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ORIGINAL ARTICLE

Trends in Major Gastrectomy for Cancer: Frequency and Outcomes

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Abstract

Background Declining incidence of gastric cancer in the USA has presumably resulted in lower rates of major gastrectomy for cancer. The impact on perioperative outcomes remains undefined. The aims of this study were to characterize national trends in frequency of major gastrectomy for cancer, identify factors associated with in-hospital mortality, and examine outcome disparities by race/ethnicity.

Methods Nationwide inpatient sample data from 1993 to 2013 were queried for procedural and diagnostic codes (ICD-9) relating to total and partial gastrectomy procedures. Gastric resections for cancer were compared to those for peptic ulcer disease for reference. Patient demographics, comorbidity score, mortality, and hospital characteristics were recorded as covariates.

Results A significant decrease in annual rates of partial and total gastrectomy was observed from 1993 to 2013 ($p < 0.0001$). The change in absolute number and percent decline was greater for partial gastrectomy (− 39.3%) than total gastrectomy (− 19%). There was a 34.0% decrease in gastrectomy for cancer in Whites and a 61.2% increase among Hispanic patients over two decades. In-hospital mortality also significantly decreased over the study period (7.7% to 2.7%). Factors associated with lower mortality rates included male sex and treatment at urban teaching hospitals. Analysis of trends revealed that gastrectomy for cancer was performed with increasing frequency at urban teaching hospitals.

Conclusions The frequency of major gastric resections in the USA has declined over two decades. Overall, in-hospital mortality rates also have decreased significantly. Declining in-hospital mortality after gastrectomy for cancer is associated with more frequent treatment at urban teaching hospitals.

Keywords Gastrectomy · Gastric Cancer · Peptic ulcer disease

Introduction

Since the first successful gastrectomy for gastric cancer by Billroth in 1881, gastric surgery has endured as fundamental to general surgery practice.[1] To this day, gastric neoplasia and peptic ulcer disease (PUD) are the most common indications for gastric resection. Gastric adenocarcinoma is the most frequent gastric neoplasm in the USA with an estimated 28,000 new cases in 2017, of which approximately 55% will have local-regional disease amenable to gastrectomy.[2, 3] Complications of PUD are often managed surgically, although introduction of histamine receptor antagonists, proton pump inhibitors, and *Helicobacter pylori* eradication has altered the treatment paradigm such that operative management of complicated PUD has become less common.[4–7]

Gastric resection techniques and post-gastrectomy sequelae, long a staple of general surgical education, are seemingly at risk for relegation to sub-specialty training and referral to

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high-volume surgeons based on recent reports.[5, 8] Reduced rates of treatment-refractory PUD are held to account for the diminishing surgeon and trainee experience.[7, 9] Moreover, the relatively low incidence of gastric adenocarcinoma in the USA, along with geographic and ethnic variability, is also to blame.[10] Consequently, the frequency of gastric resection also is presumably decreasing due to the diminishing prevalence of both complicated PUD and gastric cancer.

Commentaries on the change in frequency of major gastric resections since the end of the twentieth century have yet to be supported by data. Therefore, to better understand the contemporary surgeon's experience performing gastrectomy, the two most common indications for gastric resection (PUD and cancer) should be examined. The aims of this study were to characterize trends in annual frequencies of major gastrectomy for gastric cancer in the USA while using PUD as a reference, identify factors associated with in-hospital mortality, and assess trends in gastrectomy according to race/ethnicity.

Materials and Methods

The nationwide inpatient sample (NIS) is maintained by the Agency for Healthcare Research and Quality (AHRQ) as part of the Healthcare Cost and Utilization Project (HCUP). NIS is the largest available inpatient all-payer inclusive registry available in the USA.[11] It captures data from approximately 20% of US community hospital discharges which can be weighted to approximate the US national population.[12] The data for this study were derived from the 1993–2013 versions of the NIS database. NIS-weighted sample analysis was utilized to expand the study population to an estimated 100% sample. International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes for total gastrectomy and partial gastrectomy are listed in Supplemental Table 1. ICD-9-CM diagnostic codes used to define gastric neoplasm and peptic ulcer disease are listed in Supplemental Table 2.

All patients undergoing major gastrectomy as defined by ICD-9-CM procedure codes for total gastrectomy and partial gastrectomy with anastomosis were identified. ICD-9-CM codes for nonanatomic partial gastrectomy (wedge gastrectomy) and for bariatric gastric procedures were excluded. If the patient had an ICD-9-CM diagnosis code for gastric neoplasm, it was assumed that the procedure was an oncologic resection. If the patient did not have an ICD-9-CM diagnosis code for gastric cancer, it was assumed that the indication for operation was peptic ulcer disease if the patient's primary diagnosis was an ICD-9-CM code for peptic ulcer disease.

Covariates for analysis included sex, race, type of gastrectomy (total and partial), indication for gastrectomy (neoplasm, peptic ulcer disease, other), in-hospital mortality, length of hospital stay (days), year of hospitalization (1993–2013), number of comorbidities, and hospital characteristics (teaching or nonteaching, urban or rural, bed size, geographic region). The primary outcome was to characterize annual trends in gastric resection operations for cancer. Secondary outcomes included characterization of trends for in-patient mortality, admission by hospital type, and race-specific analysis of gastrectomy. Multiple variable analyses were performed on common covariates to assess for associations with operative outcomes.

Statistical Analysis

The study population was limited to inpatient discharges treated at hospitals in the USA. Prior to 2012, the data were obtained from all discharge records of stratified random samples of US hospitals participating in HCUP, and as the result of a revised sample design, the 2012–2013 data were obtained from stratified random samples of all discharge records from US hospitals participating in HCUP. For each year, the samples of discharges were independently sampled. The sampling stratum was based on the five hospital characteristics: ownership/control, bed size, teaching status, urban/rural location, and US Census Bureau region or division. We used the recommended newly created trend weights for 1993–2011, which were recalculated for creating consistent national estimates for trend analyses with the discharge sample weights for 2012 and 2013 data.[13, 14] For descriptive analyses of demographic, patient, and hospital covariate characteristics, we grouped the survey years 1993–2013 by 5-year categories to compare the distribution of covariates across the categories separately among gastrectomy cancer patients and PUD patients (Table 1). We employed sample-weighted multivariable logistic regression estimation of odds ratios for mortality outcomes among cancer and PUD patients for levels of each covariate adjusting for the other covariates (Table 2). Sample-weighted unadjusted counts by year were plotted by procedure type (total/partial gastrectomy), by indication of procedure (cancer/PUD) for all races, and race-specific (White/Black/Hispanic/Asian), and Wald chi-square tests were used to test for trends based on linear regression models with survey year as a covariate. All statistical analyses were conducted using SAS version 9.4, and in these, we accounted for the stratified cluster sample design in 1993–2011 (the clusters were the sampled hospitals), the stratified sample design in 2012–2013, and the sample weighting used across all years, i.e., trend/discharge sample weights.

Results

From 1993 to 2013, an estimated 318,788 patients underwent major gastrectomy for cancer or PUD in the USA. Of these operations, 58% (184,805) were for cancer and 42%

Table 1 Patient demographics and hospital characteristics

	1993–1997		1998–2002		2003–2007		2008–2013	
	Cancer	PUD	Cancer	PUD	Cancer	PUD	Cancer	PUD
Age, mean (years)	68	62	68	63	67	63	66	62
Sex, frequency (%)								
Male	30,166 (65)	24,032 (52)	26,714 (62)	14,689 (47)	24,364 (63)	11,483 (47)	27,644 (63)	11,364 (45)
Female	16,587 (35)	22,641 (48)	16,229 (38)	16,425 (53)	14,413 (37)	13,036 (53)	16,068 (37)	13,998 (55)
Race, frequency (%)								
White	28,205 (74)	29,226 (79)	22,419 (67)	18,299 (78)	18,631 (61)	13,120 (74)	22,948 (58)	16,768 (74)
Black	5134 (13)	5130 (14)	4072 (12)	2791 (12)	3831 (13)	2328 (13)	5750 (15)	2755 (12)
Hispanic	2500 (7)	1698 (5)	3364 (10)	1329 (6)	4088 (14)	1220 (7)	5333 (14)	1632 (7)
Asian/Pacific Islander	1676 (4)	620 (2)	2527 (8)	663 (3)	2793 (9)	643 (4)	3524 (9)	795 (4)
Native American	45 (0.1)	64 (0.2)	67 (0.2)	68 (0.3)	169 (0.6)	94 (0.5)	282 (0.7)	133 (0.6)
Other	753 (2)	507 (1)	894 (3)	450 (2)	859 (3)	424 (2)	1607 (4)	582 (3)
Procedure type, frequency (%)								
Total gastrectomy	16,604 (36)	1941 (4)	14,808 (35)	1425 (5)	13,973 (36)	1357 (6)	15,531 (36)	1703 (7)
Partial gastrectomy	30,149 (64)	44,732 (96)	28,149 (65)	29,688 (95)	24,882 (64)	23,173 (94)	28,240 (64)	23,659 (93)
Length of stay, mean (days)	17	18	15	17	15	17	14	16
Admission type, frequency (%)								
Elective	24,902 (61)	10,514 (25)	25,008 (66)	8036 (28)	27,914 (72)	7717 (32)	33,645 (77)	8472 (34)
Non-elective	16,096 (39)	31,483 (75)	13,116 (34)	20,112 (72)	10,879 (28)	16,776 (68)	10,090 (23)	16,838 (66)
Comorbidities, frequency (%)								
1	10,310 (22)	25,827 (55)	10,313 (24)	15,082 (49)	9865 (25)	10,614 (43)	13,670 (31)	10,611 (42)
2	23,624 (51)	12,677 (27)	20,517 (48)	9288 (30)	17,588 (45)	7764 (32)	17,191 (39)	7796 (31)
3	12,782 (27)	8168 (18)	12,109 (28)	6744 (22)	11,370 (29)	6152 (25)	12,871 (29)	6954 (27)
Hospital location, frequency (%)								
Rural	4734 (10)	8279 (18)	3894 (9)	4690 (15)	2330 (6)	3020 (12)	1599 (4)	2705 (11)
Urban, nonteaching	17,671 (38)	19,116 (41)	15,666 (37)	13,315 (43)	13,484 (35)	10,717 (44)	12,205 (28)	10,274 (41)
Urban, teaching	24,191 (52)	19,069 (41)	23,374 (54)	13,072 (42)	23,000(59)	10,775 (44)	29,468 (68)	12,195 (48)
Hospital size, frequency (%)								
Small	5399 (12)	5114 (11)	4119 (10)	3503 (11)	3172 (8)	2498 (10)	3770 (9)	2486 (10)
Medium	12,242 (26)	12,779 (28)	10,439 (24)	8594 (28)	8911 (23)	6300 (26)	8153 (19)	6220 (25)
Large	28,955 (62)	28,571 (62)	28,377 (66)	18,980 (61)	26,731 (69)	15,715 (64)	31,349 (72)	16,468 (65)
Geographic location, frequency (%)								
Northeast	11,724 (25)	9424 (20)	10,696 (25)	5657 (18)	9170 (24)	4185 (17)	10,385 (24)	3847 (15)
Midwest	8901 (19)	9893 (21)	9011 (21)	6799 (22)	6733 (17)	5300 (22)	8495 (19)	5513 (22)
South	17,362 (37)	18,907 (41)	14,537 (34)	12,847 (41)	13,419 (35)	10,390 (42)	15,393 (35)	11,209 (44)
West	8767 (19)	8449 (18)	8713 (20)	5811 (19)	9533 (24)	4655 (19)	9497 (22)	4793 (19)
In-hospital mortality, frequency (%)	3473 (7)	6082 (13)	2957 (7)	4308 (14)	2296 (6)	2858 (12)	1644 (4)	2376 (9)

Estimates by time interval are shown.

Note: Numbers rounded for ease of use. The sum of sample sizes and percentages differ by variable due to missing data

(133,983) were for management of PUD (data not shown). Of the 184,805 major gastrectomies for cancer, 172,336 (93.3%) were for adenocarcinoma. To allow for meaningful comparison, only ICD-9-CM diagnostic codes for gastric adenocarcinoma were used for further analysis (ICD-9-CM 1510–1519), with all other ICD-9-CM gastric tumors being excluded (Supplemental Table 2). Over the 20-year study period, 67,342 total gastrectomies and 232,670 partial gastrectomies were performed for cancer and PUD combined (Table 1 provides estimates by time interval). Considerably, more admissions are classified as emergent in the PUD cohort compared to the cancer cohort (Table 1). Most total gastrectomies (90.5%) and nearly half of all partial gastrectomies (47.9%) were performed for cancer. The

Table 2 Multivariate logistic regression for in-hospital mortality

	Gastric cancer		Peptic ulcer disease	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Sex				
Male	1		1	
Female	1.315(1.175,1.471)	< 0.0001	1.101(1.003,1.209)	0.043
Age (years)				
< 60	1		1	
60–69	1.493(1.228,1.815)	< 0.0001	2.167(1.867,2.516)	< 0.0001
≥ 70	3.061(2.589,3.618)	< 0.0001	4.235(3.724,4.815)	< 0.0001
Race				
White	1		1	
Black	0.884(0.749,1.044)	0.148	0.808(0.693,0.942)	0.006
Hispanic	0.818(0.669,1.001)	0.051	0.969(0.777,1.208)	0.778
Asian/Pacific Islander	0.755(0.587,0.972)	0.029	0.714(0.509,1.002)	0.051
Native American	1.226(0.498,3.019)	0.657	1.562(0.698,3.496)	0.278
Other	1.036(0.745,1.44)	0.833	0.876(0.632,1.214)	0.427
Year				
1993	1		1	
1994	0.926(0.674,1.274)	0.638	0.953(0.761,1.193)	0.673
1995	1.207(0.879,1.657)	0.245	0.855(0.667,1.095)	0.214
1996	1.099(0.792,1.525)	0.573	0.982(0.781,1.236)	0.879
1997	1.123(0.813,1.551)	0.482	1.005(0.794,1.273)	0.966
1998	1.096(0.757,1.585)	0.628	0.874(0.671,1.138)	0.318
1999	1.08(0.778,1.5)	0.646	0.976(0.75,1.271)	0.858
2000	1.06(0.751,1.495)	0.740	1.071(0.836,1.371)	0.588
2001	1.199(0.858,1.676)	0.288	0.99(0.756,1.296)	0.939
2002	0.795(0.558,1.135)	0.207	0.967(0.743,1.259)	0.803
2003	1.014(0.721,1.428)	0.935	1.005(0.775,1.302)	0.972
2004	0.974(0.67,1.415)	0.889	0.818(0.62,1.077)	0.153
2005	0.891(0.612,1.298)	0.548	0.833(0.62,1.119)	0.225
2006	0.979(0.684,1.4)	0.905	0.816(0.605,1.1)	0.182
2007	1.002(0.716,1.402)	0.990	0.665(0.483,0.915)	0.012
2008	0.857(0.601,1.221)	0.392	0.649(0.481,0.875)	0.005
2009	0.621(0.41,0.94)	0.024	0.789(0.586,1.063)	0.119
2010	0.704(0.483,1.025)	0.067	0.621(0.455,0.846)	0.003
2011	0.687(0.463,1.021)	0.064	0.634(0.468,0.858)	0.003
2012	0.756(0.524,1.09)	0.135	0.54(0.399,0.73)	< 0.0001
2013	0.51(0.332,0.784)	0.002	0.618(0.456,0.838)	0.002
Admission type				
Elective	1		1	
Non-elective	1.686(1.508,1.885)	< 0.0001	3.343(2.869,3.895)	< 0.0001
Comorbidities				
1	1		1	
2	1.388(1.187,1.622)	< 0.0001	1.685(1.501,1.891)	< 0.0001
≥ 3	2.116(1.806,2.479)	< 0.0001	2.309(2.044,2.608)	< 0.0001
Hospital location				
Urban teaching	1		1	
Rural	1.148(0.926,1.423)	0.208	0.715(0.608,0.841)	< 0.0001
Urban nonteaching	1.184(1.055,1.329)	0.004	0.949(0.86,1.046)	0.291

Table 2 (continued)

	Gastric cancer		Peptic ulcer disease	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Hospital bedsize				
Large	1		1	
Small	0.983(0.809,1.196)	0.866	0.907(0.779,1.058)	0.214
Medium	1.057(0.933,1.196)	0.383	0.921(0.828,1.026)	0.135
Length of stay	1.025(1.022,1.028)	< 0.0001	1.01(1.007,1.012)	< 0.0001

number of both partial and total gastric resections decreased significantly from 1993 to 2013 ($p < 0.0001$; Fig. 1). The differences in both absolute number and percent change were greater for partial gastrectomy (− 51.9%) than total gastrectomy (− 18.2%) (Fig. 1). Notably, gastric resections for cancer steadily declined over the study period (− 27.5%, $p < 0.0001$; Fig. 2). Gastrectomy for PUD decreased by 59.1% between 1993 and 2006, whereas after 2006, the number of resections for PUD remained relatively stable with an estimated average of 4242 operations per year (range 4080–4334).

The average age of patients undergoing gastrectomy for cancer was higher compared to patients undergoing gastrectomy for PUD across time intervals. Over half (63.2%) of cancer gastrectomies were performed on males compared to 48.2% for PUD (data not shown). The mean length of stay decreased throughout the study period for both cohorts. This change was more pronounced for the cancer cohort (18.2 days in 1993 compared to 12.6 days in 2013) than for PUD (19.2 days in 1993 compared to 15.5 days in 2013).

The annual frequency of in-hospital mortality for cancer (5.9%) was lower than for PUD (11.9%). For cancer gastrectomy patients, the in-hospital mortality rate was significantly lower in 2013 compared to 1993 (Table 2, p value = 0.002). A multivariate model was created to examine factors associated

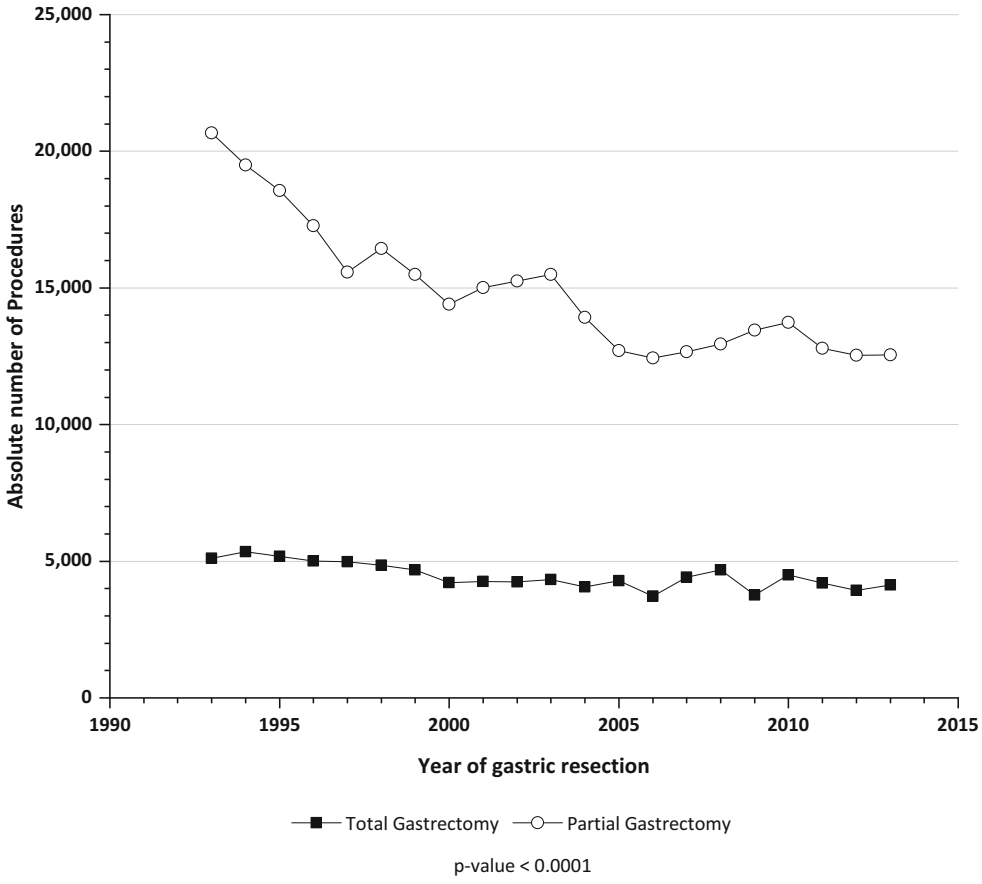

Fig. 1 Annual trends in gastrectomy by procedure type

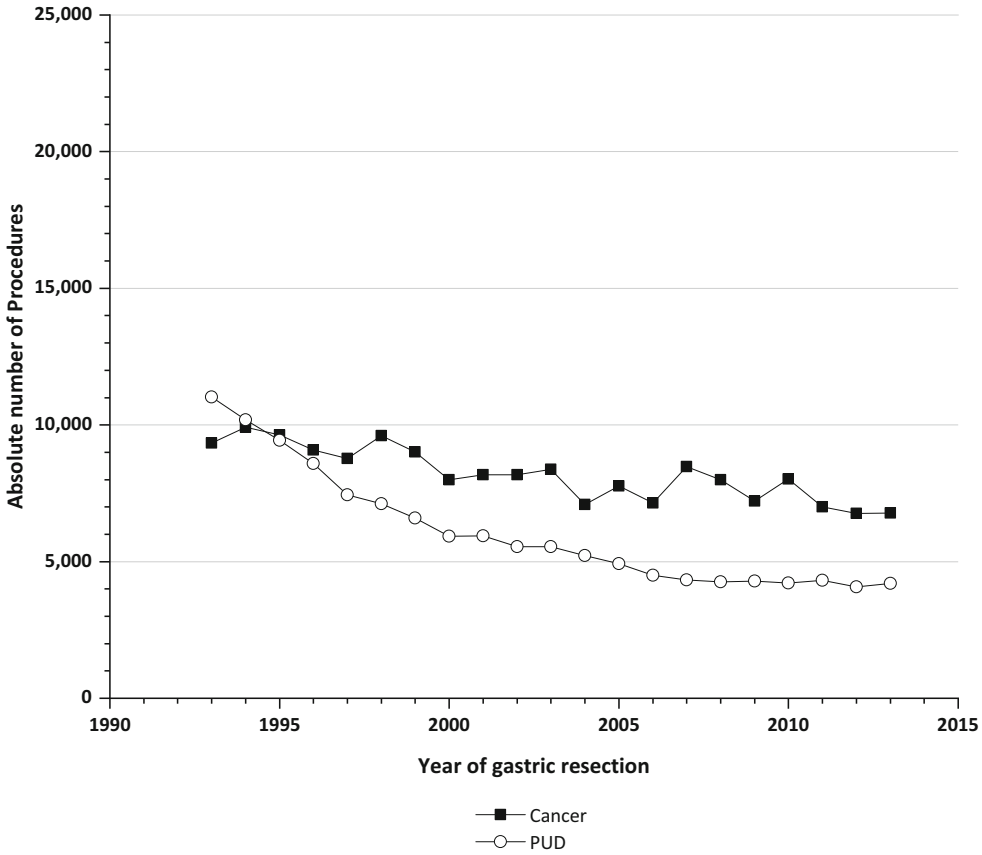

Fig. 2 Annual trends in gastrectomy by indication for procedure

with in-hospital mortality following gastrectomy for cancer and PUD which demonstrated significant variation by age, sex, and race. For patients undergoing gastrectomy for either cancer or PUD, female sex and increasing age were associated with higher rates of in-hospital mortality while treatment at an urban teaching hospital was associated with lower in-hospital mortality for the cancer cohort (Tables 2 and 3). Moreover, mortality rates differed according to race, such that Asian patients consistently experienced lower in-hospital mortality compared to Whites ($p = 0.03$ and 0.05 for cancer and PUD, respectively). Non-elective admission type and increasing number of comorbidities were also associated with significantly higher rates of in-hospital mortality. Interestingly, mortality after gastrectomy varied little by geographic region except for gastrectomy for PUD performed in the Northeast region was associated with significantly higher risk of in-patient mortality than in the South (data not shown).

Notable variation in gastric resection (by either indication) according to race was observed, even though gastrectomy was performed most frequently in White patients (Fig. 3). For instance, the percentages of gastrectomy for cancer in 1993 were 75.0% and 7.5% for Whites and Hispanics, respectively, whereas in 2013, the percentages were 60.0% and 14.7%, respectively (Fig. 3). While the absolute number of resections for PUD decreased in White and African-American patients during the study period, gastric resections for PUD remained relatively stable for Hispanics and Asians (Fig. 3).

The percentage of gastrectomy operations performed at urban teaching hospitals increased after 2005 as compared to rural and urban non-teaching hospitals, for both cancer and PUD patients (data not shown). Absolute number of gastrectomy procedures for cancer performed at urban teaching hospitals showed relative stability over the study period when compared to other hospital types, and to operations for PUD (Fig. 4). When considered together with the decline in gastrectomy procedures overall, the frequency of gastric cancer resections performed at urban teaching hospitals increased over time compared to other hospital types. In a multivariate model, factors associated with lower likelihood of admission to an urban teaching hospital for cancer gastrectomy included female sex, age greater than 60, Hispanic race (Table 3). A logistic regression model was created to test for an interaction effect between year and hospital location (urban teaching, urban non-teaching, rural) to determine if the decreasing annual rate of in-hospital mortality was associated with the increased frequency of gastric cancer resection performed at urban teaching hospitals. This analysis (not-shown) demonstrated no significant interaction effect between year and hospital location for in-hospital mortality after gastrectomy for cancer.

Table 3 Multivariate logistic regression for admission to urban teaching hospital for gastrectomy for cancer

	OR (95% CI)	*p* value
Sex		
Male	1	
Female	0.867 (0.824–0.913)	< 0.0001
Age		
< 60	1	
60–69	0.768 (0.716–0.824)	< 0.0001
≥ 70	0.559 (0.522–0.599)	< 0.0001
Race		
White	1	
Black	1.259 (1.129–1.403)	< 0.0001
Hispanic	0.802 (0.709–0.908)	< 0.0001
Asian/Pacific Islander	0.961 (0.813–1.136)	0.643
Native American	0.862 (0.524–1.418)	0.559
Other	1.419 (1.167–1.725)	< 0.0001
Year		
1993	1	
1994	0.912 (0.604–1.377)	0.662
1995	1.106 (0.735–1.666)	0.629
1996	1.121 (0.747–1.682)	0.580
1997	1.283 (0.861–1.913)	0.221
1998	1.318 (0.797–2.177)	0.282
1999	1.242 (0.832–1.853)	0.289
2000	1.099 (0.744–1.626)	0.635
2001	1.159 (0.79–1.701)	0.451
2002	1.23 (0.826–1.83)	0.308
2003	1.517 (1.009–2.281)	0.045
2004	1.194 (0.79–1.804)	0.399
2005	1.392 (0.922–2.103)	0.116
2006	1.452 (0.97–2.171)	0.070
2007	2.339 (1.378–3.968)	0.002
2008	1.929 (1.236–3.012)	0.004
2009	1.919 (1.28–2.877)	0.002
2010	2.406 (1.437–4.027)	0.001
2011	2.32 (1.509–3.567)	< 0.0001
2012	2.857 (1.958–4.169)	< 0.0001
2013	2.437 (1.659–3.581)	< 0.0001
Comorbidities		
1	1	
2	0.879 (0.823–0.94)	< 0.0001
≥ 3	0.694 (0.644–0.748)	< 0.0001
Hospital bedsize		
Large	1	
Small	2.339 (1.968–2.778)	< 0.0001
Medium	1.193 (1.068–1.333)	0.002
Length of stay	1.005 (1.003–1.007)	< 0.0001

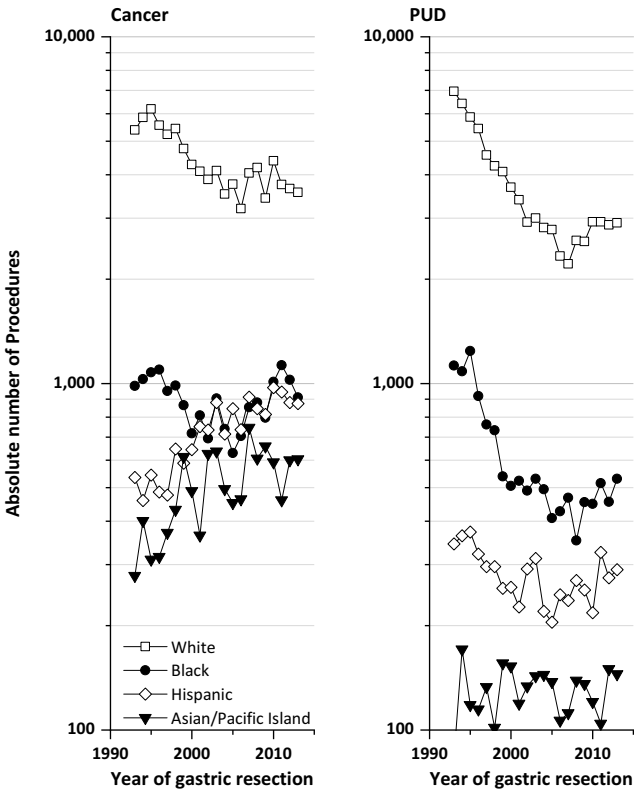

Fig. 3 Annual trends in gastrectomy for cancer and peptic ulcer disease by race

Discussion

The current study demonstrates a definite annual decline in major gastrectomy in the USA. Causes for this steady drop have been attributed to changes in both epidemiology and treatment of the two major indications for major gastrectomy, cancer and PUD. Our contemporary analysis is consistent with trends in gastrectomy for cancer in previous decades.[8] The change in gastric cancer incidence in the USA likely contributes to the concomitant decrease in the frequency of gastrectomy for cancer.[15] However, the frequency of gastrectomy for PUD decreased substantially between 1993 and 2006 but then remained stable from 2007 through 2013. This plateau in resections for PUD may be attributed to fixed morbidity rates despite medical management. In a study of Veterans Administration patients, of those who underwent an operation for PUD, only 5% were for failure of medical therapy whereas 95% were for acute complications such as bleeding or perforation; and of all procedures being performed for PUD, only 30% were gastrectomy.[16] Therefore, the frequency of gastric resection for cancer may decline along with incidence, while a relatively low but fixed rate of patients may continue to require gastrectomy for PUD.

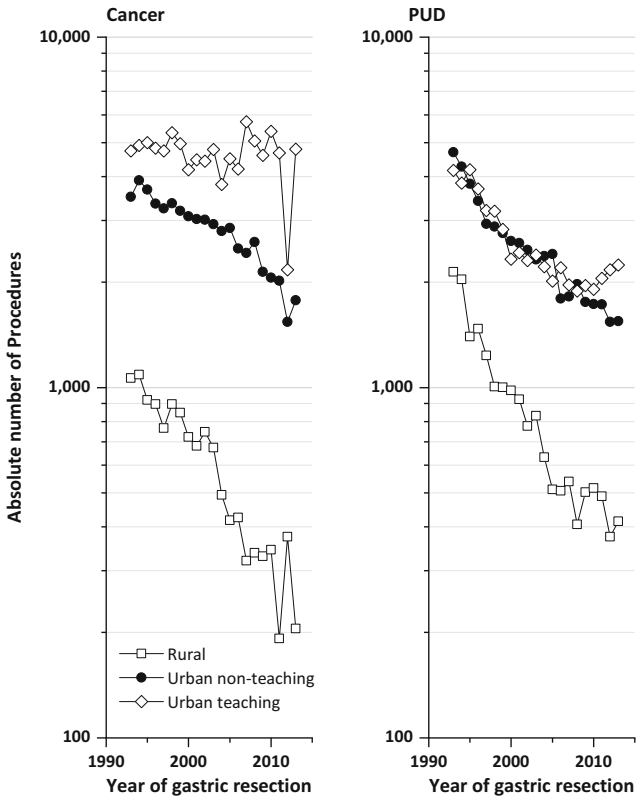

Fig. 4 Annual trends in gastrectomy for cancer and peptic ulcer disease by hospital type

Current data indicate that in-hospital mortality following gastrectomy continues to decline.[17] Over the study period, gastric resections were performed more frequently at urban teaching hospitals. During the same time, both average length of stay and in-hospital mortality rates declined. These findings suggest that in-hospital mortality is associated with annual hospital volume for gastrectomy.[18] However, the volume-outcome relationship is complex and cannot simply be attributed to high-volume surgeons and/or hospitals, especially since the frequency of gastrectomy has declined overall.[19] For instance, Reavis and coworkers demonstrated that there was no difference in length of stay, overall complications, and in-hospital mortality in patients undergoing gastrectomy for cancer when comparing high- and low-volume hospitals.[20] Even though patients were more likely overall to gain admission to urban teaching hospitals in the current study, the factors associated with admission for both cancer and PUD are likely complex. Factors associated with admission to urban teaching hospitals for gastrectomy for cancer were explored owing to the dramatic increase in the frequency of admissions to this hospital type over the most recent decade studied. The results of that analysis are considered hypothesis-generating and thus no firm conclusions should be made.

Multivariable adjusting analysis of common factors associated with mortality revealed that in-hospital death rates were significantly higher in older patients and females and were significantly lower in Asians for both cancer gastrectomy and PUD gastrectomy cohorts. This finding parallels data that report Asian patients experience improved survival after curative-intent gastrectomy for adenocarcinoma.[21] It is noteworthy that the in-hospital mortality rate of patients requiring gastrectomy for PUD trended downward during the study period but overall remained higher than the in-hospital mortality rate of patients undergoing gastrectomy for cancer. This is likely due to higher co-morbidity indices among patients undergoing operation for complications of PUD and the often urgent or emergent nature of operations in this patient population. Subsequently, direct comparison of outcomes for cancer and PUD may be inappropriate.

While the overall incidence of gastric cancer in the USA is declining, there are known variations in incidence and outcomes by race.[22] The overall annual incidence of gastric cancer is declining in all age and race groups except Hispanic men age 20–49.[23] Our analysis revealed an increase in frequency of gastrectomy for cancer in the US Hispanic population (Fig. 3) that likely is coincident with the increase in non-cardia gastric cancer among Hispanics compared to non-Hispanic Whites.[24] However, this finding could also be attributed to the growing Hispanic population in the USA.[25] Nonetheless, this is important because our data suggest that Hispanics experience similarly high rates of in-hospital mortality as non-Hispanic Whites. Likewise, a retrospective study of the Los Angeles County Cancer Surveillance Program revealed that 28% of patients undergoing cancer gastrectomy were Hispanic; yet, survival was better for Asians compared to Whites, Hispanics, and Blacks.[26] This finding correlates with our data demonstrating significantly lower in-hospital mortality in Asians compared to Whites.

Surgeon experience performing gastrectomy is inextricably linked to the prevalence of disease with indications for operation. With fewer gastrectomies performed for cancer, it follows that surgical trainees are less likely to obtain experience in a fundamental area of general surgery. Even as the rate of gastrectomy for PUD remained stable over the last 7 years of the current study period, the rate of hospitalization for PUD appeared to decrease during this timeframe.[27] Thus, a new generation of general surgeons is coming of age in an era of less frequent exposure to major gastric pathology and resectional gastric surgery, albeit accompanied by greater exposure to gastric-bypass and related gastric procedures for morbid obesity. If the frequency of major gastrectomy continues to decline, both the general surgeon and general surgery trainee's experience may be impacted substantially. Thus, further consideration should be given to insuring sufficient surgical expertise in gastric resection and its sequelae for trainees interested in caring for patients with gastric pathology.

This retrospective, population-based study is limited as the data represent only a sampling of in-patient hospitalizations that may not adequately reflect the US population. Our study

design did not incorporate non-anatomical (wedge) gastric resections or gastric surgery for morbid obesity. In this respect, we did not count these operations as major gastric resections and therefore may not account for what some may consider gastric surgery. Our aim, rather, was to focus on gastric resection vis-à-vis its complexities and peri-operative sequelae. Another limitation of our study was that NIS does not provide certain data points that could affect length of stay and in-hospital mortality after gastrectomy, such as cancer stage at diagnosis and classification of operations as elective, urgent, or emergent.

Conclusion

Major gastrectomy for cancer is significantly waning in frequency in the USA. Despite this decline, in-hospital mortality rates also decreased considerably over two decades. The upward trend in proportion of patients undergoing gastrectomy at urban teaching hospitals may account, in part, for the associated improvement in outcomes. Racial differences in rates of gastrectomy for cancer over time appear to reflect an underlying shift in the epidemiology of gastric cancer in the USA. Individual surgeon experience, and thus trainee exposure, will likely continue to decline, which has implications for general and sub-specialty surgical training in foregut surgery. While the downward trend in frequency of major gastrectomy may have many causes, the unintended consequences of less frequent gastric surgery overall must be considered.

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Compliance with Ethical Standards

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