

# Incidence and Predictors of 30-Day Readmission Among Patients Hospitalized for Chronic Pancreatitis

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**Objectives:** Chronic pancreatitis (CP) hospitalizations along with associated morbidity and costs are increasing. The goal of this study was to use the National Readmission Database to identify the incidence and risk factors for 30-day readmissions among patients with CP.

**Methods:** We performed a retrospective analysis of National Readmission Database from January 2013 to December 2013 to determine patient demographic and clinical characteristics predictive of 30-day hospital readmission for adult patients (aged >18 years) discharged with a principle diagnosis of CP. A survey logistic regression model was used to determine the predictive value of selected variables for 30-day readmission.

**Results:** In 2013, 12,545 admissions with primary diagnosis of CP were noted, and 30.4% were readmitted within 30 days. Cholecystectomy (odds ratio [OR], 0.53;  $P = 0.0024$ ) or endoscopic retrograde cholangiopancreatography (OR, 0.70;  $P = 0.01$ ) during index admission was associated with decreased all-cause readmissions. Pancreatectomy during index admission was associated with reduced (OR, 0.2;  $P = 0.0005$ ) pancreatitis-related readmissions.

**Conclusions:** Hospital readmissions for CP are frequent and pose a significant healthcare burden. Performing cholecystectomy, endoscopic retrograde cholangiopancreatography, or pancreatectomy during index admission was associated with reduced odds of readmission.

**Key Words:** chronic pancreatitis, 30-day readmission, NRD database, pancreatectomy, pancreatic resection

(*Pancreas* 2018;47: 1008–1014)

Chronic pancreatitis (CP) is a progressive inflammatory disorder of the pancreatic parenchyma characterized by abdominal pain, malabsorption, and progressive fibrosis of the pancreas, leading eventually to exocrine and endocrine pancreatic

insufficiency.<sup>1</sup> In one population-based study, prevalence of CP was estimated to be 42 per 100,000, and the incidence of CP was estimated at 4 per 100,000.<sup>2</sup> Although the underlying etiologies for CP are multifactorial, rising trends in the incidence of CP may be attributable to a rise in heavy alcohol consumption.<sup>3,4</sup>

Hospitalization rates are rising among patients with CP in many Western nations, with an aggregate cost of \$2 billion for hospitalizations in the United States.<sup>5</sup> Despite the significant overlap between acute pancreatitis (AP) and CP, especially in the early stages of CP, there are significant differences in the challenges these patients face, as well as the interventions that are effective. Patients with CP often experience significant pain requiring narcotics, and studies have found constant pain and high-dose narcotic use to be associated with increased rates of hospitalization, with pain often being the primary reason for hospitalization.<sup>6,7</sup> Surgical management of CP can be considered in appropriately selected patients as a possible intervention to improve pain and quality of life.<sup>8</sup>

There are limited studies investigating readmissions in patients with CP. One database study of approximately 1000 patients found that the majority of patients, 88.3%, had a procedure or readmission over approximately 4 years of follow-up, with 58% readmitted with AP or CP.<sup>9</sup> In that study, predictors of readmission were alcoholism and advancing age. In another study evaluating CP and AP combined, the readmission rate was 15% at 30 days, CP was the most common reason for readmission (33.5% of patients), and predictors of readmission included concomitant liver disease, pseudocyst or pancreatic tumor, and alcohol, tobacco, or substance abuse.<sup>10</sup> A recent study noted that although 30-day readmissions after complex gastrointestinal surgery were approximately 15%, in CP patients undergoing duodenal-preserving pancreatic head resection or pancreaticoduodenectomy, 30-day readmission rates were more than doubled at 30.4% and 33.3%, respectively.<sup>11</sup>

To our knowledge, there are no large-scale studies that have specifically studied the 30-day readmission rates in CP patients. This study examines the rates of all-cause and CP-specific 30-day readmission rates in patients initially hospitalized for CP, using the Nationwide Readmission Database (NRD), the largest all-payer inpatient discharge database in the United States. In addition, we examined specific variables in the NRD to identify factors associated with increased or reduced odds of all-cause and CP-specific readmissions.

## MATERIALS AND METHODS

### Study Design and Data Source

This was a retrospective longitudinal study of admissions to acute care hospitals for a primary diagnosis of CP. Data on hospital admissions of all adult patients (18 years or older) was extracted from the NRD<sup>12</sup> during the year 2013. The NRD<sup>6</sup> is the largest publicly available all-payer inpatient discharge database in the United States developed and maintained by the agency for

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Received for publication October 1, 2017; accepted June 6, 2018.

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Author contributions: S.K.G. conceived the idea, designed the study, conducted the analysis, and contributed to the writing of the manuscript; S.S., J.P.C., C.A., D.S., V.W., and R.S. contributed to the writing of the manuscript and the critical appraisal of manuscript; M.R.S. contributed to the critical appraisal of manuscript and the final approval of manuscript.

The authors declare no conflict of interest.

Supplemental digital contents are available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site ([www.pancreasjournal.com](http://www.pancreasjournal.com)).

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DOI: 10.1097/MPA.0000000000001113

Healthcare Research and Quality,<sup>13</sup> comprising all inpatient discharges from a subset of nationally representative acute care US hospitals. Admissions under observation status, short-term rehabilitation hospitals, long-term nonacute care hospitals, psychiatric hospitals, and alcoholism or chemical dependency units are not included. This study was exempt from institutional review board review given the NRD contains de-identified patient data and is publicly available.

### Study Population

Patients aged 18 years and older with principal diagnosis of CP based on an *International Classification of Diseases, Ninth Edition (ICD-9)* code of 577.1, discharged alive between January and November ( $1 \leq \text{DMONTH} \leq 11$ ) 2013 were included. Admissions were selected between January and November to allow for a 30-day readmission window. Admissions in the NRD have a listed primary discharge diagnosis and up to 24 secondary discharge diagnoses and can have up to 15 procedure codes associated with the discharges, as well as the day of the procedure conducted. All diagnostic and procedural codes used for classifications are found in Supplemental Table 1, <http://links.lww.com/MPA/A660>.

### Definition of Variables, Comorbidities, and Other Covariates

Variables were obtained from the NRD based on availability in the database. The database contains deidentified information regarding each hospitalization and rehospitalization, including demographic characteristics (age, sex, income, and primary and secondary insurance), admission status, comorbidities, discharge diagnoses, procedures, outcomes, and costs of hospitalization. A Charlson Comorbidity Index value was calculated and used for comorbidity assessment.<sup>14</sup> We also included hospital-level variables available in the NRD as covariates, such as hospital size, teaching status, location, discharge disposition, and primary payer source (government vs private).

### Outcomes

Our main outcome was identifying the incidence and predictors of 30-day all-cause and CP-specific readmissions by multivariate regression analysis. Chronic pancreatitis-specific readmission was defined as patients having a rehospitalization within 30 days with a primary *ICD-9* diagnosis code consistent with CP as listed previously, which was considered representative of recurrent or persistent CP.

### Statistical Analyses

Descriptive statistics were performed, and data are presented as mean (standard deviation) 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  $\chi^2$  tests. In addition, multivariate analysis was performed to assess differences between the groups in terms of the outcomes of interest while adjusting for patient and hospital characteristics. Survey 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. A *P* value of less than 0.01 was considered statistically significant because of the large sample size. This significance criterion has been used in previous National Inpatient Sample studies. All

analyses were performed using SAS (version 9.4; The SAS Institute, Cary, NC).

## RESULTS

### 30-Day Readmission Rates

A total of 35,580,348 patient records were available in the NRD in 2013. The weighted national frequency of index hospitalizations for CP was 12,545. The national estimate of all-cause 30-day readmissions within this CP group was 3825 (30.4%). Of these readmitted patients, 28% had a primary diagnosis of AP and 20% had a primary diagnosis of CP. Other causes of hospital readmissions are listed in Table 1.

### Characteristics of Patients With CP Readmitted for Any Cause

The demographic and baseline clinical characteristics of patients hospitalized with a diagnosis of CP and readmitted for any cause within 30 days were compared with those that were not readmitted using univariate analysis (Table 2). Table 3 presents the comparison of comorbidities and their relative percentages between the patients that were readmitted for all causes within 30 days and those that were not.

Table 4 provides the multivariate regression analysis for predictors of all-cause readmissions. Among patients hospitalized for CP, length of stay (LOS) of more than 6 days (odds ratio [OR], 1.526; 95% confidence interval [CI], 1.273–1.829;  $P < 0.0001$ ), weekend admission (OR, 1.307; 95% CI, 1.105–1.547;  $P = 0.0018$ ), and hospital course being complicated by acute kidney injury (AKI) (OR, 1.452; 95% CI, 1.098–1.921;  $P = 0.0089$ ) were associated with increased odds of all-cause 30-day readmission.

Compared with CP patients in the 18- to 44-year-old age group, patients in the 45- to 64-year-old age group (OR, 0.71; 95% CI, 0.615–0.82;  $P < 0.0001$ ), 65- to 84-year-old age group (OR, 0.392; 95% CI, 0.298–0.515;  $P < 0.0001$ ), and older than 85 years age group (OR, 0.312; 95% CI, 0.15–0.65;  $P = 0.0019$ ) had decreased rates of all-cause readmission.

**TABLE 1.** Etiology of Hospital Readmissions in CP Patients

Etiology	No. Patients, n (%)
Acute pancreatitis	438 (28.19)
CP	311 (20.01)
Abdominal pain	82 (5.28)
Complications of surgical procedures or medical care	47 (3.02)
Diabetes mellitus with complications	45 (2.9)
Septicemia	40 (2.57)
Biliary tract disease	28 (1.8)
Alcohol-related disorders	27 (1.74)
Complication of device; implant or graft	24 (1.54)
Mood disorders	21 (1.35)
Other gastrointestinal disorders	21 (1.35)
Other nervous system disorders	21 (1.35)
Fluid and electrolyte disorders	20 (1.29)
Intestinal obstruction without hernia	18 (1.16)
Other disorders of stomach and duodenum	18 (1.16)
Gastritis and duodenitis	17 (1.09)
Gastrointestinal hemorrhage	16 (1.03)

**TABLE 2.** Demographics for CP All-Cause Readmissions

Demographic Characteristics	No Readmission, n (%)	Readmission, n (%)	P
Sex, female	4382 (50.3)	1841 (48.1)	0.2547
Age, y			<0.0001
18–44	2922 (33.5)	1576 (41.2)	
45–64	4576 (52.5)	1905 (49.8)	
65–84	1100 (12.6)	315.4 (8.2)	
>84	122 (1.4)	28.3 (0.7)	
Weekend admission	1753 (20.1)	946.4 (24.7)	0.0009
Hospital bed size			0.0503
Small	1129 (13)	417 (10.9)	
Moderate	1762 (20.2)	672 (17.6)	
Large	5829 (66.8)	2736 (71.5)	
Hospital control			0.4438
Government	1483 (17)	629.3 (16.5)	
Private, not-for-profit	6047 (69.4)	2730 (71.4)	
Private, profit	1189 (13.6)	464.9 (12.2)	
Teaching status			0.3527
Metropolitan, nonteaching	2553 (29.3)	1019 (26.6)	
Metropolitan teaching	5149 (59.1)	2345 (61.3)	
Non-Metropolitan hospital	1018 (11.7)	461.3 (12.1)	
Median household income			0.6492
0–25th percentile	2868 (33.5)	1218 (32.2)	
26th–50th percentile	2440 (28.5)	1061 (28.1)	
51st–75th percentile	1907 (22.3)	842.4 (22.3)	
76th–100th percentile	1354 (15.8)	661.2 (17.5)	
Payer			0.0007
Medicare	2831 (32.5)	1311 (34.3)	
Medicaid	1929 (22.2)	1052 (27.5)	
Private insurance	2400 (27.6)	880 (23)	
Uninsured/other	1542 (17.7)	579 (15.2)	
Disposition			0.0003
Routine	7502 (86)	3092 (80.8)	
Short-term hospital	73 (0.8)	43 (1.1)	
Facility	270 (3.1)	146 (3.8)	
Home health care	633 (7.3)	372.8 (9.7)	
Other	242 (2.8)	171 (4.5)	
Charlson Comorbidity score			0.1747
0	3484 (40)	1414 (37)	
1	2646 (30.3)	1219 (31.9)	
>1	2589 (29.7)	1192 (31.2)	
Cholangitis	54 (0.6)	16 (0.4)	0.4741
CBD obstruction	749 (8.6)	218 (5.7)	0.0098
Alcoholism	2585 (29.6)	1191 (31.1)	0.4241
Cholecystectomy	480 (5.5)	102 (2.7)	<0.0001
AKI	425 (4.9)	266 (7)	0.0035
ARF	155 (1.8)	85 (2.2)	0.3958
Smoking	3852 (44.2)	1695 (44.3)	0.9298
Pancreatectomy	494 (5.7)	178 (4.7)	0.1642
Cholelithiasis	543 (6.2)	151 (4)	0.0016
ERCP	777 (8.9)	238 (6.2)	0.0022
Morbid obesity	288 (3.3)	82 (2.1)	0.0307

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

Compared with CP patients with Medicare, those with private insurance (OR, 0.668; 95% CI, 0.527–0.848;  $P = 0.0009$ ) and those who were uninsured or otherwise unspecified (OR, 0.647; 95%

CI, 0.499–0.841;  $P = 0.0011$ ) also had decreased rate of all-cause readmission. Finally, cholecystectomy during the index hospitalization (OR, 0.529; 95% CI, 0.351–0.798;  $P = 0.0024$ ) and

**TABLE 3.** Comorbidity for All-Cause 30-Day Readmissions for CP

Comorbidities	No Readmission, n (%)	Readmission, n (%)	P
History of myocardial infarction	281 (3.2)	132 (3.4)	0.7018
Congestive heart failure	351 (4)	174 (4.5)	0.467
Peripheral vascular disease	289 (3.3)	104 (2.7)	0.3279
Cerebrovascular disease	77 (0.9)	30 (0.8)	0.7235
Dementia	13.8 (0.2)	10 (0.3)	0.4597
Chronic obstructive pulmonary disease	1711 (19.6)	705.9 (18.5)	0.3713
Rheumatoid disease	191 (2.2)	99 (2.6)	0.4722
Peptic ulcer disease	262 (3)	77.9 (2)	0.0624
Mild liver disease	1149 (13.2)	463 (12.1)	0.4267
Diabetes	2459 (28.2)	1124 (29.4)	0.4561
Diabetes with complications	320 (3.7)	201 (5.3)	0.0206
Renal disease	649 (7.4)	414 (10.8)	0.0004
Cancer	113 (1.3)	58 (1.5)	0.5793
Moderate/severe liver disease	227 (2.6)	115 (3)	0.4441
Metastatic cancer	38 (0.4)	18 (0.5)	0.9031
AIDS	53 (0.6)	20 (0.5)	0.7651

AIDS indicates acquired immune deficiency syndrome.

undergoing endoscopic retrograde cholangiopancreatography (ERCP) during the index hospitalization (OR, 0.699; 95% CI, 0.533–0.918;  $P = 0.01$ ) were associated with lower risk for all-cause readmission.

### Characteristics of Patients With CP Readmitted for CP

Table 5 displays the multivariate regression analysis for patients who were readmitted specifically for CP. Compared with the 18- to 44-year-old age group, patients in the 65- to 84-year-old age group (OR, 0.41; 95% CI, 0.24–0.68;  $P = 0.0006$ ), and older than 85 years age group had decreased rates of CP-specific readmission. Uninsured or unspecified insurance status (OR, 0.45; 95% CI, 0.25–0.81;  $P = 0.0082$ ), LOS of more than 6 days (OR, 0.65; 95% CI, 0.49–0.87;  $P = 0.0041$ ), and pancreatectomy (OR, 0.21; 95% CI, 0.08–0.50;  $P = 0.0005$ ) during the initial hospitalization were all associated with a lower rate of 30-day readmission for CP. Cholecystectomy during the initial hospitalization (OR, 1.40; 95% CI, 1.01–1.94;  $P = 0.047$ ) was found to be associated with trend toward, but not statistically significant, increased risk of 30-day readmission specifically for CP.

### DISCUSSION

This study investigated a large, nationally representative readmission database to assess incidence of and risk factors for readmission in patients hospitalized for CP. Overall, we found that readmission after hospitalization for CP is common, occurring in 30.4% of all discharges, with the majority of rehospitalizations with either AP or CP (48%), or a suspected pancreatic-related condition (ie, abdominal pain or biliary tract disease). This is higher than a prior single-center retrospective study of 373 patients that noted a 30-day readmission rate of 15% for AP and CP hospitalizations combined.<sup>10</sup> Another study found readmission rates of 57.9% AP or CP over a median of 45 months but did not measure 30-day readmission rates.<sup>9</sup>

In terms of specific risk and protective factors for readmission, our findings demonstrated that in CP, older age is associated with lower rates of all-cause and CP-specific readmissions. This finding is consistent with national data, where a lower rate of

readmissions was observed in the older than 65 years age group (19%) compared with those between ages 18 to 64 years (24.1%).<sup>15</sup> However, another study over a 4-year follow-up period found increasing age to be associated with increased risk for readmission,<sup>9</sup> and a single-center retrospective study found increasing age to be associated with AP and CP 30-day readmissions.<sup>10</sup> As part of the natural history of advanced CP, some initial studies revealed spontaneous resolution of pain with age, although larger studies have not supported these findings.<sup>6,16</sup> Also, younger patients tend to be less adherent to therapy, for example, pancreatic enzyme replacement, follow-up appointments, and dietary recommendations, which may have contributed to increased readmissions in younger patients.<sup>17</sup> Lastly, older patients may have experienced higher mortality, and thus have been taken out of the readmission pool.

Consistent with previous studies showing lower rates of 30-day readmissions among patients with private insurance or those without insurance (or unspecified), lower rates of all-cause readmission were identified among CP patients with private insurance in our study when compared with Medicare patients.<sup>15</sup> When examining CP-specific readmissions, only uninsured (or unspecified) payer status was associated with lower readmission rates. Uninsured patients may be more likely than insured patients to go without receiving necessary care, so potentially these patients did not return to the hospital to seek necessary care within 30 days.<sup>18</sup> Unfortunately, these patients have also been observed to have more serious hospitalizations, with increased overall mortality in the long term.<sup>18</sup> To a lesser extent, there may be a similar process at play in explaining lower readmissions among those with private insurance, as when compared with Medicare patients, those with private insurance are also less likely to receive necessary care owing to higher health care premiums, deductibles, and costs.<sup>19</sup>

Paradoxically, a longer LOS was associated with increased all-cause readmission rates but lower CP-specific readmissions. Studies in surgical patients have shown association between LOS and various hospital-acquired conditions and postsurgical complications.<sup>20</sup> Based on these data, one possible explanation for the association between LOS and all-cause 30-day readmission is that hospital-acquired conditions, such as surgical site infections, venous thromboses, and urinary tract or upper respiratory

**TABLE 4.** Regression Analysis for All-Cause 30-Day Readmissions

Variable	Reference	OR (95% CI)	P
Sex	Male (reference)		
	Female	0.9 (0.8–1.1)	0.3005
Age group, y	18–44 (reference)		
	45–64	0.7 (0.6–0.8)	<0.0001
	65–84	0.4 (0.3–0.5)	<0.0001
	85+	0.3 (0.2–0.7)	0.0019
Morbid obesity	Yes	0.6 (0.4–0.9)	0.0153
Payer	Medicare (reference)		
	Medicaid	0.9 (0.8–1.2)	0.5785
	Private insurance	0.7 (0.5–0.8)	0.0009
	Uninsured/other	0.6 (0.5–0.8)	0.0011
Bed size	Small bed size (reference)		
	Medium	1.1 (0.8–1.5)	0.7254
	Large	1.3 (0.9–1.8)	0.1118
Disposition	Routine (reference)		
	Short-term hospital	1.6 (0.8–3.2)	0.2056
	Facility	1.3 (0.8–1.9)	0.2609
	Home health care	1.4 (1.1–1.8)	0.0108
	Other	1.4 (0.9–2)	0.095
Teaching status	Metropolitan, nonteaching (reference)		
	Metropolitan teaching	0.8 (0.7–1)	0.0892
	Non-Metropolitan hospital	1.1 (0.8–1.4)	0.6401
Hospital control	Government (reference)		
	Private, not-for-profit	1.1 (0.9–1.4)	0.4793
	Private, profit	1.1 (0.8–1.4)	0.6893
Median household income	0–25th percentile (reference)		
	26th–50th percentile	1.1 (0.8–1.3)	0.6193
	51st–75th percentile	1.2 (1–1.4)	0.1206
	76th–100th percentile	1.2 (1–1.6)	0.0671
Charlson Comorbidity score	0 (reference)		
	1	1.1 (1–1.3)	0.0889
	>1	1.1 (0.9–1.3)	0.4237
Admission day	Nonweekend (reference)		
	Weekend	1.3 (1.1–1.5)	0.0018
Length of stay	<7 (reference)		
	>6	1.5 (1.3–1.8)	<0.0001
Cholelithiasis	Yes	0.8 (0.6–1.2)	0.2809
ERCP	Yes	0.7 (0.5–0.9)	0.01
Cholecystectomy	Yes	0.5 (0.4–0.8)	0.0024
Cholangitis	Yes	0.7 (0.2–2.4)	0.5277
Bile duct obstruction	Yes	0.8 (0.5–1.1)	0.1679
Alcohol related	Yes	1 (0.8–1.2)	0.9131
Pancreatectomy	Yes	0.7 (0.5–1)	0.0787
AKI	Yes	1.5 (1.1–1.9)	0.0089
ARF	Yes	1.2 (0.7–2)	0.5991

ARF indicates acute respiratory failure.

infections, predispose patients to higher all-cause 30-day readmissions. Conversely, in pancreatitis, it has been shown that premature discharge when a patient is on less than solid diet is associated with earlier readmissions.<sup>21</sup> This may in part explain why CP patients had a lower rate of readmission specifically for CP with longer LOS, as they may have been treated with an appropriately slow diet escalation before discharge.

In terms of patient comorbidities, although previous studies have shown higher rate of readmission in morbidly obese surgical patients, our study has demonstrated the opposite.<sup>22</sup> In patients discharged with CP, obesity was associated with lower all-cause but not CP-specific readmission rate. This discrepancy may in part be explained by increased rate of morbidity among CP patients who are malnourished, and

**TABLE 5.** Regression Analysis for CP Specific 30-Day Readmissions

Variable	Reference	OR (95% CI)	P
Sex	Male (reference)		
	Female	1.1 (0.8–1.5)	0.6683
Age group, y	18–44 (reference)		
	45–64	0.8 (0.6–1.2)	0.2755
	65–84	0.4 (0.2–0.7)	0.0006
	85+	<0.001 (<0.001)	<0.0001
Morbid obesity	Yes	0.7 (0.3–1.5)	0.3383
Payer	Medicare (reference)		
	Medicaid	0.9 (0.6–1.3)	0.5938
	Private insurance	0.8 (0.5–1.2)	0.3137
	Uninsured/other	0.5 (0.3–0.8)	0.0082
Bed size	Small bed size (reference)		
	Medium	1.4 (0.8–2.4)	0.2395
	Large	1.8 (1.1–2.8)	0.0113
Disposition	Routine (reference)		
	Short-term hospital	0.2 (0.1–1.0)	0.0425
	Facility	0.8 (0.2–2.6)	0.6737
	Home health care	0.6 (0.2–1.7)	0.3612
	Other	1.0 (0.6–1.6)	0.9789
Teaching status	Metropolitan, nonteaching (reference)		
	Metropolitan teaching	1.7 (1.0–3.0)	0.0599
	Non-Metropolitan Hospital	0.6 (0.4–0.9)	0.0042
Hospital control	Government (reference)		
	Private, not-for-profit	1.5 (1.0–2.3)	0.0347
	Private, profit	1.0 (0.7–1.6)	0.8419
Median household income	0–25th percentile (reference)		
	26th–50th percentile	0.9 (0.5–1.5)	0.6626
	51st–75th percentile	1.0 (0.6–1.5)	0.9202
	76th–100th percentile	1.0 (0.7–1.6)	0.9195
Charlson Comorbidity score	0 (reference)		
	1	1.1 (0.7–1.7)	0.8352
	>1	0.5 (0.3–0.8)	0.0025
Admission day	Nonweekend (reference)		
	Weekend	0.9 (0.6–1.2)	0.3539
Length of stay	<7 (reference)		
	>6	0.7 (0.5–0.9)	0.0041
Cholelithiasis	Yes	1.1 (0.9–1.4)	0.4802
Cholecystectomy	Yes	1.4 (1.0–1.9)	0.0447
Cholangitis	Yes	0.7 (0.3–1.7)	0.4523
Bile duct obstruction	Yes	1.0 (0.6–1.6)	0.9426
Alcohol related	Yes	0.8 (0.5–1.2)	0.2661
Pancreatectomy	Yes	0.2 (0.1–0.5)	0.0005
AKI	Yes	0.7 (0.4–1.4)	0.3384

malnourished patients with lower body mass indices may also be an indication of an advanced stage of CP.<sup>23</sup> However, reasons for why morbid obesity would lead to lower all-cause but not CP-specific readmission rate would need to be evaluated further. Consistent with previous studies, AKI, a predictor of severity in pancreatitis, was associated with higher rate of 30-day all-cause readmission in CP.<sup>24</sup>

Cholecystectomy and ERCP were associated with lower all-cause readmission rates. This indicates that cholecystectomy and ERCP may have prevented AP episodes in CP patients, which contributed to approximately 28% of total readmissions. Prior studies have found that ERCP and cholecystectomy during index

hospitalization for AP were associated with lower risk of readmission, so the reduction of all-cause readmissions we found with these procedures may have reflected reductions in episodes of AP in the setting of preexisting CP.<sup>25</sup>

Importantly, pancreatectomy was associated with a reduction in CP-specific 30-day readmissions, suggesting this may be a beneficial intervention to reduce disease flares in CP. Previous studies have suggested improvement in pain and quality of life in patients who have undergone surgical management of CP.<sup>26</sup> In addition, total pancreatectomy with auto-islet transplantation is an increasingly used operation, which can help improve quality of life and pain in CP.<sup>27,28</sup>

## Limitations of This Study

This study relies on ICD-9 codes for diagnostic and procedural data and is therefore sensitive to local coding practices and errors in coding. For example, an acute flare of CP may be incorrectly coded as AP. Furthermore, the NRD does not allow measurement of variables such as local procedural expertise, various subtleties of decision making during hospitalization, and details of post hospital discharge, so there is the potential for unmeasured confounding. This database does not provide any laboratory data. Diagnosis of CP is based on physician coding. We are not able to verify diagnosis of CP data with endoscopic ultrasound or magnetic resonance pancreatography. Another limitation is that the coding for etiology of CP is done using indirect method. We have looked for secondary diagnosis of biliary etiology, smoking, and alcohol. Sometimes there is a significant overlap, and using this database, it is very hard to determine which one is predominant etiology. Procedural codes for pancreatic surgery may not accurately capture the specific procedures performed, leading to a heterogeneous population for analysis. Lastly, given the retrospective nature of the analysis, only correlations can be assessed and causation cannot be inferred for various explanatory variables and 30-day readmissions.

## CONCLUSIONS

This study is the first of its kind in examining 30-day readmission rates in CP and analyzing factors involved in all-cause and CP-specific readmission rates in a large, nationally representative readmission database. We found an all cause 30-day readmission rate of 30.4% in CP patients after an index hospitalization, most frequently for AP, CP, or abdominal pain, representing a significant burden on hospital systems. In CP patients, longer stay and AKI were associated with higher risk of all-cause readmissions. Older age, morbid obesity, and ERCP or cholecystectomy, during index hospitalization, were all protective factors against all-cause readmissions. For patients who were readmitted with the primary diagnosis of CP, there was a lower rate of readmission in patients who had pancreatectomy during initial admission. With better understanding of the specific factors that affect readmission rates, policy makers, public health officials, hospital systems, and clinical teams can devise strategies to reduce 30-day readmissions, an important quality metric, in CP patients.

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