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Research Paper

Biliary colic in the emergency department: A state-wide analysis of one-year costs and clinical outcomes

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ABSTRACT

Importance: Approximately 335,000 cases of biliary colic present to US emergency departments (EDs) annually, and most patients without complications are discharged from the ED. It is unknown what are the subsequent surgery rates, subsequent complications of biliary disease, ED revisits, repeat hospitalizations and cost; and, how does the ED disposition decision (admission versus discharge) affect long-term outcomes.
Objective: To determine whether there is a difference in one-year surgery rates, complications of biliary disease, ED revisits, repeat hospitalizations, and cost in ED patients with uncomplicated biliary colic who are admitted to the hospital versus those that are discharged from the ED.
Design, setting, and participants: A retrospective observational study was conducted using records collected from the Maryland Healthcare Cost and Utilization Project (HCUP) in the Ambulatory Surgery, the Inpatient, and the ED setting between 2016 and 2018. After applying inclusion criteria, 7036 ED patients with uncomplicated biliary colic were followed for one year after their index ED visit for repeat healthcare utilization across multiple settings. A multivariable logistic regression study was performed to asses for risk factors for surgery allocation and hospital admission. Medicare Relative Value Units (RVUs) and HCUP Cost-Charge Ratio files were used to estimate direct costs.
Exposures: Episodes of biliary colic were ascertained using ICD-10 codes at the index ED visit.
Main outcomes and measures: The primary outcome was the one-year surgery rate, defined as a cholecystectomy. Secondary outcomes included the rate of new acute cholecystitis or other related complications, ED revisits, hospital admission and costs. Associations with hospital admission and surgeries were measured using adjusted odds ratios (ORs) with 95 % CIs.
Results: Of the 7036 patients analyzed, 793 (11.3 %) were admitted and 6243 (88.7 %) were discharged on their initial ED visit. When comparing the groups who were initially admitted versus discharged, we observed similar one-year cholecystectomy rates (42 % versus 43 %, mean difference 0.5 %, 95 % CI −3.1 %–4.2 %; $P < 0.001$), lower rates of new cholecystitis occurrences (18 % versus 41 %, mean difference 23 %, 95 % CI, 20 %–26 %; $P < 0.001$), lower rates of ED revisits (96 vs 198 per 1000 patients, mean difference 102, 95 % CI, 74–130; $P < 0.001$) and higher costs ($9880 versus $1832, mean difference 8048, 95 % CI, 7478–8618; $P < 0.001$). Initial ED hospital admission was associated with increased age (adjusted odds ratio [aOR], 1.44; 95 % CI, 1.35–1.53; $P < 0.001$), obesity (aOR, 1.38; 95 % CI, 1.32–1.44; $P < 0.001$), ischemic heart disease (aOR, 1.39; 95 % CI, 1.30–1.48; $P < 0.001$), mood disorders (aOR, 1.18; 95 % CI, 1.13–1.24; $P < 0.001$), alcohol-related disorders (aOR, 1.20; 95 % CI, 1.12–1.27; $P < 0.001$), hyperlipidemia (aOR, 1.16; 95 % CI, 1.09–1.23; $P < 0.001$), hypertension (aOR, 1.15; 95 % CI, 1.08–1.21; $P < 0.001$), and nicotine dependence (aOR, 1.09; 95 % CI, 1.03–1.15; $P = 0.003$) but not associated with race ($P > 0.9$), ethnicity ($P > 0.9$), or income-stratified zip code (aOR, 1.04; 95 % CI, 0.98–1.09; $P = 0.17$).
Conclusions and relevance: In our analysis of ED patients with uncomplicated biliary colic from a single state, the majority of patients do not receive a cholecystectomy within one year and hospital admission at the initial visit was not associated with an overall change in rates of cholecystectomy but was associated with increased costs. These findings inform our understanding of the long-term outcomes and are important considerations when communicating care options with ED patients with biliary colic.

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Introduction

Biliary colic, or acute abdominal pain due to cholelithiasis, is a common presentation in the Emergency Department (ED), representing approximately 335,000 ED visits in the US annually [1]. In addition to pain, complications of biliary colic include acute cholecystitis, cholangitis, and pancreatitis. For uncomplicated biliary colic, there is variability in ED management with uncertainty regarding the need for hospital admission and the urgency of surgical intervention, typically a cholecystectomy [2]. In general, most patients are discharged from the ED after pain is controlled with advice to follow-up with a physician for consideration of a scheduled cholecystectomy at a later date. Some patients with uncomplicated biliary colic are admitted to the hospital due to persistent pain or vomiting or to expedite surgical management. For patients who are admitted, a cholecystectomy may be offered during the inpatient stay or the patient may be referred for a scheduled cholecystectomy after discharge [2]. It is unknown how many patients ultimately require surgery for uncomplicated biliary colic [3].

While hospital admission is a known driver of medical costs, admission at the initial visit for a resultant immediate cholecystectomy may lead may lead to a cumulative savings due to the reduced risk of future ED revisits, hospitalizations and other complications. A better understanding of the long-term outcomes associated with initial management of biliary colic is crucial to making informed decisions in the ED. The goals of this study are to determine whether there is a difference in one-year surgery rates, complications of biliary disease, ED revisits, repeat hospitalizations, and cost in ED patients with uncomplicated biliary colic who are admitted to the hospital versus those that are discharged from the ED.

Methods

Study design and setting. This study was a retrospective observational study using linked administrative datasets. Patient records were obtained from the state of Maryland's linked databases collected by the Agency for Healthcare Research and Quality's (AHRQ's) Healthcare Cost and Utilization Project (HCUP) between the years 2016–18 [1]. These datasets contain a census of all hospital and ambulatory surgery visits in the state for the years listed. The linked databases included the State Emergency Department Database (SEDD), the State Ambulatory Surgery Database (SASD), and the State Inpatient Database (SID). The SEDD contains records of ED visits that did not result in an inpatient floor admission; the SASD contains records of visits to ambulatory surgery centers; the SID contains records of patients who were admitted to the hospital. All three datasets contain demographic information, diagnoses (ICD-10-CM codes), procedures performed (CPT/ICD-10-PCS

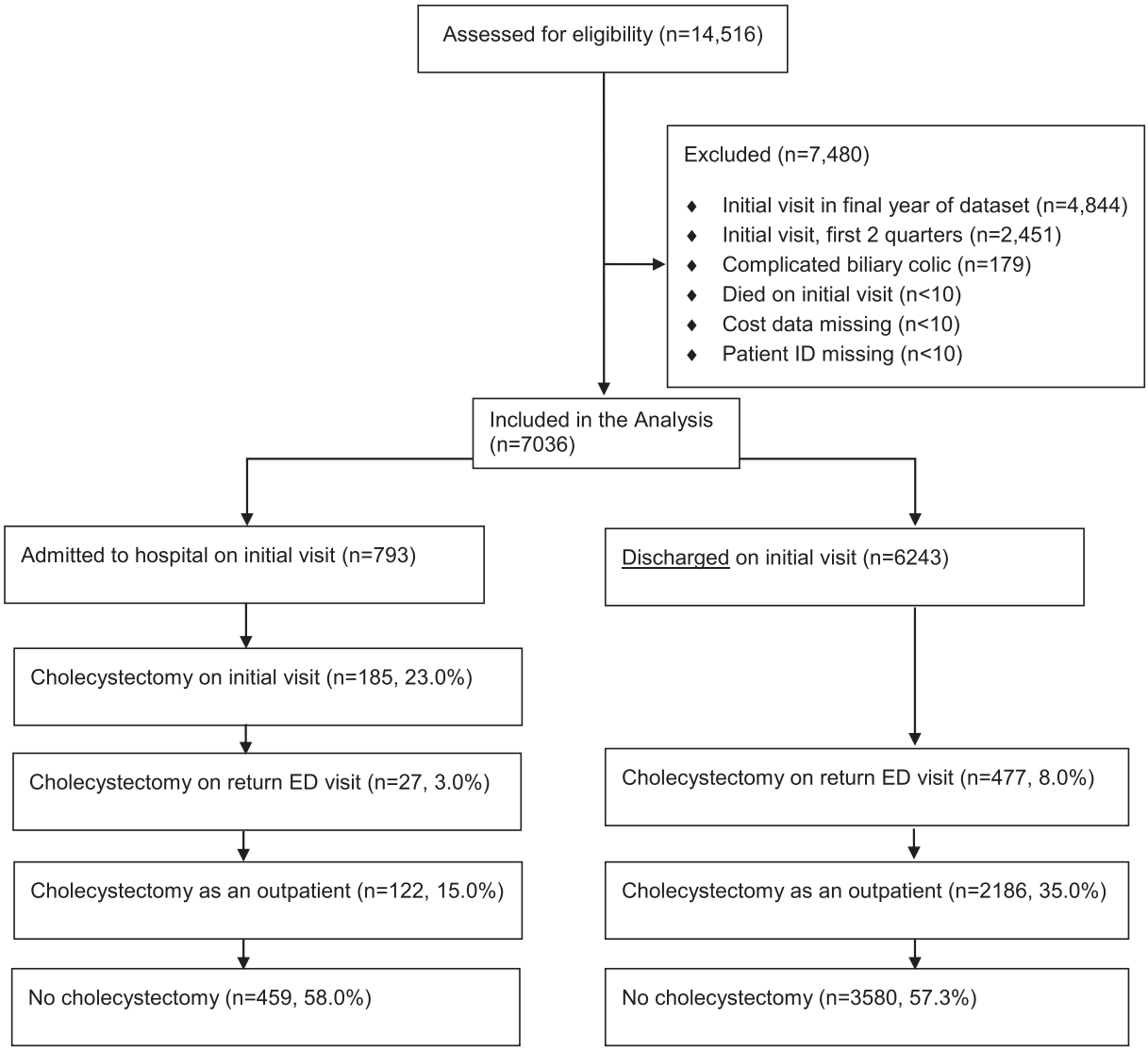

Fig. 1. Study flow diagram.

codes), length of stay, and the year and quarter of the visit. A unique patient identifier was used to link charts across databases. This study was Institutional Review Board (IRB) exempt because datasets did not include personally identifiable health information.

Study protocol. We identified patients with uncomplicated biliary colic in SEDD and SID databases using the ICD-10 codes K80.2, K80.5, K80.7, and K80.8 (various calculi of the gallbladder without cholecystitis). Complications of biliary colic were defined by ICD-10 codes K80.0, K80.1, K80.3, K80.4, K80.6, K81, K85.1, and K82.A (calculus of the gallbladder or bile duct with cholangitis or cholecystitis). We excluded patients who died either during the initial visit (since we could not verify what factors led to that death) or died due to causes unrelated to biliary colic. We also excluded patients with missing cost/charge data. Finally, we excluded patients whose initial visit occurred within the first recorded two quarters (six months) due to the possibility that these visits were somewhat likely to represent a ED revisit from a relatively recent prior visit in 2015 (we found that >90 % of revisits captured in our dataset occurred within the first 3 months after initial visit). Cholecystectomy was identified using the CPT codes 47,562, 47,563, 47,564, 47,600, 47,605, 47,610, 47,612, 47,620. Comorbidities were identified using the categorical code definitions and ICD-10 codes (Appendix A).

Measures and data analysis. The primary goal of our analysis was to assess the clinical outcomes of the cohort, specifically the development of biliary disease complications, surgery rates, ED revisits, repeat hospitalizations, and costs in ED patients with biliary colic. All outcomes were measured one year after the initial ED visit and patients who were initially admitted were compared to those who were discharged. To construct outcomes related to cost, HCUP charge-cost ratio files were used to calculate SID costs, while Medicare RVU files were used to calculate SEDD and SASD costs. All costs were summed together and analyzed as a single outcome. In addition, costs are inflation-adjusted and presented in 2018 values. Cost outcomes did not reflect patient out-of-pocket expenses since those were not present in the dataset.

We compared patients who were initially hospitalized to those who were initially discharged from the ED by patient demographics and comorbidities. In addition, we conducted a conducted multivariable logistic regression modeling to better understand which characteristics were associated with the decision to be admitted to the hospital versus discharged [4–6]. Data fields used as features for the logistic regression were selected by clinician-investigators (Appendix A), and model was built using a direct approach (without feature modification after initial selection). Researchers noted that assumptions of logistic regression were met by the dataset, including a lack of collinearity in the data, and pre-processed model data by binary encoding of all non-linear categorical variables. The logistic regression utilized patient data as known on initial visit, and the dataset only contained one row per unique patient identifier. A separate subgroup analysis was performed for all discharged patients to compare those who received surgery at one year versus those who did not receive surgery at one year. Additionally, we compared cost differences between all possible admission/surgery pathway groups using Welch's *t*-test. P-value cutoffs for all logistic regression analyses were 0.001 due to dataset size. We assessed model discrimination using the c statistic and model calibration using the Hosmer –Lemeshow test.

Results

Based on our search, 14,516 patients were identified and 7036 patients who were eligible for the study were analyzed (Fig. 1). Of these, 11.3 % (n = 793) were admitted to the hospital and 88.7 % (N = 6243) were discharged on their initial visit. Any differences in demographics between groups were significant only in a univariate comparison and not multivariate comparisons (Table 1). Of the 793 patients admitted, 185 (23.0 %) received a cholecystectomy during that initial hospitalization, 27 (3.0 %) returned to the ED within one year after discharge to receive an emergency cholecystectomy, 122 (15.0 %) received a scheduled cholecystectomy after discharge and 459 (58.0 %) did not receive a cholecystectomy within one year. Of the 6243 patients discharged after their initial visit, 477 (8.0 %) returned to the ED within one year after discharge to receive an emergency cholecystectomy, 2186 (35.0 %) received a scheduled cholecystectomy after discharge and 3580 (57.0 %) did not receive a cholecystectomy within one year (Fig. 1).

We identified predictors of admission (Table 2A) and determined if discharged patients were likely to need surgery (cholecystectomy) in the next year (Table 2B). There was no association between either admission or post-discharge cholecystectomy and race, gender, or insurance status. Discharged patients had higher rates of cholecystitis within one year, and were more likely to return to the ED than admitted patients; both the cost and mortality were higher if patients were admitted during the initial visit. Repeat hospitalizations were not different

Table 1
Baseline characteristics of admitted versus discharged patients.

	Admitted at initial visit (%, 95 % CI, N)	Discharged at initial visit (%, 95 % CI, N)	Difference of group means (univariate 95 % CI)[a]
Totals	793 (11.3 %)	6243 (88.7 %)	
Age (mean years)	59.3 (57.8, 60.8)	44.9 (44.5, 45.4)	14.4 (12.8, 15.9)
Pediatric (<18)	1 % (1.0, 2.0), 11.0	2.0 % (2.0, 2.0), 120	−0.5 % (−1.4 %, 0.3 %)
White	55.0 % (52.0, 59.0), 438.0	53.0 % (52.0, 55.0), 3330.0	1.9 % (−1.8 %, 5.6 %)
African American or Hispanic	39.0 % (35.0, 42.0), 308.0	39.0 % (38.0, 41.0), 2458.0	−0.5 % (−4.1 %, 3.1 %)
Female	66.0 % (63.0, 70.0), 525.0	72.0 % (71.0, 73.0), 4511.0	−6.1 % (−9.5 %, −2.6 %)
Married	41.0 % (37.0, 44.0), 324.0	45.0 % (44.0, 46.0), 2819.0	−4.3 % (−7.9 %, −0.7 %)
Medicaid	21.0 % (19.0, 24.0), 170.0	25.0 % (24.0, 26.0), 1534.0	−3.1 % (−6.2 %, −0.1 %)
Medicare	45.0 % (42.0, 48.0), 357.0	16.0 % (16.0, 17.0), 1026.0	28.6 % (25.0 %, 32.2 %)
Private insurance	29.0 % (26.0, 33.0), 233.0	46.0 % (45.0, 47.0), 2874.0	−16.7 % (−20.1 %, −13.2 %)
Uninsured	3.0 % (2.0, 4.0), 22.0	10.0 % (9.0, 10.0), 602.0	−6.9 % (−8.2 %, −5.5 %)
Zip code income (mean quartile)	3.1 (3.0, 3.2)	3.1 (3.1, 3.2)	0.0 (−0.1, 0.0)
Diabetes mellitus	25.0 % (22.0, 29.0), 202.0	11.0 % (11.0, 12.0), 713.0	14.1 % (10.9 %, 17.2 %)
Hyperlipidemia	35.0 % (32.0, 39.0), 280.0	14.0 % (13.0, 15.0), 864.0	21.5 % (18.0 %, 24.9 %)
Obesity	20.0 % (17.0, 23.0), 161.0	14.0 % (13.0, 15.0), 886.0	6.1 % (3.2 %, 9.0 %)
Hypertension	58.0 % (55.0, 62.0), 462.0	29.0 % (27.0, 30.0), 1780.0	29.7 % (26.1 %, 33.4 %)
Ischemic heart disease	19.0 % (16.0, 21.0), 147.0	4.0 % (4.0, 5.0), 272.0	14.2 % (11.4 %, 16.9 %)
Mood disorders	22.0 % (19.0, 24.0), 171.0	12.0 % (11.0, 13.0), 747.0	9.6 % (6.6 %, 12.6 %)
Mean Charleston Comorbidity Index	0.75 (0.7, 0.8)	0.43 (0.4, 0.5)	0.3 (0.3, 0.4)
Aspirin	14.0 % (11.0, 16.0), 109.0	5.0 % (5.0, 6.0), 319.0	8.6 % (6.2 %, 11.1 %)
Smoker	38.0 % (35.0, 42.0), 305.0	25.0 % (24.0, 27.0), 1591.0	13.0 % (9.4 %, 16.5 %)
Alcohol-related disorders	4.0 % (3.0, 5.0), 32.0	1.0 % (1.0, 1.0), 69.0	2.9 % (1.5 %, 4.3 %)

[a] Difference of group means CI was calculated using a univariate Welch's T-test.

Table 2A
Multivariate logistic regression models for admission versus discharge at initial visit. Characteristics of biliary colic patients who presented to Emergency Department in Maryland 2016–2017*.

	Odds ratio of admission (95 % CI)
Obesity	1.38 (1.32, 1.44)
Age	1.44 (1.35, 1.53)
Ischemic heart disease	1.39 (1.30, 1.48)
Mood disorders	1.18 (1.13, 1.24)
Charleston Comorbidity Index (CMDF CCI Method)	1.17 (1.11, 1.23)
Alcohol-related disorders	1.20 (1.12, 1.27)
Hyperlipidemia	1.16 (1.09, 1.23)
Systemic hypertension	1.15 (1.08, 1.21)

* Calibration was calculated (Chi-statistic = 7022, P < 0.01, Hosmer-Lemeshow) and had good discrimination with a c-statistic (area under the curve) of 0.75.

Table 2B
Multivariate logistic regression for the subgroup of discharged patients (6243) to predict the outcome of cholecystectomy (2663) versus no cholecystectomy (3580)*.*

	Odds Ratio of Cholecystectomy (95 % CI)
Obesity	2.40 (2.33, 2.48)
Nicotine dependence	1.31 (1.25, 1.37)
Age	0.71 (0.66, 0.76)
Mood disorders	1.23 (1.17, 1.30)
Hyperlipidemia	1.23 (1.15, 1.32)
Charleston Comorbidity Index (CMDF CCI Method)	1.18 (1.11, 1.25)
Systemic hypertension	1.17 (1.09, 1.25)
Aspirin prescription	1.15 (1.07, 1.22)

* The adjusted model was calibrated well (Chi-statistic = 11.632, P > 0.99, Hosmer-Lemeshow) and had good discrimination with a c-statistic (area under the curve) of 0.74.

between groups (Table 3). The cost was significantly higher if patients were admitted on the initial visit rather than discharged ($9879.98 versus $1823.03). Notably, the distinction between initial admission to the hospital versus discharge seemed to affect the overall costs of care more than the difference between those who obtained an immediate versus delayed cholecystectomy. For patients who were initially admitted, there was no difference in the 1-year costs for patients who received a cholecystectomy as part of the first ED visit versus those who received a cholecystectomy at later date (Table 4).

Discussion

In this retrospective observational study, we attempted to analyze the one-year clinical outcomes and acquired direct costs of patients presenting to the ED with uncomplicated biliary colic and compare outcomes and costs for those who are initially admitted versus those discharged. Our analysis suggests that initial admission and hospitalization in patients with uncomplicated biliary colic was associated with fewer ED revisits and fewer new-onset cholecystitis cases but higher one-year costs. There was no difference in surgical rates but a large difference in cost between the group that was initially admitted versus discharged, indicating that disparities in cost are more likely related to hospital admission, and not surgery itself.

A priori, we hypothesized that race, insurance or zip code might predict hospital admission rates but we found no significant relationship. There was no association between race, sex, and income-stratified zip code with either admission or need for surgery. Other risk factors for admission included obesity and several co-morbidities. We found that obesity was associated with both admissions during initial ED visits and cholecystectomy after discharge. While obesity is a well-established risk factor for biliary colic [7], it is unknown if obesity directly increases the likelihood of a more severe disease course. We also found that the presence of an underlying mood disorder was significantly associated with hospital admission and prior research supports the link between obesity and mood disorders [10]. Other studies have found that underlying co-morbidities (specifically obesity, male sex, cardiovascular disease, diabetes mellitus, and cerebrovascular accidents) may increase the risk of complicated biliary colic [8,9]. Our analysis found that several of these comorbidities (specifically obesity, age, and cardiovascular disease) are also significant risk factors for hospital admission.

Limitations. This study analyzed data from a single state over three years, and thus could be limited by the short duration of follow-up and lack of prospective validation of the presented results. It is possible that patients followed up across state lines and we were not able to capture that data. Since the study analyzed billing and administrative data, it is limited by the nature of such data, including possible issues of data integrity, lack of clinical context, inconsistencies in documentation between facilities, etc. Both of these points may reduce the external validity of the results presented. Our results can be only interpreted as associations and not causations. There might be unobserved patient characteristics that explain the differences across the groups. Also, given the Hosmer Lemeshow chi square and p-value calculation, our regression model prompts greater caution in interpreting the results. For example, other factors that are unavailable in our dataset could underly a cost differential besides admission itself, including the overall medical complexity of patients who required admission or immediate surgery, psychosocial considerations influencing providers' confidence in outpatient follow-up, and patients' individual preferences in their care.

Table 3
One year clinical and cost outcomes per ED disposition.

	Admitted (N = 793) (%, 95 % CI, N)	Discharged (N = 6243) (%, 95 % CI, N)	Difference (95 % CI)
New cholecystitis	18.0 % (15.0, 20.0), 141.0	41.0 % (39.0, 42.0), 2530.0	−22.7 % (−25.7 %, −19.8 %)
ED revisits (#/1000 patients)	95.8 (70.7, 120.9)	198.0 (185.6, 210.4)	−102.1 (−130.1, −74.2)
Repeat Hospitalizations (#/1000 patients)	97.1 (74.2, 120.0)	80.9 (73.5, 88.3)	16.2 (−7.9, 40.3)
Cost (USD)	9880.0 (9317.4, 10,442.6)	1832.0 (1741.2, 1922.9)	8048.0 (7478.1, 8617.8)
Death	3.4 % (2.1, 4.7), 27.0	0.6 % (0.4, 0.8), 37.0	2.8 % (1.5 %, 4.1 %)

Difference of group means CI was calculated using a univariate Welch's T-test.

Table 4
Cost for patients initially admitted or discharged per timing of surgery.

	Cholecystectomy during initial hospitalization[a]	Cholecystectomy obtained after discharge[a]	No cholecystectomy one year after ED visit[a]
Admitted at initial visit	$10,072 ($9025, $11118), 183	$10,368 ($8907, $11830), 121	$8777 ($8220, $9334), 452
Discharged at initial visit	N/A	$3236 ($3046, $3426), 2625	$794 ($740, $849), 3523

[a] Formatted as Cost $ (95 % CI), N.

Conclusions. In our analysis of ED patients with uncomplicated biliary colic from a single state, the majority of patients do not receive a cholecystectomy within one year and hospital admission at the initial visit was not associated with an overall change in rates of cholecystectomy but was associated with increased costs. These findings inform our understanding of the long-term outcomes and are important considerations when communicating care options with ED patients with biliary colic. Future studies require higher-level evidence in the form of prospective or randomized control studies. Additionally, future studies should explore the risk factors associated with the progression of uncomplicated biliary colic to acute cholecystitis, gallstone pancreatitis, or cholangitis to provide a clinical decision-making framework for ED physicians.

CRediT authorship contribution statement

MM, AM, SN, YM, ACM were involved in the conception, the analysis, the writing and/or the editing of this manuscript.

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Ethical approval

This study was Institutional Review Board (IRB) exempt because datasets did not include personally identifiable health information.

Prior presentations

Oral abstract at ACEP 2021, Boston MA.
Poster Presentation at AMA Research Challenge 2021, Virtual.

Declaration of competing interest

None.

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Appendix A. List of variables used for summary table and logistic regression models, as well as variable source and calculation technique

Variable name	Variable calculation
Median Zip Income	Read from HCUP – income quartile of the patient's zip code
Age	Read from HCUP
Marital Status	Read from HCUP – options include: Widowed, Divorced, Married, Legally Separated, Single
Race	Read from HCUP – options include: Native American, White, Asian, African American, Hispanic, Other
Gender/Sex	Read from HCUP – signifies biological sex (male or female)
Payer	Read from HCUP – options include: Medicare, Medicaid, Private Insurance, Self-Pay, No Charge, or Other
Initial Discharge Quarter	Read from HCUP – fiscal quarter that of the patient's index ED visit
Charleston Comorbidity Index (CMDF CCI)	Calculated from ICD-10 codes using methods in Glassen et al
Appendicolith and bowel obstruction	Positive for ICD-10 codes K381, K56
Pregnancy status	Positive for ICD-10 codes O, Z33, Z34, Z3A
Systemic hypertension	Positive for ICD-10 codes I10 - I16, O10, O11, O13-O16
Obesity	Positive for ICD-10 codes O99.21, O66, Z68.3, Z68.4
Aspirin	Positive for ICD-10 code Z79.82
Nicotine dependence	Positive for ICD-10 codes F17, T65.2, Z87.891, Z72.0
Hyperlipidemia	Positive for ICD-10 codes E78.0-E78.5
Diabetes mellitus	Positive for ICD-10 codes E09-E11, E13, O24, Z86.32
Ischemic heart disease	Positive for ICD-10 codes I20-I25
Alcohol-related disorders	Positive for ICD-10 codes F10
Mood disorders	Positive for ICD-10 codes F2-F4

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