Incidence and Predictors of Readmissions in Acute Pancreatitis

A Nationwide Analysis

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Objectives: Acute pancreatitis (AP) is a common cause for hospitalization, and readmission is common, with variable associated risk factors for readmission. Here, we assessed the incidence and risk factors for readmission in AP in a large national database.

Methods: We analyzed data from the National Readmission Database during the year 2013. Index admissions with a primary discharge diagnosis of AP using the *International Classification of Diseases, Ninth Revision, Clinical Modification* were identified from January to November to identify 30-day readmission rates. Demographic, hospital, and clinical diagnoses were included in multivariate regression analysis to identify readmission risk factors.

Results: We identified 243,816 index AP discharges with 39,623 (16.2%) readmitted within 30 days. The most common reason for readmission was recurrent AP (41.5%). Increased odds of all-cause readmission were associated with younger age, nonhome discharge, increasing Charlson Comorbidity Index, and increased length of stay. Cholecystectomy during index admission was associated with reduced all-cause and recurrent AP readmissions (odds ratios of 0.5, and 0.35, respectively).

Conclusions: Readmission for AP is common, most often due to recurrent AP. Multiple factors, including cholecystectomy, during index admission, are associated with significantly reduced odds of all-cause and recurrent AP readmissions.

Key Words: 30-day readmission, acute pancreatitis, cholecystectomy, national readmission database

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Acute pancreatitis (AP), defined as the inflammation of pancreatic tissue, occurs because of autodigestion of the pancreas by pancreatic enzymes. Although the precise mechanism for tissue damage is unclear, the trypsin-centered hypothesis, where intracinar inflammation results from oxidative and endoplasmic stress as well as mitochondrial dysfunction, represents the most current understanding.[1] Despite improvement in overall care, including imaging and interventional techniques, AP is still a leading cause of nonmalignant gastrointestinal hospitalization, and in severe cases, mortality can be as high as 30% to 50%.[2] Incidence of AP worldwide ranges from 8 to 50 per 100,000 populations, with one of the highest incidences being in the United States.[3] There is a myriad of other causes for AP, including biliary disease most commonly, autoimmune disease, and toxins (such as alcohol), as well as iatrogenic causes, such as endoscopic retrograde cholangiopancreatography (ERCP) and medications.[4] Severity of AP is variable, and prognosis is largely dependent on the development of systemic dysfunction, persistent organ failure, and necrotizing disease with infection.[5–8] A significant percentage of episodes results in severe disease characterized by local and systemic complications with high mortality rates. Increased severity of disease has been associated with multiple factors, including increasing age, hypocalcemia, and presence of comorbidities such as hypertension and diabetes mellitus.[9,10] Risk stratification scores, such as the revised Atlanta criteria, determinant-based classification, PANC 3, and Acute Physiology and Chronic Health Evaluation II, can be used clinically to stratify patients and in turn determine severity and prognosis.[1,11,12]

Recurrence after resolution of an initial episode of AP is a major health care problem, with rates of readmission ranging from 15% to 29% in prior studies.[13–17] Various risk factors for readmission after an initial episode of AP have been identified, including the severity of the initial episode of AP, male sex, necrotizing pancreatitis, tobacco smoking, continued alcohol use, idiopathic pancreatitis, and delay in receiving adequate treatment for the underlying cause of AP, such as cholecystectomy in cases of acute biliary pancreatitis.[13–15,18–20] Hospital readmission within 30 days of discharge has also been shown to be associated with increased mortality.[21] While some consistent risk factors for readmission have been identified as previously mentioned, there are no large-scale population studies investigating the risk factors for readmission after an episode of AP. The goal of this study was to analyze the impact of patient demographic characteristics, as well as hospitalization and procedural factors, on readmissions within 30 days after an initial hospitalization for AP using a large population-based national readmission database from the United States.

MATERIALS AND METHODS

Study Design and Data Source

This was a retrospective longitudinal study of admissions to acute care hospitals for AP. Data on hospital admissions of all adult patients (≥18 years old) were extracted from the National Readmission Database (NRD) from the year 2013. The NRD is the largest publicly available all-payer inpatient discharge database in the United States. Developed and maintained by the Agency for Healthcare Research and Quality, it comprises inpatient discharges

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The National Readmission Database consists of deidentified data with no risk of loss of confidentiality. The data user agreement was completed with the Agency for Healthcare Research and Quality before using the National Inpatient Sample database.

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from a subset of US hospitals and is meant to be representative of nationwide acute care hospitalizations. The database contains deidentified information regarding each hospitalization, including demographic characteristics, admission status, comorbidities, discharge diagnoses, procedures performed, outcomes, and costs of hospitalization. Admissions under observation status, short-term rehabilitation hospitals, long-term non–acute-care hospitals, psychiatric hospitals, and alcoholism or chemical dependency units are not included.

Study Population

We used *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes to identify all hospitalized adults at least 18 years old who were discharged with a primary diagnosis of AP (*ICD-9-CM* code 577.0) and survived their first admission. Admissions in the NRD have listed a primary discharge diagnosis and up to 24 secondary discharge diagnoses and can have up to 15 procedure codes associated with the discharge, as well as the day of the procedure conducted. Admissions were classified as having AP by querying all diagnostic codes for the *ICD-9-CM* codes corresponding to AP. All diagnostic and procedural codes used for classifications have been described by Krishna et al.[22]

Definition of Variables, Comorbidities, and Other Covariates

The NRD contains demographic information on all hospitalizations, including age, sex, income, and primary and secondary insurance. It also contains hospital information regarding bed size, location, teaching status, and ownership. Charlson Comorbidity Index (CCI) was calculated and used for comorbidity assessment. Apart from the comorbidities scored by the CCI, we also identified the presence of specific comorbidities that may have played an important role in the severity of AP, including acute renal failure, respiratory failure, and the frequency of various supportive interventions as surrogate indicators of comorbid disease, such as endotracheal intubation.

Outcomes

Our main outcome was to identify predictors of all-cause 30-day readmissions and recurrent AP readmissions in multivariate regression analysis. We also analyzed the overall rates of 30-day all-cause readmissions after index hospitalization for AP.

Statistical Analysis

Data are presented as mean (standard deviation [SD]) for continuous variables or weighted frequency (%) for categorical variables. A univariate analysis was performed to assess differences between the 2 groups (no 30-day readmission vs yes); continuous variables were compared using t tests, and categorical variables were compared using χ^2 tests. In addition, multivariable analysis was performed to assess differences between the groups in terms of the outcomes of interest while adjusting for patient and hospital characteristics. Logistic regression analysis was used to model 30-day readmission risk. The NRD is based on a complex sampling design that includes stratification, clustering, and weighting; SAS Survey procedures facilitate the unbiased assessment of population estimates. $P < 0.001$ was considered statistically significant because of the large sample size; this significance criterion has been used by previous National Inpatient Sample studies. All analyses were performed using SAS (version 9.4; The SAS Institute, Cary, NC).

RESULTS

Rates of Readmission and Reason for Readmission

There were of total of 35,580,348 patient records in the NRD. From this, 243,816 index AP discharges were identified during the study period. Using a threshold of 30 days to define readmission, 39,623 patients (16.2%) were readmitted within 30 days for all causes, and 17,588 (7.2%) were readmitted with primary diagnosis of AP. Recurrent AP was the most common reason for readmission, accounting for 41.5% of cases. Table 1 comprises the major causes of readmission within 30 days. Etiologies for pancreatitis during the index admission were difficult to ascertain from this retrospective database, but 20% of patients had cholelithiasis, 5.14% had bile duct obstruction, 16.5% had chronic pancreatitis, and 31.5% had alcohol-related disease listed as secondary diagnosis.

Baseline Patient Characteristics

Tables 2 and 3 compare the demographic baseline characteristics and comorbidities of patients admitted with a primary diagnosis of AP during index hospitalization, separated by those not readmitted within 30 days and those readmitted within 30 days. The mean age of patients who were readmitted versus not was 51.5 (SD, 16.1) years versus 52.4 (SD, 16.9) years. Distribution of disease severity, using the calculated CCI, between the 2 groups of patients differed significantly as shown, with those readmitted in 30 days having higher CCI scores. Importantly, among those who had cholecystectomy at the index admission, approximately 5% were readmitted compared with 11.8% who were not readmitted. As displayed in Table 3, multiple comorbidities were associated with higher rates of 30-day readmission as compared with no readmission.

Predictors of Readmission, All Etiologies of Pancreatitis

Results of the multivariate logistic regression analysis to identify predictors of all-cause readmission are displayed in Table 4, whereas predictors of AP-specific readmission are displayed in Table 5.

Demographic and Patient-Level Factors

The odds of all-cause readmission decreased with patient's advancing age. This age trend was also true for AP-specific readmissions. There was no difference in all-cause readmissions in females compared with males (odds ratio [OR], 0.9; 95% confidence interval

TABLE 1. Most Common Reasons for 30-Day Readmission for AP

Etiology	Percent
AP	41.47
Chronic pancreatitis	4.43
Pancreatic cyst	2.1
Biliary tract disease	4.14
Septicemia	3.52
Alcohol-related disorders	2.74
Diabetes mellitus with complications	2.29
Abdominal pain	2.27
Complications from surgical procedure	1.92
Acute and unspecified renal failure	1.65
Fluid and electrolyte disorders	1.31
Clostridium difficile	0.85

TABLE 2. Demographic Characteristics of the AP Patients During Index Admissions Based on Their 30-Day Readmission Status

	30-d Readmission		
	No	Yes	
Demographic Characteristics	**n (%)**	**n (%)**	***P***
Sex, female	96,951.0 (47.5)	17,938.0 (45.3)	<0.0001
Age group, y			<0.0001
18–44	68,798.0 (33.7)	13,945.0 (35.2)	
45–64	87,059.0 (42.6)	17,763.0 (44.8)	
65–84	40,511.0 (19.8)	6612.0 (16.7)	
>84	7825.0 (3.8)	1303.0 (3.3)	
Weekend, yes	53,486.0 (26.2)	10,654.0 (26.9)	0.1065
Hospital bed size			<0.0001
Small	30,432.0 (14.9)	5327.0 (13.4)	
Moderate	53,096.0 (26.0)	9425.0 (23.8)	
Large	120,666.0 (59.1)	24,871.0 (62.8)	
Hospital control			0.5323
Government	26,679.0 (13.1)	5302.0 913.4)	
Private, not for profit	145,100.0 (71.1)	27,899.0 (70.4)	
Private, profit	32,415.0 (5.9)	6422.0 (16.2)	
Teaching status			<0.0001
Metropolitan, nonteaching	84,142.0 (41.2)	15,337.0 (38.7)	
Metropolitan teaching	88,463.0 (43.3)	18,801.0 (47.4)	
Nonmetropolitan hospital	31,589.0 (15.5)	5485.0 (13.8)	
Median household income			<0.0001
0–25th percentile	62,681.0 (31.2)	12,872.0 (33.0)	
26th–50th percentile	55,867.0 (27.8)	11,135.0 (28.5)	
51st–75th percentile	47,444.0 (23.6)	8830.0 (22.6)	
76th–100th percentile	34,905.0 (17.4)	6214.0 (15.9)	
Payer			<0.0001
Medicare	65,260.0 (32.0)	13,951.0 (35.3)	
Medicaid	32,560.0 (16.0)	8946.0 (22.6)	
Private insurance	65,059.0 (31.9)	9242.0 (23.4)	
Uninsured/other	40,980.0 (20.1)	7427.0 (18.8)	
Disposition			<0.0001
Routine	179,281.0 (87.80)	31,316.0 (79.0)	
Short-term hospital	1712.0 (0.8)	523.2 (1.3)	
Facility	7752.0 (3.8)	2137.0 (5.4)	
Home health care	9420.0 (4.6)	3277.0 (8.3)	
Other	6028.0 (3.0)	2369.0 (6.0)	
CCI score			<0.0001
0	90,883.0 (44.5)	14,458.0 (36.5)	
1	61,436.0 (30.1)	11,349.0 (28.6)	
>1	51,876.0 (25.4)	13,816.0 (34.9)	
Cholangitis	1859.0 (0.9)	423.1 (1.1)	0.073
CBD obstruction	10,062.0 (4.9)	2474.0 (6.2)	<0.0001
Pancreatic cancer	454.7 (0.2)	252.8 (0.6)	<0.0001
Alcoholism	63,272.0 (31.0)	13,342.0 (33.7)	<0.0001
Cholecystectomy	24,108.0 (11.8)	2029.0 (5.1)	<0.0001
Percutaneous biliary drainage	373.8 (0.2)	107.3 (0.3)	0.0379
AKI	16,819.0 (8.2)	4739.0 (12.0)	<0.0001
ARF	7463.0 (3.7)	1834.0 (4.6)	<0.0001
Smoking	78,153.0 (38.3)	16,527.0 (41.7)	<0.0001
ERCP	29,505.0 (14.4)	10,885.0 (27.5)	<0.0001
Detox	4873.0 (2.4)	1312.0 (3.3)	<0.0001
Pancreatectomy	962.1 (0.5)	505.8 (1.3)	<0.0001
Cholelithiasis	43,113.0 (21.1)	43,113.0 (21.1)	<0.0001

AKI indicates acute kidney injury; ARF, acute respiratory failure; CBD, common bile duct.

TABLE 3. Comorbidities of the AP Patients During Index Admissions Based on Their 30-Day Readmission Status

	30-d Readmission		
	No	Yes	
Comorbidities	n (%)	n (%)	*P*
AMI	6633.0 (3.2)	1602.0 (4.0)	<0.0001
CHF	10,394.0 (5.1)	3099.0 (7.8)	<0.0001
PVD	6654.0 (3.3)	1554.0 (3.9)	<0.0001
CEVD	2605.0 (1.3)	646.4 (1.6)	0.0006
Dementia	1297.0 (0.6)	263.8 (0.7)	0.6769
COPD	30,509.0 (14.9)	7378.0 (18.6)	<0.0001
Rheumatoid disease	4120.0 (2.0)	1032.0 (2.6)	<0.0001
Peptic ulcer disease	3488.0 (1.7)	879.0 (2.2)	<0.0001
Mild liver disease	30,509.0 (14.9)	5979.0 (15.1)	0.6745
Diabetes	48,412.0 (23.7)	9659.0 (24.4)	0.1329
Diabetes + complications	5498.0 (2.7)	1579.0 (4.0)	<0.0001
Hemi or paraplegia	615.3 (0.3)	204.0 (0.5)	<0.0001
Renal disease	15,837.0 (7.8)	5231.0 (13.2)	<0.0001
Cancer	3188.0 (1.6)	1121.0 (2.8)	<0.0001
Moderate/severe liver disease	2751.0 (1.3)	1041.0 (2.6)	<0.0001
Metastatic cancer	1444.0 (0.7)	570.6 (1.4)	<0.0001
AIDS	679.2 (0.3)	288.9 (0.7)	<0.0001

AMI indicates acute myocardial infarction; CEVD, cerebrovascular disease; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease.

[CI], 0.9–0.1), but females were less likely to be readmitted for AP (OR, 0.87; 95% CI, 0.8–0.9). Patients with private insurance had a lower likelihood of all-cause readmission (OR, 0.6; 95% CI, 0.6–0.7) and AP-specific readmission (OR, 0.66; 95% CI, 0.6–0.7) compared with Medicare patients. Uninsured patients had lower odds of all-cause and AP-specific readmissions as well compared with Medicare patients, whereas there was no difference between Medicare and Medicaid patients. There was no relationship between median household income and odds of readmission.

Hospitalization-Level Factors

Odds of all-causes readmission for patients discharged to short-term hospitals (OR, 1.7; 95% CI, 1.4–2.0), to nursing facilities (OR, 1.4; 95% CI, 1.3–1.5), or with home health care (OR, 1.68; 95% CI, 1.55–1.84) were higher compared with patients routinely discharged home, but interestingly odds of readmission for AP were lower for patients who were discharged to a facility (OR, 0.72; 95% CI, 0.59–0.87) compared with routine home discharge. Patients who had a hospital stay of 6 days or more had an increased likelihood of readmission compared with those with a length of stay (LOS) of less than 6 days (OR, 1.5; 95% CI, 1.4–1.5). Weekend admissions were associated with a trend toward, but not statistically significant, increase in the risk of all-cause and AP-specific readmissions.

Comorbidities

A rising CCI correlated with a higher odd for all-cause of readmission as shown by an OR of 1.08 (95% CI, 1.03–1.14) for CCI of 1 and OR of 1.44 (95% CI, 1.36–1.51) for scores greater than 1 when compared with CCI of 0, but there was no difference in AP-specific readmissions as shown by an OR of 0.99 (95% CI, 0.92–1.06) for CCI of 1 and OR of 0.97 (95% CI, 0.89–1.04) for scores greater than 1 when compared with CCI of 0. Patient who had acute kidney injury and acute respiratory failure had higher chance of all-cause, but not AP-specific, readmission. Chronic pancreatitis was associated with a significant increase in the risk of all-cause and AP-specific readmissions.

Procedural Factors

Odds of all-cause readmission were higher if the patient had bile duct obstruction in index hospitalization (OR, 1.3; 95% CI, 1.1–1.4), whereas odds of all-cause and AP-specific readmissions were decreased in patients who had had cholecystectomy during that admission with ORs of 0.46 (95% CI, 0.42–0.51) and 0.35 (95% CI, 0.29–0.41), respectively. Because cholecystectomy was associated with reduced readmission rates of 54% for all-cause and 65% for AP-specific readmissions, we evaluated the predictors for cholecystectomy in index hospitalization (Table 6). Females, younger patients, and those with private insurance were more likely to receive a cholecystectomy, whereas patients with higher CCI, chronic pancreatitis, alcohol abuse, and pancreatic cancer were less likely to receive cholecystectomy. Cholelithiasis was the strongest predictor for receiving cholecystectomy with an OR of 70.08.

Predictors of Readmission by Etiology of Pancreatitis

Multivariate analyses for predictors of all-cause readmission based on etiology of index episode of pancreatitis (biliary, alcoholic, or acute on chronic) are presented in Supplementary Tables 1 to 3, http://links.lww.com/MPA/A619. Of note, cholecystectomy was associated with significantly reduced odds of readmission in biliary pancreatitis (OR, 0.3; 95% CI, 0.2–0.3) and with a trend toward reduction in odds of readmission in alcoholic pancreatitis, but not reaching significance (OR, 0.6; 95% CI, 0.4–0.9). There was no

TABLE 4. Multivariate Analysis for Predictors of All-Cause 30-Day Readmission for the AP Patients

Variable	OR	Lower CI	Upper CI	*P*
Sex				
Male (reference)				
Female	1.0	0.9	1.0	0.3111
Age group, y				
18–44 (reference)				
45–64	0.9	0.8	0.9	<0.0001
65–84	0.6	0.5	0.6	<0.0001
≥85	0.5	0.4	0.6	<0.0001
Payer				
Medicare (reference)				
Medicaid	1.0	1.0	1.1	0.614
Private insurance	0.6	0.6	0.7	<0.0001
Uninsured/other	0.7	0.7	0.8	<0.0001
Bed size				
Small bed size (reference)				
Medium	1.0	0.9	1.0	0.4086
Large	1.1	1.0	1.2	0.0111
Disposition				
Routine (reference)				
Short-term hospital	1.7	1.4	2.0	<0.0001
Facility	1.4	1.3	1.5	<0.0001
Home health care	1.7	1.5	1.8	<0.0001
Other	2.1	1.9	2.3	<0.0001
Teaching status				
Metropolitan, nonteaching (reference)				
Metropolitan teaching	0.9	0.9	1.0	0.0041
Nonmetropolitan hospital	0.9	0.8	0.9	0.001
Owner				
Government (reference)				
Private, not for profit	1.0	0.9	1.1	0.8143
Private, profit	1.1	1.0	1.2	0.1105
Median household income				
0–25th percentile (reference)				
26th–50th percentile	1.0	1.0	1.1	0.1401
51st–75th percentile	1.0	1.0	1.1	0.3283
76th–100th percentile	1.0	1.0	1.1	0.317
CCI score				
0 (reference)				
1	1.1	1.0	1.1	0.0022
>1	1.4	1.4	1.5	<0.0001
Admission day				
Nonweekend (reference)				
Weekend	1.1	1.0	1.1	0.0111
Length of stay				
<7 (reference)				
>6	1.5	1.4	1.5	<0.0001
Cholelithiasis				
No (reference)				
Yes	1.0	0.9	1.0	0.2801
Chronic pancreatitis				
No (reference)				
Yes	1.9	1.8	2.0	<0.0001
Cholecystectomy				
No (reference)				
Yes	0.5	0.4	0.5	<0.0001
Cholangitis				
No (reference)				
Yes	1.2	1.0	1.5	0.0872
Bile duct obstruction				
No (reference)				
Yes	1.3	1.1	1.4	<0.0001
Pancreatic cancer				
No (reference)				
Yes	2.2	1.7	2.9	<0.0001
Alcohol abuse				
No (reference)				
Yes	0.9	0.9	1.0	0.0008
Pancreatectomy				
No (reference)				
Yes	1.7	1.4	2.1	<0.0001
Acute kidney injury				
No (reference)				
Yes	1.2	1.1	1.3	<0.0001
Acute respiratory failure				
No (reference)				
Yes	0.9	0.9	1.0	0.1928
Morbid obesity				
No (reference)				
Yes	0.9	0.8	1.0	0.0021

effect of cholecystectomy on odds of readmission in acute on chronic pancreatitis.

DISCUSSION

In this study of a large national readmission database in the United States, we identified an all-cause 30-day readmission rate of 16.2%. This trend is along the lower end of the range identified in prior studies, where readmission rates ranged from 15% to 29%.[13–17] Our findings are likely more representative of the actual 30-day readmission rate after AP in the United States, given the large sample size and representative distribution of hospitals and states included in the NRD. A total of 7.2% of all admissions were readmitted with a primary diagnosis of AP, representing 41.5% of all readmissions, easily representing the most common cause for readmission.

In multivariate regression analyses, multiple factors impacted the odds of readmission. In analyzing demographic factors, readmissions were largely driven by the younger age group, as patients aged 18 to 44 years had significantly higher rates of readmission compared with every group of older patients. It is unclear why this group was readmitted at a higher rate; possible explanations include continued exposure to specific risk factors in the younger population, death in older patients removing them from being available to be included in readmission statistics, and differing etiologies of AP in both populations.[23] Younger patients with AP were also found to have higher rates of readmission in another study.[15] Male patients were more likely to be readmitted for acute AP, consistent with a prior study,[14] but there were no sex differences for all-cause readmissions. Patients with private insurance had a lower likelihood of readmission compared with Medicare

TABLE 5. Multivariate Analysis for Predictors of Recurrent AP 30-Day Readmission for the AP Patients

Variable	Point Estimate	95% CI	*P*
Sex			
Male (reference)			
Female	0.87	0.82–0.92	<0.0001
Age group, y			
18–44 (reference)			
45–64	0.79	0.74–0.86	<0.0001
65–84	0.45	0.39–0.51	<0.0001
≥85	0.35	0.27–0.44	<0.0001
Payer			
Medicare (reference)			
Medicaid	1.04	0.93–1.17	0.4696
Private insurance	0.66	0.59–0.73	<0.0001
Uninsured/other	0.82	0.74–0.91	0.0003
Bed size			
Small bed size (reference)			
Medium	0.96	0.86–1.07	0.4266
Large	1.03	0.93–1.14	0.6411
Disposition			
Routine (reference)			
Short-term hospital	1.39	1.08–1.79	0.0118
Facility	0.72	0.59–0.87	0.0009
Home health care	1.32	1.14–1.53	0.0002
Other	1.98	1.75–2.23	<0.0001
Teaching status			
Metropolitan, nonteaching (reference)			
Metropolitan teaching	0.95	0.88–1.02	0.1605
Nonmetropolitan hospital	0.96	0.86–1.07	0.4819
Owner			
Government (reference)			
Private, not for profit	0.98	0.90–1.07	0.6733
Private, profit	1.00	0.90–1.12	0.9793
Median household income			
0–25th percentile (reference)			
26th–50th percentile	1.11	1.02–1.21	0.0151
51st–75th percentile	1.08	1.00–1.18	0.0632
76th–100th percentile	1.07	0.97–1.17	0.1622
CCI score			
0 (reference)			
1	0.99	0.92–1.06	0.7402
>1	0.97	0.89–1.04	0.3735
Admission day			
Nonweekend (reference)			
Weekend	1.07	1.01–1.13	0.0317
Length of stay			
<7 (reference)			
>6	1.33	1.23–1.44	<0.0001
Cholelithiasis			
No (reference)			
Yes	0.88	0.79–0.98	0.0159
Chronic pancreatitis			
No (reference)			
Yes	2.43	2.27–2.61	<0.0001
Cholecystectomy			
No (reference)			
Yes	0.35	0.29–0.41	<0.0001
Cholangitis			
No (reference)			
Yes	0.71	0.47–1.08	0.1065
Bile duct obstruction			
No (reference)			
Yes	1.14	1.01–1.28	0.0388
Pancreatic cancer			
No (reference)			
Yes	1.05	0.64–1.70	0.8558
Alcohol abuse			
No (reference)			
Yes	0.99	0.92–1.06	0.7279
Pancreatectomy			
No (reference)			
Yes	1.07	0.78–1.48	0.6699
Acute kidney injury			
No (reference)			
Yes	1.03	0.90–1.18	0.6827
Acute respiratory failure			
No (reference)			
Yes	0.95	0.82–1.10	0.4559
Morbid obesity			
No (reference)			
Yes	0.94	0.83–1.06	0.2882

patients for all-cause and AP-specific readmissions. This is consistent with national data indicating higher readmission rates in patients on Medicare compared with those on private insurance.[24] This seems to be independent of income, as there was no relationship between median household income and odds of readmission.

When analyzing hospitalization factors, weekend admission was associated with a trend toward higher rates of readmission. Previous studies have found worse outcomes when patients were admitted on the weekend in specific disease states; however, general medicine patients did not have higher rates of readmission on the weekends in a prior study.[25,26] In a Japanese database study, no differences in mortality rates, LOS, or total costs were seen between weekday and weekend admissions in AP,[27] and a UK population study did not find increased mortality in AP patients admitted on the weekend.[28] Possible reasons for increased readmission rates after a weekend admission in our study include decreased staffing on weekends, decreased access to specialists, and subsequent delays in care. Given the importance of early aggressive management in AP, a weekend admission may result in delay in care that could lead to adverse patient complications.

Discharge to long-term-care facilities was associated with higher rates of all-cause readmission compared with routine home discharges. This could reflect increased frailty and comorbidities in patients who required long-term care as compared with patients able to be discharged home. Discharge to long-term care has previously been associated with higher rates of 30-day readmission in older patients.[29] Interestingly, in the cases of AP-specific

TABLE 6. Multivariate Analysis for Predictors of Cholecystectomy in Index Hospitalization for AP

Variable	OR	Lower CI	Upper CI	*P*
Sex				
Male (reference)				
Female	1.14	1.07	1.22	<0.0001
Age group, y				
18–44 (reference)				
45–64	0.81	0.75	0.87	<0.0001
65–84	0.86	0.77	0.96	0.0062
≥85	0.42	0.36	0.50	<0.0001
Payer				
Medicare (reference)				
Medicaid	1.02	0.90	1.15	0.7938
Private insurance	1.20	1.08	1.34	0.001
Uninsured/other	1.13	1.00	1.28	0.0447
Bed size				
Small bed size (reference)				
Medium	1.17	0.99	1.39	0.0608
Large	1.26	1.08	1.47	0.0038
Disposition				
Routine (reference)				
Short-term hospital	0.17	0.11	0.26	<0.0001
Facility	0.66	0.57	0.76	<0.0001
Home health care	0.78	0.69	0.90	0.0004
Other	0.07	0.04	0.12	<0.0001
Teaching status				
Metropolitan, nonteaching (reference)				
Metropolitan teaching	1.16	1.03	1.29	0.0109
Nonmetropolitan hospital	0.82	0.68	0.98	0.0304
Owner				
Government (reference)				
Private, not for profit	1.08	0.92	1.26	0.3666
Private, profit	1.18	0.99	1.41	0.0633
Median household income				
0–25th percentile (reference)				
26th–50th percentile	0.98	0.89	1.07	0.6236
51st–75th percentile	0.95	0.86	1.05	0.3223
76th–100th percentile	0.85	0.75	0.96	0.0091
CCI score				
0 (reference)				
1	0.77	0.72	0.83	<0.0001
>1	0.55	0.50	0.60	<0.0001
Admission day				
Nonweekend (reference)				
Weekend	1.07	1.01	1.14	0.0255
Length of stay				
<7 (reference)				
>6	1.92	1.75	2.10	<0.0001
Cholelithiasis				
No (reference)				
Yes	70.08	64.00	76.73	<0.0001
Chronic pancreatitis				
No (reference)				
Yes	0.40	0.34	0.47	<0.0001
Cholangitis				
No (reference)				
Yes	0.82	0.66	1.00	0.0512
Bile duct obstruction				
No (reference)				
Yes	1.20	1.04	1.39	0.0124
Pancreatic cancer				
No (reference)				
Yes	0.06	0.01	0.43	0.0054
Alcohol abuse				
No (reference)				
Yes	0.26	0.23	0.29	<0.0001
Pancreatectomy				
No (reference)				
Yes	3.89	2.09	7.26	<0.0001
Acute kidney injury				
No (reference)				
Yes	0.74	0.66	0.84	<0.0001
Acute respiratory failure				
No (reference)				
Yes	0.83	0.70	0.97	0.0222
Morbid obesity				
No (reference)				
Yes	1.11	1.00	1.23	0.0551

readmissions, discharge to facility was associated with lower odds of readmission, potentially due to a removal of a specific AP risk factor, such as alcohol, in patients managed at a facility as opposed to home. However, when stratified by cause of pancreatitis, the association of facility discharge with reduced rates of readmission was strongest in the acute on chronic pancreatitis group, as opposed to alcoholic pancreatitis.

In this database, we were not able to classify severity of AP because there is no separate *ICD-9* code for severe AP. However, when looking at the CCI, increasing scores were associated with increased rates of all-cause readmission, which may be reflective of overall illness severity and patient comorbidities. Patients who had acute renal failure and acute respiratory failure during index hospitalization were also more likely to be readmitted for any cause, but not for AP. Readmission after increased disease severity is consistent with another study that was able to risk-stratify patients and found that those with higher Ranson scores (but not the Bedside Index for Severity in Acute Pancreatitis or Acute Physiology and Chronic Health Evaluation) were more likely to be readmitted.[14] They also found patients with intensive care unit stay, organ failure, local complications, and increased LOS, likely all reflecting higher disease severity, were more likely to be readmitted. Our study also found that increased LOS was associated with higher odds of all-cause and AP-specific readmissions, and intensive care unit stay trended toward higher odds of readmission, but it was not statistically significant.

Interestingly, in our study, alcohol use was not associated with increased risk of all-cause or AP-specific readmission, which is converse to multiple previous studies.[13–16] We do not have a clear explanation for why this was the case; potentially, patients who resumed alcohol use were less likely to return to seek care because of continued substance use or because of limited resources or ability to seek care.

An important finding in this study is that the odds of all-cause and AP-specific readmissions were decreased in patients who had had cholecystectomy during the index admission. In addition, when stratifying for the initial etiology of pancreatitis, only those with biliary pancreatitis achieved a statistically significant reduction in readmission rate from cholecystectomy during index admission. Taken together, these findings are consistent with previous studies that found a reduction in readmissions with cholecystectomy during index admission for AP,[30] and multiple guidelines recommend performing cholecystectomy during index admission in cases of suspected biliary pancreatitis.[31,32] When looking specifically at acute biliary pancreatitis, a previous study found reduced readmission rates when either cholecystectomy or ERCP was performed.[33] In addition, a randomized trial comparing cholecystectomy during index hospitalization with delayed cholecystectomy found that surgery during the initial stay was associated with fewer gallstone-related readmissions and was more cost-effective, compared with delayed surgery.[34] These findings were again reinforced in a retrospective analysis.[35]

Hospital systems will need to be designed to assist with performing cholecystectomy during index admission, because this can occasionally be resource intensive if surgical teams are directed away from their normal operating schedules. One potential program is the implantation of an acute care surgical service and admission of patients with biliary pancreatitis to this service, which in a retrospective analysis was associated with higher rates of cholecystectomy done during index admission, along with lower rates of readmissions and ED visits compared with prior to the existence of the service.[36] In our study, we found that males, older patients, and patients with a higher CCI were less likely to undergo cholecystectomy at index admission, so this helps identify a population that may need more close coordination on admission for AP with the surgical team to assess their ability to undergo surgery during admission. In addition, there was a higher odd of cholecystectomy in metropolitan (teaching and nonteaching) hospitals compared with nonmetropolitan hospitals, as well as in large hospitals compared with small hospitals. This suggests that patients hospitalized with AP may be better served at a larger, metropolitan hospital which may have adequate resources for performing cholecystectomies during index admission. Lastly, patients with private insurance were more likely to undergo cholecystectomy compared with Medicare patients, offering a specific population where quality improvement initiatives could be targeted.

The strength of this study is the large database sample size, allowing for robust associations to be obtained. Weaknesses of this study include the retrospective nature of the data collected, meaning only associations and not causality could be inferred; reliance on *ICD-9* coding, which may be inaccurate; lack of clinical data such as laboratory values in the database; and limited time frame of the data (data available only for 2013). Future large-scale prospective studies are needed to further elucidate the specific risk factors for readmission in AP, ideally to infer causation, as well as to develop a risk-stratification model that could be used clinically.

CONCLUSIONS

In this large, nationally representative retrospective database analysis of hospitalizations for AP, readmission for AP is common, occurring in 16.7% of cases. Almost half of readmissions are due to recurrent AP. Cholecystectomy during index admission was significantly associated with a lower risk of all-cause and AP-specific readmission, with the strongest reduction in risk of readmission in the setting of biliary pancreatitis during admission, supporting current international guidelines recommending cholecystectomy during admission for acute biliary pancreatitis. Factors that were associated with higher risk of all-cause readmission included younger age, nonprivate insurance, increasing CCI, and overall LOS. Even though increased LOS may be related to severity of disease, early collaboration of the surgical and medical teams to expedite management may prove valuable in reducing the rates of readmissions. Planning of early and regular follow-up of patients with increased risk of readmission, such as those with higher burden of comorbid disease, may help reduce readmission and associated increased health care costs.

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