0001
Uninsured	3795 (8.9%, 95% CI: [8.7%-9.2%])	3305 (7.4%, 95% CI: [7.2%-7.6%])	<0.0001
ASC to OR, d[‡]	0	0	1.0
LOS, d[‡]	0 [0, 0]	0 [0, 0]	0.06

[*] Missing covariable data for emergency cholecystectomies includes $N = 0$ for age, $N = 6$ for sex, $N = 1176$ each for Black and Latino, $N = 78$ for lowest income, $N = 0$ each for Medicaid and uninsured.
[†] Lowest income is defined as residence in a zip code with the lowest median income quartile in NJ.
[‡] ED = emergency department; OR = operating room; LOS = length of stay; ASC = ambulatory surgery center. Kaplan–Meier and log rank test are used for LOS.
[§] Excluded are inpatient elective cholecystectomies $N = 13,068$ total, with pre-expansion $N = 8144$ and post-expansion $N = 4924$, as well as the direct admit cholecystectomies $N = 5846$, with pre-expansion $N = 3660$ and post-expansion $N = 2186$.

of incidence in the pre-expansion period (slope estimate, 0.0063) reversed and became a small downward slope of incidence in the post-expansion period (slope estimate, −0.0079) [(−0.0142) = (−0.0079)-(0.0063)]. This downward slope was not explained by the increase in the Medicaid population. Ambulatory cholecystectomies performed in patients with Medicaid increased from 2797 of 42,552 (6.6%, 95% CI: [6.3%-6.8%]) before expansion to 4917 of 44,687 (11.0%, 95% CI: [10.7%-11.3%]) after expansion ($P < 0.0001$) (Table 1).

Fatalities following emergency cholecystectomies

There were 644 fatalities following emergency cholecystectomies over the 10 y (Table 2). The overall annual case fatality rate decreased from 99 of 10,377 (0.95%) to 42 of 7003 (0.60%) in years 2009 to 2018 (for annual count: slope estimate, −5.19; SE 1.15, P-value 0.002; 95% CI, −7.84 to −2.53; for case fatality rate (%): slope estimate, −0.025; SE 0.012, P-value 0.073; 95% CI, −0.054 to 0.003). Fatalities following emergency cholecystectomies before compared to after expansion decreased from 384 of 51,916 (0.7%, 95% CI: [0.7%-0.8%]) to 260 of 41,507 (0.6%, 95% CI: [0.6%-0.7%]) ($P = 0.04$) (Table 2).

The unadjusted odds ratio for case fatality of emergency cholecystectomies after expansion as compared to before expansion was 0.85 (95% CI, 0.72-0.99). As highlighted above and summarized in Table 1, those who underwent emergency cholecystectomy post-expansion were different from those who underwent emergency cholecystectomy pre-expansion in multiple variables (Table 1). However, none of these were confounders of the 15% reduction in odds of case fatality (Table 3). Our findings were confirmed in a final multivariable logistic regression model (Table 3). In particular, we found that Medicaid was not a confounder or effect modifier; that is, the 15% decrease in case fatality rate did not disappear when Medicaid *versus* non-Medicaid was added to the models, and there was no heterogeneity of effects of Medicaid insurance itself by period ($P = 0.75$). Medicaid also was not independently associated with case fatality (adjusted odds ratio, 1.27; (95% CI, 0.86-1.87)). In contrast, age was found to modify the effect of post- as compared to the pre-expansion time on case fatality ($P = 0.005$), with the main effect of age 65 y or greater decreasing the odds of case fatality by 33% [OR = 0.67, 95% CI, 0.56-0.81], while age less than 65 y did not change the odds of case fatality [OR = 1.10 (95% CI, 0.78-1.56)].

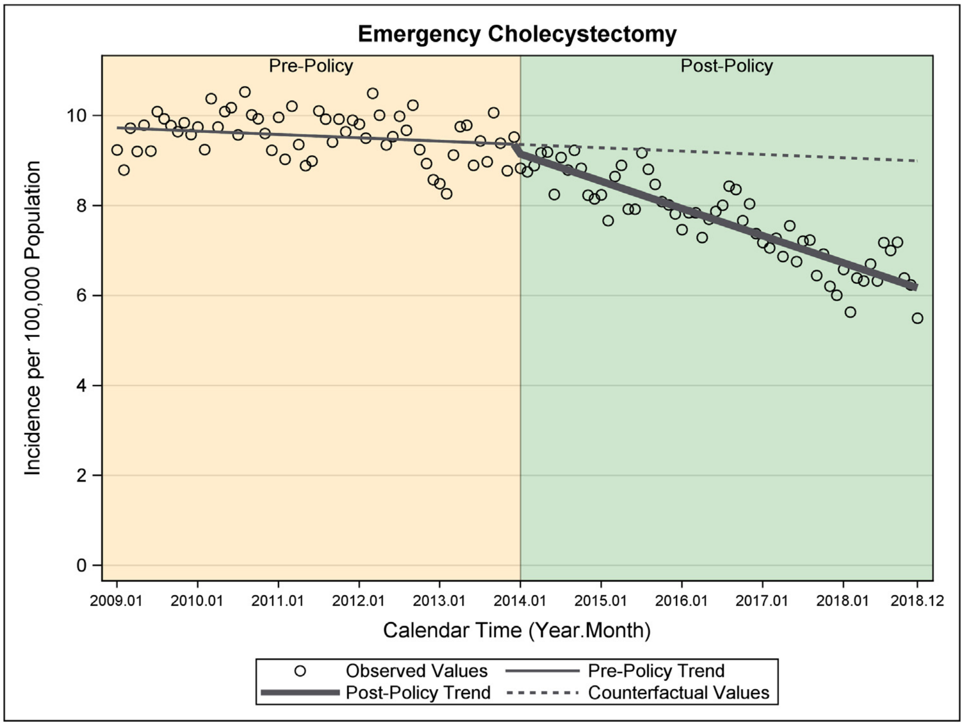

Fig. 3 – Trends in the incidence of emergency cholecystectomies before and after the NJ January 1, 2014, Medicaid expansion policy. Each dot on this plot represents the observed value of the monthly incidence of emergency cholecystectomies per 100,000 NJ population. 120 dots represent 12 mo over 10 y. The thick solid line is the modeled slope of the monthly incidence as a trend in the post-policy period. The thin solid line is the modeled slope of the monthly incidence as a trend in the pre-policy period. The dashed line is the counterfactual post-policy trend had the January 1, 2014, Medicaid expansion not been implemented. This figure represents a full-segmented regression model with adjustments for the observed values of monthly incidence that lack independence on the order of one and twelve.

Fatalities following ambulatory cholecystectomies

There were fewer than 10 fatalities following ambulatory cholecystectomies over the 10 y (Table 2). None occurred in the pre-expansion period (0%, 95% CI: [0%-0.001%]) and fewer than 10 (0.004%, 95% CI: [0%-0.02%]) occurred in the post-expansion period ($P = 0.50$). Given the extremely low number of fewer than 10 fatalities following ambulatory cholecystectomies in the postexpansion period, there was no change in the fatality rate to analyze.

Discussion

In our 2009-2018 study of the incidence of and fatalities following emergency and ambulatory cholecystectomies in NJ, we found cholecystectomies are performed far more often following admission to the hospital from an ED than an ASC. After Medicaid expansion, there was a marked decrease in the incidence of the riskier emergency cholecystectomies, but the incidence of ambulatory cholecystectomies did not increase sufficiently to explain this decrease. Further, nearly all fatalities following cholecystectomies were found to be in patients having emergency cholecystectomies. With our follow-up time limited to the extent of index facility stay as high as twenty-five times longer for emergency as compared to ambulatory cholecystectomies, the 322-fold rate of fatalities was still at least crudely very disproportionate. Importantly, the decreasing case fatality of emergency cholecystectomies in the post-expansion period as compared to pre-expansion period was persistent after adjustment for the effects of Medicaid. The decreasing case fatality was isolated to only people aged 65 or greater, where Medicaid expansion would be expected to have the least impact.

To date, the limited available previous research found no association between the 2014 Medicaid expansion and *emergency* and *ambulatory* cholecystectomy. Chiu *et al.* find an association between the 2014 Medicaid expansion and a decrease in the uninsured undergoing *inpatient* cholecystectomy[1] and Loehrer *et al.* a shorter ED to OR time for laparoscopic cholecystectomy after compared to before expansion for the Medicaid population admitted through the ED.[28] While neither of these studies explored case fatality, Hamel *et al.* did include a mortality outcome, but they lumped gallstone disease and cholecystectomies in with four other common diseases requiring *urgent* surgery, finding no association between the 2014 Medicaid expansion and improved surgical mortality.[29] In the only previous trend analysis of cholecystectomies performed, the overall frequency of *inpatient* and *outpatient* cholecystectomies from 1995 to 2013 in New York did not

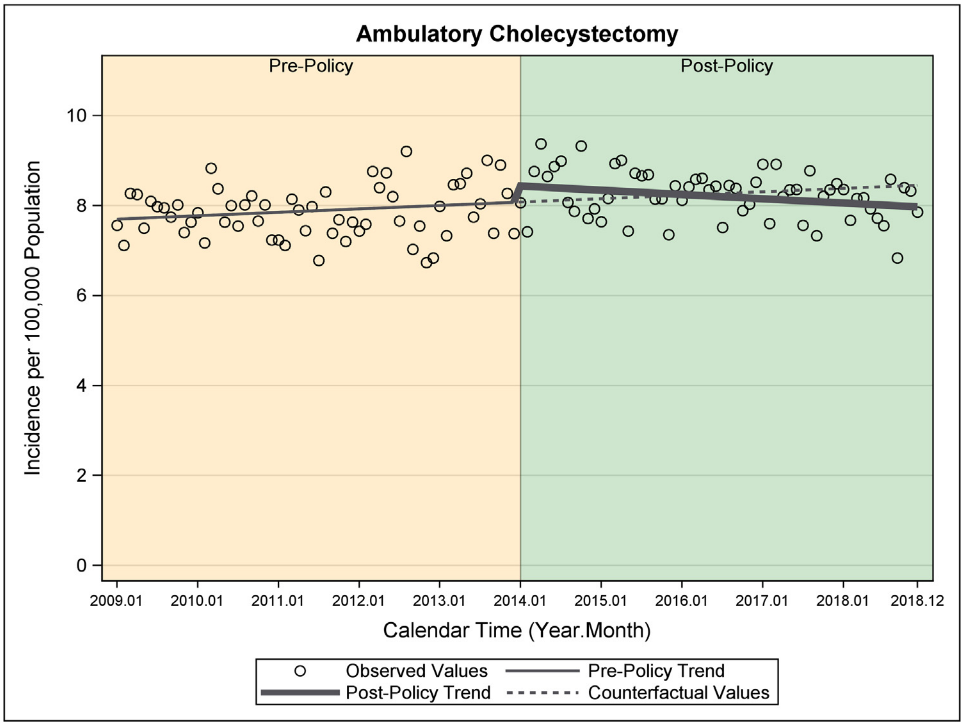

Fig. 4 – Trends in the incidence of ambulatory cholecystectomies before and after the NJ January 1, 2014, Medicaid expansion policy. Each dot on this plot represents the observed value of the monthly incidence of ambulatory cholecystectomies per 100,000 NJ population. 120 dots represent 12 mo over 10 y. The thick solid line is the modeled slope of the monthly incidence as a trend in the post-policy period. The thin solid line is the modeled slope of the monthly incidence as a trend in the pre-policy period. The dashed line is the counterfactual post policy trend had the January 1, 2014, Medicaid expansion not been implemented. This figure represents a full-segmented regression model with adjustment for the observed values of monthly incidence that lack independence on the order of twelve.

increase.[30] These data preceded the Medicaid expansion, however. In a four state study of the effect of the January 1, 2014 Medicaid expansion on utilization of *ambulatory* cholecystectomies, a higher likelihood of having ambulatory cholecystectomy after expansion in Michigan and New York expansion states as compared to two other nonexpansion states disappeared when removing cholecystectomies performed in freestanding ASCs, that is, nonhospital affiliated ASCs.[8] In Kentucky, Bhutaini *et al.* found *inpatient* cholecystectomies decreased slightly from 21.9% to 20%, and a greater proportion of patients received *ambulatory* cholecystectomies after compared to before the 2014 Medicaid expansion.[31] However, *emergency* cholecystectomies were not differentiated from other *inpatient* cholecystectomies, nor were hospital-affiliated differentiated from nonhospital-affiliated *ambulatory* cholecystectomies. In none of the above studies were trends of *emergency* and *ambulatory* cholecystectomies and case fatality rates explored together. However, a consistent lexicon is necessary so that epidemiological comparisons and electronic phenotype of gallstone disease and cholecystectomy can be made clear.

The trends we observed of emergency and ambulatory cholecystectomies treating gallstone disease in the NJ population reflect the impact of a public health intervention resulting from 470,874 additional people receiving Medicaid insurance coverage as a result of the 2014 Medicaid expansion.[13,14] Our work adds uniquely to the prior literature as the first to show in the total state population a decrease in emergency cholecystectomies with Medicaid expansion.[16,32] Dimou *et al.* find outpatient follow-up surgical consultation after patients with gallstone disease are discharged from the ED decreases their chance of later presenting again to the ED and increases their chance of later having instead 'elective' cholecystectomies.[33] This practice may have been promoted, especially with a smaller proportion of the NJ population uninsured in the post-expansion period. The modest increase in ambulatory cholecystectomies from the pre-expansion to the post-expansion period in NJ, however, was not sufficient to explain the decrease in emergent cholecystectomies. The lower reimbursements of outpatient compared to inpatient surgeon professional fees or a fixed outpatient capacity may have also slowed an increase in ambulatory cholecystectomies.[34] If NJ quality-based incentives or systematic guidelines were implemented to ensure primary care prevent patients from developing emergency gallstone disease or detects or refers patients early in their uncomplicated stages of disease, this might explain our marked decrease in emergency

Table 2 – Demographics and clinical information of case fatalities following emergency and ambulatory cholecystectomies before and after the January 1, 2014, NJ Medicaid expansion.[*,†,‡,§]

	Pre-expansion 2009-2013	Post-expansion 2014-2018	P value
Case fatality rate, emergency	384/51,916 (0.7%, 95% CI: [0.7%-0.8%])[*]	260/41,507 (0.6%, 95% CI: [0.6%-0.7%])	0.04
Age, median [IQR]	78 [69, 85]	75 [65, 83]	0.005
<65 y old	72/37,113 (0.19%, 95% CI: [0.15%-0.24%])	64/28,016 (0.23%) (95% CI: [0.17%-0.28%])	0.38
Female	208/33,290 (0.62%, 95% CI: [0.54%-0.71%])	137/25,738 (0.53%) (95% CI: [0.44%-0.62%])	0.16
Black	45/5,737 (0.78%, 95% CI: [0.56%-1.01%])	33/4,717 (0.70%) (95% CI: [0.46%-0.94%])	0.70
Latino	28/10,269 (0.27%, 95% CI: [0.18%-0.39%])	34/9,279 (0.37%) (95% CI: [0.24%-0.49%])	0.30
Lowest income[†]	51/6,291 (0.81%, 95% CI: [0.59%-1.03%])	42/6,751 (0.62%) (95% CI: [0.43%-0.81%])	0.24
Medicaid	12/3,384 (0.35%, 95% CI: [0.18%-0.62%])	21/6,005 (0.35%) (95% CI: [0.22%-0.53%])	1.0
Uninsured[§]	19/9,109 (0.21%, 95% CI: [0.13%-0.33%])	Ω/5,305	0.26
ED to OR, d	4 [2, 9]	3 [1, 7]	0.007
LOS, days to fatality[‡]	14 [9, 25]	13 [7, 22]	0.07
Case fatality rate, ambulatory[§]	0 (0%) (95% CI: [0%-0%])	Ω (0.001%) (95% CI: [0%-0.01%])	0.50
variables[§]	–	Ω	–

[*] The 4 of 51,916 records in the pre-expansion period that were missing fatality data were in 2009.
[†] Lowest income is defined as residence in a zip code with the lowest median income quartile in NJ.
[‡] ED = emergency department; OR = operating room; LOS = length of stay. Kaplan-Meier and log rank test are used for LOS.
[§] Data is not presented when 10 or fewer events per HCUP's data use agreement.

cholecystectomies. However, we are not aware of any specific actions or regional implementations like these.

We found Medicaid itself to have no impact on the odds of case fatality for those in the population requiring emergency cholecystectomy. Rather, it appears that other secular trends in that time period besides expansion of Medicaid must have been occurring regarding case fatality. Although, to our knowledge, cholecystectomy itself was not improved technically or otherwise after 2014 compared to before 2014, a decreased case fatality rate occurred in the overall population having emergency cholecystectomy. Importantly, emergency cholecystectomy incidence dropped markedly, as did its case fatality rate yet, as previously reported, it did not change overall gallstone disease-related mortality found on average to be 160 annual deaths.[12] If, when gallstone disease is identified and cholecystectomies are indicated, the procedure is performed in the ambulatory setting rather than in the emergency setting, the population's surgical morbidity and mortality from gallstone disease should ideally be reduced.[4,5]

Thus, given emergency cholecystectomy has decreased, as well as the case fatality rate from those emergency surgeries that were performed, case fatality from ambulatory surgery was extremely low and unchanged, inpatient elective and direct office admit cholecystectomies were uncommon, and overall mortality was unchanged, the incidence of *non*-surgically related gallstone disease mortality must have increased over this time period. Perhaps now patients are presenting earlier to primary care but are not being diagnosed as patients who would benefit from earlier cholecystectomy.[11,35] Then, a window of opportunity may close, and uncomplicated gallstone disease may become complicated gallstone disease, increasing the overall mortality risk. These and other possible changing trends in the interventions for nonsurgical gallstone disease, for example, cholecystostomy potentially becoming inappropriately more utilized in the disadvantaged and frail first,[36-38] could be possible etiologies of the increasing mortality from nonsurgical gallstone disease. Or perhaps the incidence of nonsurgical gallstone disease itself is increasing.

These together have important public health implications. Although Medicaid expansion may have been associated with decreased emergency cholecystectomies in the overall population, more work still needs to be done to decrease the overall mortality of gallstone disease in general. Older age itself is expected to contribute to higher risk of mortality. Thus, factors associated with age and cholecystectomy that are protective, for example, decreases in frailty or surgery done upon first, less complicated presentation that carries less risk of peri-operative fatality due to prevention of cardiovascular or venous thromboembolic events,[4] require more elucidation for emergency compared to ambulatory cholecystectomy risk models in the elderly.[39,40]

The major strength of our work is that it is population-based; we include data on all eligible patients in a defined population before and after the 2014 Medicaid expansion.[11] This is in contrast to prior studies, which investigated only select clinical/hospital or narrow subpopulations and so are subject to referral or other selection biases. For example, several other studies compare outcomes of emergency general surgeries in patients with Medicaid before expansion to those in patients with Medicaid after expansion only. However, this is contrasting two different subgroups that are not comparable. As Scott *et al.* state, "this approach is likely to lead to faulty conclusions regarding the impact of this public health intervention because studies are needed of the impact of Medicaid expansion on the total population".[41]

The limitations to our study are inherent to measuring outcomes with procedure codes that span the transition of the ICD-9-CM to the ICD-10-CM/PCS era in 2015. For the emergency surgery outcome, we risk a differential misclassification

Table 3 – The odds of case fatality of emergency cholecystectomies after as compared to before Medicaid expansion in New Jersey.*,†,‡,§,‖

	After expansion	Before expansion†	OR‡ (95% CI)	P-value interaction§	OR for Time Period‖	OR for Final Model*
Crude effect	260	384	0.85 (0.72-0.99)	–	–	–
Case fatality	41,247	51,528				
No case fatality	41,507	51,912[4]				
Age				0.005	n/a	
Age <65	64	72	1.2 (0.84-1.65)			1.10 (0.78-1.56)
Case fatality	27,952	37,041				
No case fatality	28,016	37,113[4]				
Age ≥65	196	312	0.69 (0.57-0.82)			0.67 (0.56-0.81)
Case fatality	13,295	14,487				
No case fatality	13,491	14,799				
Sex				0.84	0.84 (0.72-0.98)	0.89 (0.76-1.04)
Female	137	208	0.85 (0.69-1.06)			
Case fatality	25,601	33,082				
No case fatality	25,738	33,290[2]				
Male	123	176	0.82 (0.65-1.04)			
Case fatality	15,640	18,446				
No case fatality	15,763	18,622[2]				
Ethnicity				0.06	0.85 (0.72-0.99)	0.64 (0.49-0.85)
Latino	34	28	1.34 (0.81-2.22)			
Case fatality	9,245	10,241				
No case fatality	9,279	10,269				
Not Latino	219	353	0.80 (0.68-0.95)			
Case fatality	31,450	40,673				
No case fatality	31,669	41,026[4]				
Income				0.63	0.84 (0.72-0.99)	1.34 (1.07-1.69)
Lowest Income	42	51	0.77 (0.51-1.15)			
Case fatality	6,709	6,240				
No case fatality	6,751	6,291				
Not lowest income	216	330	0.86 (0.72-1.02)			
Case fatality	34,273	44,776				
No case fatality	34,489	45,106[4]				
Medicaid				0.75	0.88 (0.75-1.03)	1.27 (0.86-1.87)
Medicaid	21	12	0.99 (0.49-2.01)			
Case fatality	5,984	3,372				

No case fatality	6,005	3,384[1]	
Not Medicaid	239	372	0.87 (0.75-1.03)
Case fatality	35,263	48,156	
No case fatality	35,502	48,528[3]	

* Evaluation of the row variable for the independent effect on case fatality, including in the final multivariable logistic regression model the expansion period, age and expansion period interaction, sex, ethnicity, income, and Medicaid.
† Analyses include data available for each covariable with the superscript number indicating the missing data on case fatality.
‡ Odds Ratio (OR) for the crude effect and stratified OR by the level of each row variable.
§ Evaluation of the row variable for potential effect modification. P value < 0.05 was considered significant.
‖ Evaluation of the row variable for potential confounding by time.

bias away from the null if the coding transition omits ICD-10-PCS procedure codes from our 2014 to 2018 quasi-experimental time. For the ambulatory surgery outcome, a differential misclassification bias toward the null could occur if the cholecystectomies done in nonhospital-affiliated 'free-standing' ASCs increased after expansion. Because NJ submits only hospital affiliated ASC data to the HCUP, we missed data on cholecystectomies done at "freestanding" centers, which have been found to strengthen the effect measure of an association between expansion and increased ambulatory cholecystectomy when comparing expansion to control states.[8] Our interpretation of the case fatality data is limited because we were not able to measure complications or fatalities longitudinally from the index hospital encounter; the NJ HCUP SASDs containing the index outpatient encounters and the SIDs containing index and subsequent inpatient encounter data do not allow for a link after discharge. A lack of a unique patient identifier in the 2014, 2015, and 2016 NJ source data reflected in the SIDs and SASDs core files prevents this analysis. There is potential for residual confounding by demographics according to the NJ subpopulations that may not be as stable over time. Finally, probably the most important limitation is that of generalizability; these results need to be re-examined in other states' data.

Conclusions

We observed a decreasing trend of the higher-risk emergency cholecystectomies in the total population and a decrease in case fatality rate of emergency cholecystectomy over time. The decrease in case fatality rate among patients undergoing emergency surgery was not related to or improved by Medicaid expansion, however, and was restricted only to the elderly, with an etiology that remains to be elucidated. The use of population-based data to examine interventions that decrease emergency cholecystectomies therefore was important, especially given our prior data indicating that overall mortality with gallstone disease did not change during this same time period. These results remain to be reproduced in data from other states, and more work is needed to understand interventions that may change the incidence of gallstone disease and mortality in general.

Supplementary Materials

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jss.2023.03.006.

Authors Contributions

Gregory L. Peck (G. L. P.) contributed to the study design, data analysis, data interpretation, writing, and critical revision. Yen-Hong Kuo (Y. K.) contributed to the data analysis, data interpretation, and critical revision. Shawna V. Hudson (S. V. H.) and Vicente H. Gracias (V. H. G.) contributed to the data interpretation and critical revision. Jason A. Roy (J. A. R.) contributed to the study design, data analysis, data interpretation, and critical revision. Brian L. Strom (B. L. S.) contributed to the study design, data interpretation, and critical revision.

Disclosure

Gregory L. Peck, DO, MPH, FACS was first author in the intellectual content and writing of the manuscript to take public responsibility for it. He has reviewed the final manuscript, believe it represents valid work, and approves it for submission. He is currently supported by the NIH National Center for Advancing Translational Sciences' (NCATS) Rutgers Clinical Translational Science KL2 Career Development Award (CTSA 5 KL2 TR003018-4). He reports no proprietary or commercial interest in any product mentioned or concept discussed in this article and has no potential conflicts of interest. Yen-Hong Kuo, PhD participated sufficiently in the intellectual content and writing of the manuscript to take public responsibility for it. He has reviewed the final manuscript, believes it represents valid work, and approves it for submission. He reports no proprietary or commercial interest in any product mentioned or concept discussed in this article and has no potential conflicts of interest. Shawna V. Hudson, PhD participated sufficiently in the intellectual content and writing of the manuscript to take public responsibility for it. She has reviewed the final manuscript, believes it represents valid work, and approves it for submission. She reports no proprietary or commercial interest in any product mentioned or concept discussed in this article and has no potential conflicts of interest. Vicente H. Gracias, MD, FACS participated sufficiently in the intellectual content and writing of the manuscript to take public responsibility for it. He has reviewed the final manuscript, believes it represents valid work, and approves it for submission. He reports no proprietary or commercial interest in any product mentioned or concept discussed in this article and has no potential conflicts of interest. Jason A. Roy, PhD participated sufficiently in the intellectual content and writing of the manuscript to take public responsibility for it. He has reviewed the final manuscript, believes it represents valid work, and approves it for submission. He reports no proprietary or commercial interest in any product mentioned or concept discussed in this article and has no potential conflicts of interest. Brian L. Strom, MD, MPH participated sufficiently in the intellectual content and writing of the manuscript to take public responsibility for it. He has reviewed the final manuscript, believes it represents valid work, and approves it for submission. He reports no proprietary or commercial interest in any product mentioned or concept discussed in this article and has no potential conflicts of interest.

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