Pancreatology 17 (2017) 534–542

Contents lists available at ScienceDirect

Pancreatology

journal homepage: www.elsevier.com/locate/pan

Original Article

Predictors for early readmission in acute pancreatitis (AP) in the United States (US) – A nationwide population based study

Satish Munigala, MBBS, MPH [a], Divya Subramaniam, PhD, MPH [a], Dipti P. Subramaniam, PhD, MPH [b], Paula Buchanan, PhD, MPH [a], Hong Xian, PhD [c], Thomas Burroughs, PhD [a], Guru Trikudanathan, MD [d, *]

[a] Saint Louis University Center for Outcomes Research, St. Louis, MO, United States
[b] University of Kansas Medical Center, Kansas City, KS, United States
[c] Division of Biostatistics, Saint Louis University College of Public Health and Social Justice, St. Louis, MO, United States
[d] Division of Gastroenterology and Hepatology, University of Minnesota, Minneapolis, MN, United States

ARTICLE INFO

Article history:
Received 17 January 2017
Received in revised form
23 May 2017
Accepted 25 May 2017
Available online 29 May 2017

Keywords:
Acute pancreatitis
Early readmissions
Risk factors
Recurrent pancreatitis

ABSTRACT

Background & Aims: Population based data on the burden and patterns of acute pancreatitis (AP) early readmissions (≤30-days) are limited.
Methods: 2013 Nationwide Readmission Database (NRD) was queried. AP etiology was determined using associated diagnoses codes. Proportion, reasons for readmission, and associated costs were evaluated. Multivariate logistic regression analysis was performed to identify independent predictors for 30-day readmission.
Results: After exclusions, we identified 178,541 patients with primary diagnosis of AP (mean age 53 ± 17 years, 51% male). 13.7% were readmitted ≤30 days [7.1% in acute biliary pancreatitis (ABP) patients with index cholecystectomy (CCY), 16.3% in ABP patients without CCY, and 14.3% in non-biliary AP patients ($p < 0.0001$)]. Reasons for readmission included AP, chronic pancreatitis, Pseudocyst/walled off necrosis, biliary tract disease, smoldering symptoms and others. On multivariate analysis male gender, comorbidity status (≥3), non-biliary etiology, organ failure, Pseudocyst/walled off necrosis complications, and patients discharged to extended care facilities were associated with increased risk of readmission. ABP patients with index CCY had a significantly lower risk of early unplanned readmission (odds ratio 0.45, $p < 0.0001$) but ABP patients with index ERCP did not ($p = 0.96$).
Conclusions: About 1 in 7 AP patients had a 30-day readmission after index hospitalization and about half of these were related to AP. Our data confirms the higher risk of readmission in alcohol and idiopathic AP and a lower risk in ABP. Risk of early unplanned readmission is significantly lower in ABP patients who underwent CCY and not ERCP during index hospitalization. Cholecystectomy should be performed in all ABP patients as per recommended guidelines.

Introduction

Acute pancreatitis (AP) is a common gastrointestinal cause for hospital admission in the United States, accounting for nearly 274,000 hospitalizations at an estimated cost of $2.6 billion annually [1]. Although most patients with AP fully recover, a small fraction are readmitted with recurrent pancreatitis or due to other causes [2–5]. Approximately two-thirds of these patients get readmitted within the first two weeks of index hospitalization [6], signifying that early unplanned readmission poses a burden to health care expenses, morbidity and mortality [6–8].

Thirty-day readmission rate for AP is regarded as a quality metric, which has now been shown to be the strongest predictor of mortality at 1 year [9]. It has also been suggested that the sustained pro-inflammatory milieu from pancreatitis may exert deleterious effects on or accelerate preexisting comorbidities [9].

* Corresponding author. Division of Gastroenterology, Hepatology and Nutrition University of Minnesota, 406 Harvard Street, MMC 36 Minneapolis MN 55455, United States.
E-mail address: triku001@umn.edu (G. Trikudanathan).

http://dx.doi.org/10.1016/j.pan.2017.05.391
1424-3903/

Population based data on early unplanned readmissions are limited. Previous studies on incidence and risk factors for early readmission are derived from single-tertiary care referral center studies with unique patient population, wherein readmission to other hospitals are not accounted for [6,8,10,11]. Lastly, no studies have estimated the cost implications associated with early readmissions.

The objectives of this study were to: 1) measure the frequency of early unplanned readmissions following acute pancreatitis index hospitalization, 2) evaluate the causes of readmission, 3) identify independent predictors for readmission, and 4) compare the aggregated costs of readmission by age, gender, income, expected payer of index stay using a large cohort of Nationwide Readmissions Database (NRD).

Methods

Study design and setting

This was a retrospective cohort study of patients from the 2013 NRD, which is a calendar-year, discharge level database constructed from Healthcare Costs and Utilization Project's (HCUP) State Inpatient Database (SID). Twenty one states (Supplement 1) accounted for 49.3% of the total US population and 49.1% of all US hospitalizations contributed to the data. Overall, this constitutes about 14 million discharges (unweighted) which approximate to 36 million discharges (weighted) [12].

Hospitals and discharges included in the NRD

The NRD database includes inpatient discharges for all hospitals provided by the HCUP partners (community, specialty hospitals and federal hospitals including public hospitals and academic medical centers) (Supplement 2). Non-community hospitals were excluded because of inconsistent capture of data across HCUP States. Rehabilitation or LTAC hospitals were excluded because they treat a unique patient population that has longer stays and higher costs [13]. All SID discharges from selected States and hospitals were included in the NRD. Discharges with missing or unverified patient linkage numbers, documentation errors, etc. were excluded as a part of NRD methodology (Supplement 2).

Identification of acute pancreatitis index cases

NRD database contains clinical and non-clinical variables essential to readmission analysis like verified patient linkage number that identifies discharges belonging to the same individual (NRD_VisitLink) and a timing variable (NRD_DaysToEvent) that can be used to calculate the days between hospital admissions for each patient. From the NRD database, we identified *index cases* as all patients discharged with primary diagnosis of AP (ICD 9 code 577.0) from February 1st 2013 through November 30th 2013, who were $\geq$18 years at the time of discharge, no death recorded during hospital stay, those without any missing length of stay (LOS), and with timing variable (NRD_DaysToEvent). We excluded AP cases with pregnancy status, concurrent diagnosis of chronic pancreatitis (CP) and pancreatic cancer, and those discharged against medical advice. These were the additional exclusions that were applied after SID data exclusions (see supplement 2 "*Discharges included by NRD*").

Early unplanned readmissions

Using patient linkage number and timing variable, we identified all readmissions for a patient $\leq$30 days of index admissions. These are estimates of unplanned readmission for any cause to any acute care hospital $\leq$30 days of discharge from a hospitalization. If a patient had >1 readmissions $\leq$30 days, only first readmission was considered for the analysis.

Other definitions

Acute pancreatitis etiology

Using associated diagnostic codes, AP patients were classified into mutually exclusive biliary, alcohol, other and idiopathic etiologies [14] (Supplement 3).

Comorbidity status

Comorbidities for risk adjustment were derived from AHRQ comorbidity measures based on the algorithm developed by Elixhauser et al. [15,16]. In our study, we excluded alcohol abuse as comorbidity since we evaluated alcohol as an etiology for AP. Patients were given a score of <3 or $\geq$3 based on the number of comorbidities.

Statistical analysis

Proportion of AP patients with readmissions was first identified. Subsequently, among the AP patients with readmissions, we evaluated the causes for 30-day readmission. Risk factors for early readmission were assessed using univariate analyses (Chi-squared test/univariate logistic regression/Wilcoxon Rank Sum test). Factors significant on univariate analyses ($p < 0.05$) were included in the multivariate logistic regression analysis to ascertain independent predictors for early readmission. Finally, median cost ($) per stay for index stays and readmissions was calculated (overall, by age group, sex, insurance status, and median income level). Analyses were performed on weighted frequencies obtained by WEIGHT option. All analyses were 2-tailed and the p-value level of 0.05 denotes significance. SAS version 9.3 (SAS Inc., Carey, NC, USA) was used.

Results

Study cohort

After exclusions, the final cohort included 178,541 hospital discharges with primary AP diagnosis (Fig. 1). Mean age of all AP patients was 53.0 years (±17), 51% were male. The etiologies of AP included biliary (27.5%), alcohol (25.7%), other (19.5%) and idiopathic (27.3%) (Table 1).

Frequency and causes of readmissions

Of the 178,541 patients, 13.7% (n = 24,446) were readmitted to the hospital within 30 days of their index hospitalization (7.1% in ABP patients with index CCY, 16.3% in ABP patients without CCY, and 14.3% in patients without biliary etiology) (Fig. 1). The primary reasons (principal diagnoses) for readmission included: pancreatic disorders [42.6%, (AP-37.3%, CP-2.8%, pancreatic Pseudocyst/walled off necrosis-2.1%)], biliary tract disease (5.3%), infections (5.2%), alcohol related (2.4%), smoldering symptoms and others (Fig. 2).

Predictors for early unplanned readmissions

Univariate analysis shows that AP patients in age group 45–64 years, with Medicare and Medicaid insurance, $\geq$3 comorbidities, discharged from Metropolitan teaching and large hospitals, with Pseudocyst/walled off necrosis complications, acute kidney injury (AKI), cardiovascular failure (CVF), hypotensive shock, bariatric

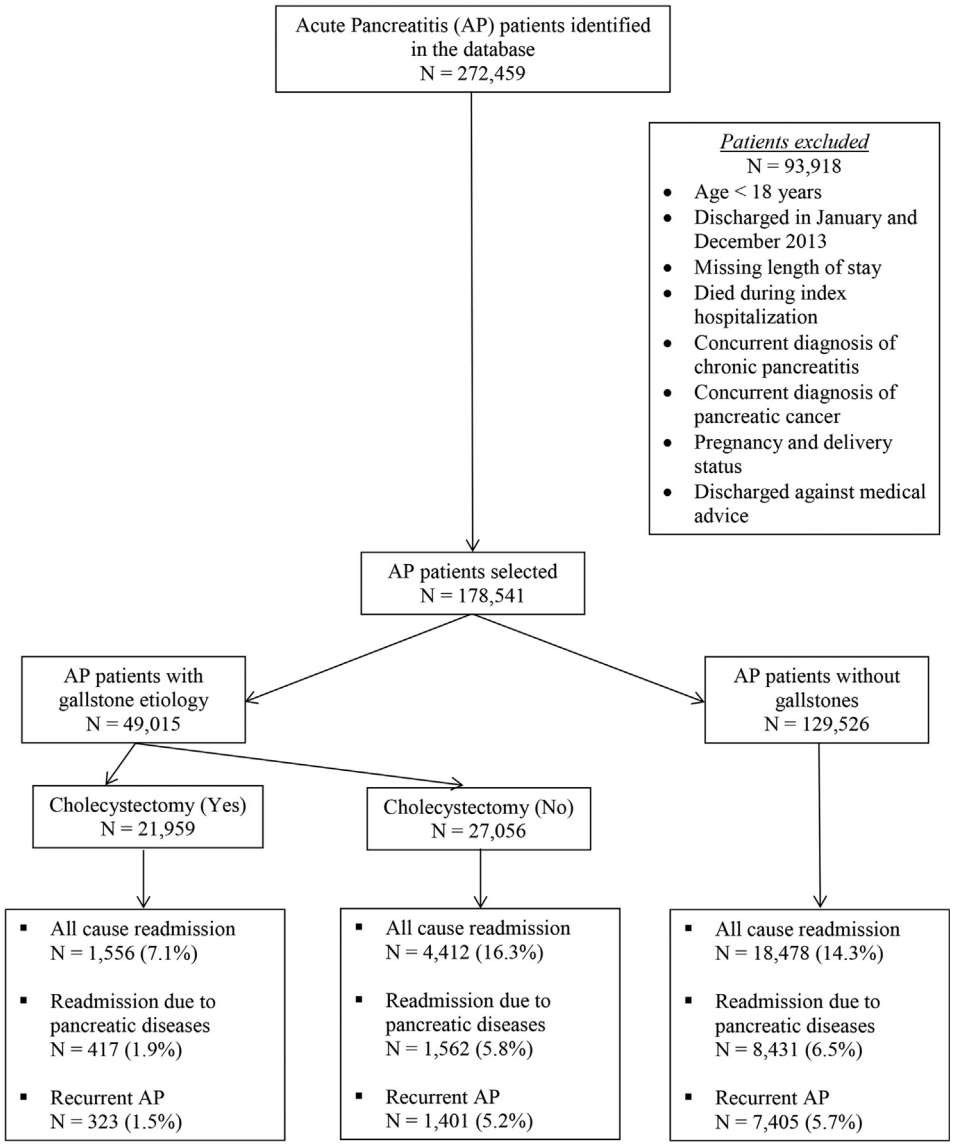


Fig. 1. Study cohort.

surgery and those with non-routine discharges (who were transferred to short term hospital/other facility or discharged to home health care) during index hospitalizations were associated with increased risk of early unplanned readmissions ($p < 0.0001$). Alcohol, idiopathic and other etiologies were found to have greater risk of readmissions compared to biliary etiology. We also found that AP patients with index CCY were at a lower risk of readmission when compared to those without index CCY (7.1% vs. 13.9%, $p < 0.0001$) (Table 1).

On multivariate analysis, after adjusting for demographic, hospital, and comorbidity status, AP patients with alcohol (odds ratio (OR) 1.09, 95% confidence interval (CI) 1.04, 1.13, $p < 0.001$), other (OR 1.12, 95%CI 1.07, 1.17, $p < 0.001$) and idiopathic etiologies (OR 1.27, 95%CI 1.22, 1.32, $p < 0.0001$) were found to have an increased risk of early unplanned readmission when compared to biliary etiology. Other independent predictors included organ failure (AKI, CVF, and ARF), Pseudocyst/walled off necrosis complications, bariatric surgery and those with non-routine discharges during their index hospitalization (Table 2).

Predictors for early unplanned readmissions in ABP cohort

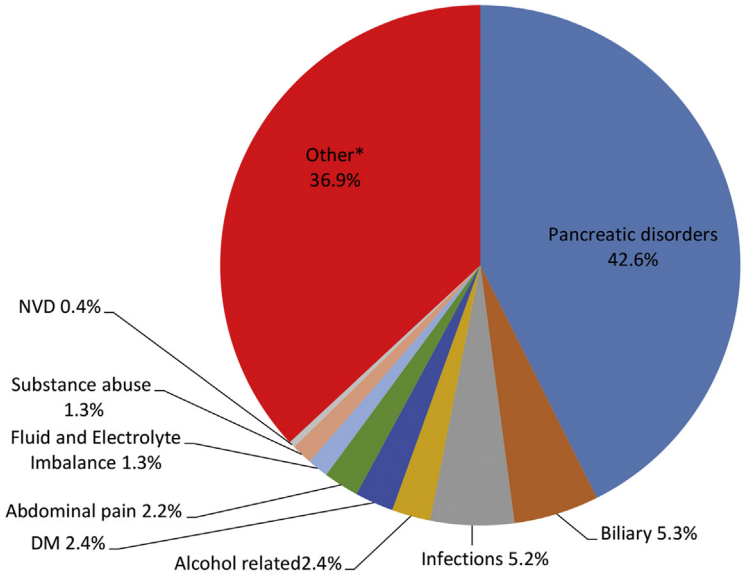
Given that CCY was associated with lower risk of readmission, we evaluated the ABP cohort separately. About 45% (21,959/49,015) of ABP patients underwent index CCY. Organ failure (CVF, AKI and ARF), Pseudocyst/walled off necrosis complications and the risk of readmissions were much lower in patients who underwent CCY compared to those who did not undergo index CCY ($p < 0.0001$). About 25% (12,207/49,015) of ABP patients underwent Endoscopic Retrograde Cholangiopancreatography (ERCP) during index hospitalization. ERCP was not associated with lower risk of readmissions ($p = 0.96$) (Table 3). On multivariate analysis, after controlling for demographics, hospital characteristics, organ failure and other relevant covariates, the risk of readmission was significantly lower in patients who underwent CCY during index admission (OR 0.45, 95%CI 0.42, 0.48, $p < 0.0001$) (Supplement 4).

We validated our findings in ABP patients with and without CCY using a separate 2013 Nationwide Inpatient Sample (NIS) database. We found that ABP patients with CCY were indeed at lower risk of

Table 1
Comparison of AP patients with and without readmissions.

	All AP Patients N = 178,541		AP Patients without readmissions N = 154,095		AP Patients with all cause readmissions N = 24,446		P value
	n	%	n	%	n	%	
Age group							
18-44	58,101	32.5	50,331	32.7	7770	31.8	Ref
45-64	73,934	41.4	63,509	41.2	10,425	42.6	0.0001
+65	46,506	26.0	40,255	26.1	6251	25.6	0.75
Gender							0.046
Male	91,037	51.0	78,330	50.8	12,707	52.0	
Female	87,504	49.0	75,764	49.2	11,740	48.0	
Income							
1 ($1-$37,999)	53,325	30.4	45,758	30.2	7567	31.4	Ref
2 ($38,000-$47,999)	48,874	27.8	41,964	27.7	6911	28.7	0.81
3 ($48,000-$63,999)	42,157	24.0	36,529	24.1	5628	23.4	0.0002
4 ($64,000 or more)	31,305	17.8	27,343	18.0	3962	16.5	<0.0001
Type of Insurance							
Medicare	60,010	33.7	50,558	32.9	9452	38.7	Ref
Medicaid	27,210	15.3	22,458	14.6	4752	19.5	<0.0001
Private (including HMO)	57,391	32.2	51,348	33.4	6043	24.8	<0.0001
Others, self-pay, no charge	33,627	18.9	29,463	19.2	4164	17.1	<0.0001
AHRQ-Elixhauser comorbidity index							<0.0001
< 3	96,752	54.2	86,021	55.8	10,730	43.9	
≥ 3	81,790	45.8	68,073	44.2	13,716	56.1	
Admission day							0.073
Weekday	131,810	73.8	113,954	74.0	17,856	73.0	
Weekend	46,731	26.2	40,141	26.0	6590	27.0	
Hospital designation							
Large metropolitan area	87,237	48.9	74,998	48.7	12,238	50.1	Ref
Small metropolitan area	63,572	35.6	54,813	35.6	8759	35.8	0.17
Micropolitan areas	19,117	10.7	16,674	10.8	2443	10.0	<0.0001
Not metropolitan or micropolitan (non-urban residual)	8616	4.8	7610	4.9	1006	4.1	<0.0001
Teaching status							
Metropolitan Non-teaching	74,431	41.7	64,606	41.9	9825	40.2	Ref
Metropolitan Teaching	76,378	42.8	65,206	42.3	11,172	45.7	<0.0001
Non- Metropolitan	27,732	15.5	24,283	15.8	3449	14.1	0.0012
Hospital bed size							
Small	26,788	15.0	23,374	15.2	3414	14.0	Ref
Medium	45,789	25.6	40,126	26.0	5662	23.2	0.14
Large	105,964	59.4	90,594	58.8	15,370	62.9	<0.0001
Etiology							
Gallstones	49,015	27.5	43,046	27.9	5969	24.4	Ref
Alcohol	45,824	25.7	39,495	25.6	6329	25.9	<0.0001
Other	34,800	19.5	29,735	19.3	5064	20.7	<0.0001
Idiopathic	48,902	27.3	41,818	27.1	7084	29.0	<0.0001
Smoking	63,866	35.8	54,930	35.6	8936	36.6	0.10
Morbid obesity	9685	5.4	8431	5.5	1253	5.1	0.18
Bariatric surgery	2864	1.6	2307	1.5	557	2.8	<0.0001
Interventions							
ERCP	14,209	8.0	12,301	8.0	1909	7.8	0.586
Percutaneous biliary procedures	393	0.2	308	0.2	85	0.3	0.007
Cholecystectomy	23,103	12.9	21,357	13.9	1746	7.1	<0.0001
PTC or CBDE	405	0.2	346	0.2	59	0.2	0.765
Complications and outcomes							
Cardiovascular Failure	993	0.6	690	0.4	303	1.2	<0.0001
Acute Kidney Injury	16,632	9.3	13,135	8.5	3496	14.3	<0.0001
Acute Respiratory Failure	7658	4.3	6180	6.0	1478	6.0	<0.0001
Hypotension	2651	1.5	2148	1.4	503	2.1	<0.0001
Pseudocyst/walled off necrosis	8003	4.5	5861	3.8	2141	8.8	<0.0001
Length of Stay (days, median, IQR)	3	2–5	3	2–5	4	2–7	<0.0001
Total charges ($, median, IQR)	23,996	14,158 –42127	21,839	13,086 –37774	24,684	13,923 –45069	<0.0001
≥1 CMS Hospital-Acquired Conditions	12,311	6.9	10,515	6.8	1796	7.3	0.07
Discharge Disposition							
Routine	159,110	89.1	139,037	90.2	20,073	82.1	Ref
Transfer to short-term hospital	1737	1.0	1357	0.9	380	1.6	<0.0001
Transfer other: Skilled Nursing Facility, Intermediate Care Facility, Another Type of Facility	8046	4.5	6359	4.1	1687	6.9	<0.0001
Home Health Care	9620	5.4	7318	4.7	2302	9.4	<0.0001
Discharged Alive, destination unknown	28	0.0	24	0.0	4	0.0	0.64

AHRQ, Agency for Healthcare Research and Quality; AP, Acute pancreatitis; CBDE, common bile duct exploration under ICD-9-CM code for 'open biliary procedures'; CMS, Center for Medicare & Medicaid Services; ERCP, endoscopicretrograde cholangiopancreatography; HMO, health maintenance organization; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; IQR, Interquartile range; PTC, percutaneous transhepatic cholangiography. P-value, testing the significance between AP patients without readmissions and AP patients with all cause readmissions.



*Other reasons for readmission include primary diagnoses which constituted ≤ 1% of readmission cohort individually.
Pancreatic disorders: Acute pancreatitis-37.3%, chronic pancreatitis-2.8%, pancreatic pseudocyst-2.1%, pancreatic disorders not otherwise specified/ necrosis-0.2% and unspecified pancreatitis- 0.1%.
NVD= Nausea, Vomiting and Diarrhea
DM= Diabetes Mellitus

Fig. 2. Reasons for readmission.

having Pseudocyst/walled off necrosis complications, disease severity, and in-hospital mortality (1.8% vs. 6.4%, 10.4% vs. 16.9% and 0.3% vs. 1.6% respectively; $p < 0.0001$) (data not shown).

Early unplanned readmissions and healthcare costs

21,623 unique patients contributed to 24,446 readmissions during the study period. About 84% of AP patients had one readmission, 14% had two readmissions, 2% had three readmissions, and <1% had four or more readmissions. The median length of stay (LOS) for readmissions was 4 days (interquartile range (IQR) 2–7). Majority of the AP patients (~65%) returned to hospital within the first 2 weeks [days to readmission from index hospitalization, median (IQR): 11 (5–19) days]. The first readmission ≤30 days contributed to a total of $1.07 billion in hospital charges with the median charges being $24,380 (IQR $13,662-$46,628). Readmission charges were higher in patients +65 years, females, with Medicare insurance and those who were in high income group (3rd and 4th quartile). Total aggregated cost of all readmissions was $3.85 billion. Table 4 illustrates the readmission charges by age, sex, insurance, and income status.

Discussion

In this study, frequency, causes, risk factors, and the costs for early unplanned readmissions using a large national readmissions database were evaluated. We identified that 14% patients with index hospitalization for AP were readmitted within 30 days and 5% were hospitalized for AP (recurrent AP). Other common causes for readmission include biliary tract disease, infections, alcohol, and diabetes related. We confirmed that alcohol and idiopathic etiologies were associated with increased risk, whereas ABP patients who had undergone index CCY had a lower risk and better outcomes.

This is the first study to estimate the burden and patterns of early readmission after hospitalization for AP from the nationwide readmission database. Thirty day readmission for AP was reported to be approximately 15–22% in previous studies [6,8,10]. It is important to note that two of those studies were single tertiary care referral centers with their unique patient population which does not capture readmissions to other hospitals. Moreover, one of those studies was based exclusively on severe AP cohort who are vulnerable for readmission [10]. In contrast, the NRD is a unique dataset which encompasses health care data from a nationally representative US population of all ages and AP with varying degrees of severity, which is crucial to gain insight into the readmission risk in a community setting. It included data from 22 states which represents 49% of the population, includes transfers and readmission to different facilities within the state, lending veracity to the generalization of our conclusions.

We evaluated the reasons and timing of readmissions to focus on prevention strategies to mitigate risk of readmission. Results indicate that risk of readmission is higher in patients with organ failure and fluid collection/Pseudocyst/walled off necrosis complications as indicated by previous studies [17]. Patients transferred to short term hospital/other facility or discharged to home health care during their index hospitalization were found to have higher risk of readmission.

About half of the readmissions are due to pancreatic/biliary causes. Moderate to heavy alcohol consumption are established risk factors even in prior studies [6,17]. However, this is significantly lower in patients who stop drinking after the index attack [4]. A randomized controlled trial clearly demonstrated the efficacy of repeated 6 month behavior modification such as alcohol cessation over the course of two years in reducing the risk for relapses and disease progression [18]. This underscores the critical need to establish structured alcohol cessation counselling programs that extend beyond the index hospitalization, to also include subsequent pancreas clinic visit. Such intervention can aid in minimizing the risk of readmission for AP.

Table 2
Multivariable logistic regression analysis of factors associated with 30-day readmission.

	Odds Ratio	95% CI		P value
		Lower	Higher	
Age group				
18-44	Ref			
45-64	0.94	0.91	0.97	0.0002
+65	0.59	0.56	0.62	<0.0001
Gender				
Female	Ref			
Male	1.07	1.04	1.10	<0.0001
Income				
1 ($1-$37,999)	Ref			
2 ($38,000-$47,999)	1.04	1.01	1.08	0.0263
3 ($48,000-$63,999)	1.01	0.97	1.05	0.5381
4 ($64,000 or more)	0.99	0.95	1.03	0.6412
Type of Insurance				
Medicare	Ref			
Medicaid	0.96	0.92	1.01	0.114
Private (including HMO)	0.56	0.54	0.59	<0.0001
Others, self-pay, no charge	0.67	0.64	0.71	<0.0001
AHRQ-Elixhauser comorbidity index				
< 3	Ref			
≥ 3	1.36	1.32	1.41	<0.0001
Teaching status				
Metropolitan Non-teaching	Ref			
Metropolitan Teaching	1.08	1.04	1.11	<0.0001
Non- Metropolitan	0.93	0.89	0.98	0.0021
Hospital bed size				
Small	Ref			
Medium	0.94	0.90	0.99	0.0094
Large	1.10	1.05	1.14	<0.0001
Bariatric surgery	1.58	1.44	1.74	<0.0001
Etiology				
Gallstones	Ref			
Alcohol	1.08	1.04	1.13	0.0002
Other	1.14	1.10	1.19	<0.0001
Idiopathic	1.25	1.21	1.30	<0.0001
Complications and outcomes				
Cardiovascular Failure	1.36	1.17	1.58	<0.0001
Acute Respiratory Failure	1.05	0.98	1.12	0.1451
Acute Kidney Injury	1.39	1.33	1.45	<0.0001
Pseudocyst/walled off necrosis	2.10	1.99	2.22	<0.0001
Discharge Disposition				
Routine	Ref			
Transfer to short-term hospital	1.82	1.61	2.05	<0.0001
Transfer other: Skilled Nursing Facility, Intermediate Care Facility, Another Type of Facility	1.57	1.47	1.66	<0.0001
Home Health Care	1.84	1.74	1.94	<0.0001
Discharged Alive, destination unknown	1.22	0.43	3.46	0.7048

AHRQ, Agency for Healthcare Research and Quality; AP, Acute pancreatitis; CI, confidence interval; HMO, health maintenance organization.

Table 3
Risk of readmission in gallstone AP patients.

	All Patients N = 49,015	Patients without index CCY N = 27,056	Patients with index CCY N = 21,959	P-value	Patients without index ERCP N = 36,808	Patients with index ERCP N = 12,207	P-value
	n (%)	n (%)	n (%)		n (%)	n (%)	
Cardiovascular Failure	333 (0.7)	223 (0.8)	110 (0.5)	0.009	207 (0.6)	126 (1.0)	0.001
Acute Respiratory Failure	2730 (5.6)	1699 (6.3)	1031 (4.7)	<0.0001	1973 (5.4)	758 (6.2)	0.043
Acute Kidney Injury	4739 (9.7)	3202 (11.8)	1537 (7.0)	<0.0001	3475 (9.4)	1264 (10.4)	0.07
Hypotension	858 (1.8)	551 (2.0)	307 (1.4)	0.02	609 (1.7)	249 (2.0)	0.11
Pseudocyst/walled off necrosis	1654 (3.4)	1273 (4.7)	381 (1.7)	<0.0001	1273 (3.5)	380 (3.1)	0.31
Readmissions	5969 (12.2)	4413 (16.3)	1556 (7.1)	<0.0001	4479 (12.2)	1489 (12.2)	0.96

AP, Acute pancreatitis; CCY, cholecystectomy.

Other reasons for readmission included smoldering symptoms such as abdominal pain, nausea, vomiting and diarrhea, alcohol related, diabetes, fluid and electrolyte disorders, substance abuse, and more. Although these other reasons contributed to <3% individually as a primary cause of readmission, our study indicates that 25% of patients with readmissions had some form of alcohol related diagnosis, 15% had smoldering symptoms, 11% had diabetes, 37% had fluid and electrolyte disorders, and 40% had substance abuse issues (any diagnosis). This suggests that apart from managing the patient from AP perspective, providers need to address the

Table 4
Healthcare costs of AP 30-day readmissions.

		Index Stays		Readmissions					
				Readmission for any cause			Readmissions from AP		
		N	Median cost $ per stay	N	%	Median cost $ per stay	N	%	Median cost $ per stay
Overall		178,541	23,996	24,446	13.7	24,380	9129	5.1	21,320
Age group	18–44	58,101	20,857	7770	13.4	21,208	3614	6.2	20,110
	45–64	73,934	21,360	10,425	14.1	24,486	3972	5.4	20,857
	65+	46,506	25,792	6251	13.4	29,289	1543	3.1	26,753
Sex	Male	91,037	21,247	12,707	14.0	23,432	5101	5.6	20,704
	Female	87,504	23,242	11,740	13.4	25,255	4029	4.6	22,196
Payer	Medicare	60,010	24,242	9452	15.8	26,926	2705	4.5	23,411
	Medicaid	27,210	21,873	4752	17.5	21,262	1929	7.1	19,654
	Private insurance	57,391	21,164	6043	10.5	25,493	2492	4.3	22,237
	Self-pay/other	33,627	20,903	4164	12.4	21,737	1980	5.9	19,539
Median income for zip code	First quartile (lowest)	53,325	21,332	7567	14.2	23,208	2741	5.1	20,375
	Second quartile	48,874	21,713	6911	14.1	23,852	2641	5.4	20,207
	Third quartile	42,157	22,602	5628	13.4	25,465	2108	5.0	22,167
	Fourth quartile (highest)	31,305	23,991	3962	12.7	26,597	1503	4.8	24,113

AP, Acute pancreatitis.

aforementioned diagnosis to reduce the potential risk of readmissions. Proper discharge planning as well as care coordination involving inpatient and outpatient management was shown to have better results in high risk-populations [19,20].

ABP patients who underwent index CCY had significantly lower risk of readmission. This is concordance with a recent multicenter randomized trial (PONCHO trial) of 264 patients from 23 Dutch hospitals which showed that delaying CCY after discharge (interval CCY) was associated with readmission for biliary related complications or mortality within 6 months of randomization in nearly one fifth of patients (23 of 136, 17%) assigned to this treatment group [21]. Furthermore, a systematic review which pooled 9 studies involving 998 patients also concluded that interval CCY after mild ABP was associated with a high risk of readmission for recurrent biliary events, especially recurrent biliary pancreatitis [22]. This is also endorsed in the most recent IAP and ACG guidelines which recommends CCY during the same hospital admission [23,24]. Despite these recommendations, nationwide and international audits have shown that laparoscopic CCY is usually done 6 weeks post discharge even for mild ABP [25–30]. Our study also shows that only about half (45%) of ABP patients undergo CCY during index hospitalization. Although there is a perceived risk of perioperative complications such as bile duct injury and conversion to open CCY in the setting of inflammation from AP, the low incidence rates of such complications in the recently concluded PONCHO trial provides compelling evidence which suggest otherwise [21]. Cost-effectiveness analysis within this multicenter randomized controlled trial concluded that same admission CCY was overall less costly per patient by a mean of ∈234 than interval CCY in patients with mild ABP [31]. These findings along with the two model-based studies from UK suggest that early CCY is cost-effective [32,33]. Recently published study by Kamal A et al. [34] suggest that about 64% of AP patients underwent index cholecystectomy and these patients had fewer comorbidities and lower subsequent hospitalization for pancreatitis. Previous findings also showed that patients with laparoscopic CCY had non-specific abdominal pain, obstructive jaundice, AP, bile like and other; however, the proportion of patients with such complications were much lower (6.6%) [35]. All these findings together with the conclusions from our study substantiate that index CCY is both efficient and cost-effective and should be adopted nationwide where feasible to reduce readmissions and overall cost in the management of ABP.

In patients with ABP, ERCP with sphincterotomy has been suggested as a bridge to CCY particularly in patients with severe AP with necrosis and/or peri-pancreatic fluid collections [36,37]. However, in our study nearly 25% of ABP patients that underwent ERCP during index hospitalization had no reduced risk of early unplanned readmission. Our findings are in line with the conclusions from the PONCHO trial which clearly showed that patients are vulnerable for recurrent gallstone-related complications even after sphincterotomy [21]. Thus, our study suggests that only same-admission CCY and not ERCP can potentially reduce the risk for 30-day readmission.

Readmissions account for significant amount of Medicare spending [7]. Data from HCUPNet shows that readmissions rates for pancreatic diseases (not including diabetes) over the last 5 years almost remained same [38] (Supplement 5). AP constitutes about 90% of the pancreatic disorders. Rate of readmission for AP (14%) is lower than rate of readmission due to congestive heart failure (23.5%), Schizophrenia and other psychotic disorders (22.7%), respiratory failure (21.5%) and chronic obstructive pulmonary disease and bronchiectasis (20.0%), which are some of the high volume conditions ranked by the rates of readmission for all causes within 30 days in 2013 in the US [39]. In our study, the total charges (weighted) from first readmissions were about $1.10 billion and from all readmissions was about $3.86 billion. Therefore, reducing readmissions would potentially reduce costs and alleviate economic burden.

We measured all-cause readmission from patients' perspective where readmission for any cause is considered an adverse event. This is also in accordance with the Centers for Medicare & Medicaid Services readmission measures [40].

Results from this study are consistent with previous literature regarding the higher risk of readmissions for alcohol related AP [6], patients discharged home with home health care [41], and lower risk of readmission for ABP [6]. The median time to first readmission (11 days) and median readmission LOS (4 days) were similar to the previous study as well [6].

There are limitations to our study. The NRD data files included patients admitted in the prior year and discharged in the current year, while excluding patients admitted to a hospital in the current year but discharged in the following year. Therefore, 30-day readmissions for patients admitted in the latter part of the year may not be captured if the subsequent admission crossed into the next year. Also it was not possible from NRD to identify patients who were hospitalized in one state had been readmitted or transferred to a hospital in a different state as such information is not tracked. To

evaluate the impact of this, NRD performed a sensitivity analysis and found that readmission rates were less than 5% higher if a patient could be tracked across all States, for most of the diagnoses [42]. Unfortunately our database does not distinguish planned readmission from an unplanned readmission. Furthermore, there are limitations of administrative database due to use of ICD 9 codes for AP and AP etiology. We selected all AP patients with any biliary ICD 9 codes and categorize them as biliary pancreatitis. Then we looked for secondary codes for alcohol and other. There might be some patients in the biliary pancreatitis group may actually have alcoholic pancreatitis. However, we believe that number was small. Etiology of AP from our study is similar to previously published studies using similar administrative databases [14]. Although we have excluded patients with concurrent diagnosis of chronic pancreatitis, we may have included few CP patients presenting as sentinel AP. Finally, we did not validate the ICD 9 codes used for diagnosing AP; however, ICD 9 codes for AP was shown to have 93% sensitivity and 79% specificity [43].

Despite limitations, the strengths of our study include use of large nationally representative database with >175,000 AP patients and >24,000 30-day readmissions. This is the largest study to examine the AP readmissions and also addresses the limitations from studies which failed to account for readmissions to other facilities. If a patient is transferred between hospitals within the State, NRD readmission analyses collapsed the pairs of records representing a transfer into a single “combined” record and removed the original separate discharge records from the NRD [13]. Moreover, NRD data is a discharge level data which can identify unique patients unlike other similar databases.

In conclusion, our study shows that about 1 in 7 patients had a 30-day readmission after index hospitalization for AP and half of these were related to AP. Our study confirms the higher risk of readmission in alcohol and idiopathic AP and lower risk in biliary AP. Patients with non-routine discharges during index hospitalization are other independent factors for readmission. Additionally, our study also indicates that the risk of readmission is significantly lower in ABP patients who underwent CCY and not ERCP during index hospitalization. This suggests that cholecystectomy should be performed in ABP patients as per recommended guidelines.

Funding source

The authors of this study did not receive any funding for undertaking this study.

IRB approval

Saint Louis University Institutional Review Board (IRB) determined that this study does not constitute Human Subjects Research and therefore required no additional IRB review.

Author contributions

S.M: study concept and design, statistical analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content and approved the final draft of the manuscript.

D.S: critical revision of the manuscript for important intellectual content and approved the final draft of this study.

D.P.S: critical revision of the manuscript for important intellectual content and approved the final draft of this study.

P.B: statistical analysis and interpretation of data, critical revision of the manuscript for important intellectual content, and approved the final draft of the manuscript.

H.X: interpretation of data, critical revision of the manuscript for important intellectual content and approved the final draft of this study.

T.B: critical revision of the manuscript for important intellectual content and approved the final draft of this study.

G.T: interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content and approved the final draft of this study.

Conflict of interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.pan.2017.05.391.

References

[1] Peery AF, Dellon ES, Lund J, et al. Burden of gastrointestinal disease in the United States: 2012 update. Gastroenterology 2012;143. 1179–1187–3.
[2] Ahmed Ali U, Issa Y, Hagenaars JC, et al. Risk of recurrent pancreatitis and progression to chronic pancreatitis after a first episode of acute pancreatitis. Clin Gastroenterol Hepatol Off Clin Pract J Am Gastroenterol Assoc 2016;14:738–46.
[3] Yasuda T, Ueda T, Takeyama Y, et al. Long-term outcome of severe acute pancreatitis. J Hepatobiliary Pancreat Surg 2008;15:397–402.
[4] Takeyama Y. Long-term prognosis of acute pancreatitis in Japan. Clin Gastroenterol Hepatol Off Clin Pract J Am Gastroenterol Assoc 2009;7:S15–7.
[5] Bertilsson S, Swärd P, Kalaitzakis E. Factors that affect disease progression after first attack of acute pancreatitis. Clin Gastroenterol Hepatol Off Clin Pract J Am Gastroenterol Assoc 2015;13. 1662–1669.e3.
[6] Whitlock TL, Repas K, Tignor A, et al. Early readmission in acute pancreatitis: incidence and risk factors. Am J Gastroenterol 2010;105:2492–7.
[7] Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360:1418–28.
[8] Whitlock TL, Tignor A, Webster EM, et al. A scoring system to predict readmission of patients with acute pancreatitis to the hospital within thirty days of discharge. Clin Gastroenterol Hepatol Off Clin Pract J Am Gastroenterol Assoc 2011;9:175–80. quiz e18.
[9] Lee PJW, Bhatt A, Lopez R, et al. Thirty-day readmission predicts 1-year mortality in acute pancreatitis. Pancreas 2016;45:561–4.
[10] Vipperla K, Papachristou GI, Easler J, et al. Risk of and factors associated with readmission after a sentinel attack of acute pancreatitis. Clin Gastroenterol Hepatol Off Clin Pract J Am Gastroenterol Assoc 2014;12:1911–9.
[11] Suchsland T, Aghdassi A, Kühn K, et al. Predictive factors for and incidence of hospital readmissions of patients with acute and chronic pancreatitis. Pancreatol Off J Int Assoc Pancreatol IAP Al 2015;15:265–70.
[12] 2013 Introduction to the NRD. Healthcare cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; December 2015. www.hcup-us.ahrq.gov/db/nation/nrd/NRD_Introduction_2013.jsp.
[13] NRD database documentation. Healthcare cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; November 2016. www.hcup-us.ahrq.gov/db/nation/nrd/nrddbdocumentation.jsp.
[14] Chen YJ, et al. The epidemiology of idiopathic acute pancreatitis, analysis of the nationwide inpatient Sample from 1998 to 2007. Pancreas 2013;42(1):1–5.
[15] Elixhauser A, et al. Comorbidity measures for use with administrative data. Med Care 1998;36(1):8–27.
[16] Li B, et al. Risk adjustment performance of Charlson and Elixhauser comorbidities in ICD-9 and ICD-10 administrative databases. Bmc Health Serv Res 2008:8.
[17] Yadav D, Lee E, Papachristou GI, et al. A population-based evaluation of readmissions after first hospitalization for acute pancreatitis. Pancreas 2014;43:630–7.
[18] Nordback I, Pelli H, Lappalainen-Lehto R, et al. The recurrence of acute alcohol-associated pancreatitis can be reduced: a randomized controlled trial. Gastroenterology 2009;136:848–55.
[19] Naylor M, Brooten D, Jones R, et al. Comprehensive discharge planning for the hospital elderly. A randomized clinical trial. Ann Int Med 1994;120:999–1006.
[20] Kasper EK, Gerstenblith G, Heft er G, et al. A randomized trial of the efficacy of multidisciplinary care in heart failure outpatients at high risk of hospital readmission. J Am Coll Cardiol 2002;39:471–80.
[21] da Costa DW, Bouwense SA, Schepers NJ, et al. Same-admission versus interval CCY for mild biliary pancreatitis (PONCHO): a multicentre randomised controlled trial. Lancet lond Engl 2015;386:1261–8.
[22] van Baal MC, Besselink MG, Bakker OJ, et al. Timing of CCY after mild biliary pancreatitis: a systematic review. Ann Surg 2012;255:860–6.

[23] Working Group IAP/APA Acute Pancreatitis Guidelines. IAP/APA evidence-based guidelines for the management of acute pancreatitis. Pancreatol Off J Int Assoc Pancreatol IAP Al 2013;13:e1–15.
[24] Tenner S, Baillie J, DeWitt J, et al. American College of Gastroenterology guideline: management of acute pancreatitis. Am J Gastroenterol 2013;108:1400–15. 1416.
[25] Bakker OJ, van Santvoort HC, Hagenaars JC, et al. Timing of CCY after mild biliary pancreatitis. Br J Surg 2011;98:1446–54.
[26] Nguyen GC, Boudreau H, Jagannath SB. Hospital volume as a predictor for undergoing CCY after admission for acute biliary pancreatitis. Pancreas 2010;39:e42–47.
[27] Lankisch PG, Weber-Dany B, Lerch MM. Clinical perspectives in pancreatology: compliance with acute pancreatitis guidelines in Germany. Pancreatol Off J Int Assoc Pancreatol IAP Al 2005;5:591–3.
[28] El-Dhuwaib Y, Deakin M, David GG, et al. Definitive management of biliary pancreatitis in England. Ann R Coll Surg Engl 2012;94:402–6.
[29] Sandzén B, Haapamäki MM, Nilsson E, et al. CCY and sphincterotomy in patients with mild acute biliary pancreatitis in Sweden 1988-2003: a nationwide register study. BMC Gastroenterol 2009;9:80.
[30] Pezzilli R, Uomo G, Gabbrielli A, et al. A prospective multicentre survey on the treatment of acute pancreatitis in Italy. Dig Liver Dis Off J Ital Soc Gastroenterol Ital Assoc Study Liver 2007;39:838–46.
[31] da Costa DW, Dijksman LM, Bouwense SA, et al. Cost-effectiveness of same-admission versus interval CCY after mild biliary pancreatitis in the PONCHO trial. Br J Surg 2016;103:1695–703.
[32] Monkhouse SJW, Court EL, Dash I, et al. Two-week target for laparoscopic CCY following biliary pancreatitis is achievable and cost neutral. Br J Surg 2009;96:751–5.
[33] Morris S, Gurusamy KS, Patel N, et al. Cost-effectiveness of early laparoscopic CCY for mild acute biliary pancreatitis. Br J Surg 2014;101:828–35.
[34] Kamal A, Akhuemonkhan E, Akshintala VS, Singh VK, Kalloo AN, Hutfless SM. Effectiveness of guideline-recommended cholecystectomy to prevent recurrent pancreatitis. Am J Gastroenterol 2017 Mar;112(3):503–10. http://dx.doi.org/10.1038/ajg.2016.583. Epub 2017 Jan 17.
[35] Sanjay P, Weerakoon R, Shaikh IA, Bird T, Paily A, Yalamarthi SA. 5-year analysis of readmissions following elective laparoscopic cholecystectomy - cohort study. Int J Surg 2011;9(1):52–4. http://dx.doi.org/10.1016/j.ijsu.2010.08.007. Epub 2010 Sep. 15.
[36] Heider TR, Brown A, Grimm IS, et al. Endoscopic sphincterotomy permits interval laparoscopic CCY in patients with moderately severe biliary pancreatitis. J Gastrointest Surg Off J Soc Surg Aliment Tract 2006;10:1–5.
[37] Sanjay P, Yeeting S, Whigham C, et al. Endoscopic sphincterotomy and interval CCY are reasonable alternatives to index CCY in severe acute biliary pancreatitis (GSP). Surg Endosc 2008;22:1832–7.
[38] HCUPnet. Healthcare cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; 2009-2013 (Accessed 30 June 30, 2016, http://hcupnet.ahrq.gov/.
[39] Fingar K, Washington R. Trends in hospital readmissions for four high-volume conditions, 2009-2013: statistical Brief #196, in Healthcare cost and Utilization Project (HCUP) statistical Briefs. 2006. Rockville (MD).
[40] https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/downloads/MMSHospital-WideAll-ConditionReadmissionRate.pdf.
[41] Sanford DE, et al. Association of discharge home with home health care and 30-day readmission after pancreatectomy. J Am Coll Surg 2014;219(5). p. 875-U323.
[42] HCUPnet query on the expected primary payer for the 2011 Nationwide Inpatient Sample. Accessed June 30, 2016.
[43] Yadav D, Dhir R. How accurate are ICD-9 codes for acute (AP) and chronic (CP) pancreatitis? A large VA hospital experience [abstr]. Pancreas 2006;33:508.