Original Article

Inpatient burden of gastric cancer in the United States

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Background: Gastric cancer is associated with significant morbidity and mortality. Over one-half of patients have advanced disease at the time of presentation, leading to a significant burden on the healthcare system. Limited epidemiological data exists on national inpatient hospitalization trends. The aim of this study is to determine the inpatient burden of gastric cancer in the United States.

Methods: We analyzed the Nationwide Inpatient Sample (NIS) database for all subjects with the diagnosis of malignant neoplasm of the stomach (ICD-9 code 151.x) as primary diagnosis during the period from 2001–2011. NIS is the largest all-payer inpatient care database in the U.S. Statistical significance of variation in the number of hospitalizations, patient demographics, and comorbidity measures was determined using Cochran-Armitage trend test.

Results: From 2001 to 2011, the number of hospitalizations with the diagnosis of malignant neoplasm of the stomach ranged between 22,430 and 25,371, however, the trend was not significant. Men were always more affected than women with no significant change in overall proportion (P<0.0001). Overall, in-hospital mortality decreased from 11.19% in 2001 to 6.47% in 2011 (P<0.0001). However, average cost of care per hospitalization increased from $21,710 in 2001 to $24,706 in 2011 (adjusted for inflation, P<0.0001).

Conclusions: The total number of hospitalizations remained relatively stable throughout the study period with higher proportion of men affected every year. Although in-hospital mortality in patients with the diagnosis of gastric cancer decreased over the study period, there was a significant rise in the cost of care.

Keywords: Gastric cancer; mortality; cost; survival

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Introduction

Gastric cancer was the leading cause of cancer death in the United States (U.S.) until the late 1930s (1). Since then, the proportion of gastric cancer has decreased substantially in the U.S. and is now the fifteenth leading cause of cancer death (2). In the U.S., annual age-standardized mortality from gastric cancer was estimated to be 3.00 per 100,000 men and 1.46 per 100,000 women between 2000 to 2004 by Ferro and colleagues (3). These rates decreased to 2.55 per 100,000 men and 1.28 per 100,000 women from 2005 to 2009 in that study, showing a clear decrease in the

mortality rates in the U.S. However, survival remains poor and 65% of the gastric cancers are discovered at an advanced stage (4,5).

Over one-half of patients have advanced disease at the time of presentation, leading to a significant burden on the healthcare system (6). The total cost of gastric cancer was estimated to be $1.82 billion in 2010 by Mariotto *et al.* at the National Cancer Institute in the U.S. (7). This study noted that the total cost of care of gastric cancer in the U.S. is projected to be $2.31 billion in 2020. However, it was performed on a population based registry and therefore was not a strictly inpatient study. Knopf *et al.* estimated mean monthly costs for gastric cancer patients to be $10,653 between 2007 and 2009 (8). Again, this study was done using IMS LifeLink Health Plan Claims Database, which includes both inpatient and outpatient diagnoses (9).

An accurate understanding of trends in gastric cancer related hospitalizations is necessary for future healthcare planning considering the enormous rise in cost care anticipated by year 2020. A national study which identifies vulnerable groups may permit more effective future reductions in health care disparities than a single center and/or multi-center studies (10,11). Thus, we designed our study using a national inpatient database.

The Nationwide Inpatient Sample (NIS), designed by Agency for Healthcare Research and Quality (AHRQ), is the largest all-payer inpatient database in the U.S. Data are compiled yearly and contain discharge information from over 1,200 hospitals located across 45 states in the U.S. The NIS was designed to approximate a 20% stratified sample of community hospitals in the country and provides sampling weights to calculate national estimates (12). The NIS contains information included in a typical discharge summary, with safeguards in place to protect the privacy of individual patients, physicians, and hospitals. Each individual hospitalization is de-identified and maintained in the NIS as a unique entry with one primary discharge diagnosis and approximately twenty-four secondary diagnoses during that hospitalization (13). Each entry also carries information on demographic details, insurance status, comorbidities, primary/secondary procedures, hospitalization outcomes, length of stay, and cost of care. The internal validity of the database is guaranteed by annual data quality assessments of the sample. Moreover, comparisons with data sources like the American Hospital Association (AHA) Annual Survey of Hospitals, National Hospital Discharge Survey from the National Center for Health Statistics, and Medicare Provider and Analysis Review (MedPAR) inpatient data from the Centers for Medicare and Medicaid Services strengthen the external validity of the sample (14,15).

Methods

Study design

This is a retrospective cohort study in which we queried the NIS database from year 2001 to 2011 to identify all the hospitalizations with gastric cancer. We extracted data regarding all the hospitalizations from 2001 to 2011 with primary diagnosis of gastric cancer, which in turn was identified with International Classification of Diseases, 9th Revision, Clinical Modification, ICD-9 code 151.x. Patients with age less than 18 years were excluded, as were hospitalizations with missing information related to age, gender, admission/discharge date, and in-hospital mortality status and demographics and comorbidities as seen in other NIS based studies (11,16). To calculate estimated cost of hospitalizations, NIS data were merged with cost-to-charge ratio (CCR) files available from the Healthcare Cost and Utilization Project. We estimated the cost of each inpatient stay by multiplying the total hospital charge with CCR. This study was exempted from ethics approval because we did not use personally identifiable information (PII).

Variables and statistical analysis

SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA) was utilized for complex statistical analyses. Since NIS represents a 20% stratified random sample of U.S. hospitals, analyses were performed using hospital-level discharge weights provided by the NIS, to obtain national estimates of hospitalizations. Gastric cancer-related hospitalizations per million U.S. population were calculated by dividing the number of such hospitalizations in each year by U.S. census population greater than 18 years age for that year. Gastric cancer hospitalizations were also calculated in subgroups of age (18–34, 35–49, 50–64, 65–79, and ≥80 years), gender, race (White, Black, Hispanic, Asian or Pacific Islander, Native American, and others), insurance status (Medicare/Medicaid, private insurance, self-pay/other), hospital location in different U.S. regions (Northeast, Midwest, South, West), and teaching status of the hospital. According to AHRQ, a hospital is considered to be a teaching hospital if it is: (I) an AMA-approved residency program,; (II) a member of the Council of Teaching Hospitals; or (III) a

hospital with a full-time intern and resident-to-bed (IRB) ratio more than 0.25 (17). The Cochrane-Armitage trend test was used to calculate trends in categorical variables (18). The Wilcoxon rank sum test was used to assess continuous variables (19).

Results

Demographics

A total of 264,686 hospitalizations for gastric cancer (as primary diagnosis) were identified in the U.S. population from 2001 to 2011, with 23,880 hospitalizations in 2001 and 23,281 in 2011 (P=0.3). Patient characteristics are described in *Table 1*. Gastric cancer patients were predominantly White (49.0%) and between 65 and 79 years of age (38.6%) (*Figure 1*). There were more hospitalizations in males (62.7%) than females (37.2%). The gender ratio was stable throughout the study period. Medicare/Medicaid was the primary payer for 63.3% of gastric cancer hospitalizations. The majority of gastric cancer hospitalizations were reported in the South (34.3%), followed by the Northeast (24.4%), West (21.3%), and Midwest (20.0%) (*Table 1*). However, the incidence of gastric cancer hospitalizations was highest in the Northeast, accounting for 84.7 hospitalizations per 100,000 hospitalizations when compared to 61.0 per 100,000 hospitalizations in the South.

Trends in hospitalizations

The gastric cancer hospitalization rate remained relatively stable between 2001 and 2011 (P=0.3) (*Table 2*). The magnitude of rise in gastric cancer-related hospitalizations was higher in 50–64 age group (relative increase 36.9%, P<0.0001) than 18–34 age group (relative increase 20%, P<0.0001) (*Table 2*). Age group 35–49 showed 12.5% decline in the hospitalization rate between 2001 and 2011 (P<0.0001). Women accounted for 38.8% of total gastric cancer hospitalizations in 2001 and 36.9% of total gastric cancer hospitalizations in 2011. The gastric cancer hospitalization rate was higher in White than other racial groups throughout the study. All racial groups showed an increase in the rates between 2001 and 2011 (P<0.0001) (*Table 2*).

All-cause in-hospital mortality

The rate of in-hospital mortality in gastric cancer showed a significant decrease from 11.2% in 2001 to 6.5% in 2011 (P<0.0001) (*Table 3*). Across the age groups, the mortality rate was highest in ≥80 years age group at 10.6%. The average mortality rates between men and women were similar during the study period (9.0% *vs.* 8.8%, respectively) (P=0.0141) (*Table 3*). The highest mortality rate (10.4%) was among Black (P<0.0001) (*Figure 2*) and lowest in the Native American population (8.0%). Mortality was highest in Northeast (10.8%) and lowest in the West (7.8%). It was higher in hospitals in the rural area (10.6%) than urban teaching hospital (7.9%) (*Table 1*).

Cost of care

After adjustment for inflation, the mean cost of hospitalizations with a gastric cancer diagnosis increased from $21,710 in 2001 to $24,706 in 2011 (P<0.0001) (*Table 4*). The estimated annual cost of managing patients with gastric cancer was $518 million in 2001 and $575 million in 2011. The mean cost of care was lowest if gastric cancer-related hospitalization was in the Midwest ($4,819) and rural hospitals ($1,855). It was highest in the South ($8,245) and urban teaching hospitals ($13,233) (*Table 4*).

Comorbidities associated with hospitalizations

AHRQ comorbidities most commonly associated with gastric cancer-related hospitalizations were hypertension (40.3%), anemia (23.8%), and diabetes without complications (15.5%) (*Table 1*).

Predictors of mortality

After adjusting for confounding factors, Black race was found to be at have a stronger association with risk of mortality in gastric cancer-related hospitalizations as compared to White (OR 1.3; 95% CI: 1.2 to 1.4; P<0.0001). Alcohol abuse and obesity were also significantly associated with increased the risk of mortality (*Table 5*).

Discussion

To our knowledge, this is the second retrospective study determining the *inpatient* burden of gastric cancer in the U.S. Liu *et al.* conducted a similar study using NIS database in 2018 (20). All other studies have reported findings from population-based cancer registries like Surveillance, Epidemiology, and End Results (SEER), United States

Table 1 Baseline characteristics of the gastric cancer hospitalizations

Variable	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Overall	P value
Number of hospitalizations (n)	23,880	23,955	24,950	23,590	24,728	22,430	25,371	24,415	22,793	25,294	23,281	264,686	0.3
Age in years (%)													
18–34	1.5	1.9	1.4	1.4	1.8	1.9	1.9	2.1	1.7	1.6	1.8	1.7	0.0011
35–49	10.4	10.5	10.6	11.1	10.9	9.1	11.0	10.0	10.7	11.1	9.1	10.4	0.0068
50–64	23.3	25.3	25.1	27.5	28.1	28.2	30.0	28.7	31.1	32.0	31.9	28.3	<0.0001
65–79	42.3	39.4	40.4	37.8	37.9	39.0	38.1	36.9	37.6	37.0	38.7	38.6	<0.0001
≥80	22.5	22.9	22.4	22.1	21.1	21.9	19.0	22.2	18.9	18.2	18.4	20.9	<0.0001
Gender (%)													
Male	61.2	62.1	62.3	62.5	63.1	61.4	63.6	64.1	62.6	64.0	63.0	62.7	<0.0001
Female	38.8	37.9	37.6	37.4	36.7	38.5	36.3	35.8	37.3	36.0	36.9	37.2	
Race (%)													
White	50.1	47.1	48.1	48.0	47.3	44.4	46.1	52.1	49.1	51.2	56.0	49.0	<0.0001
Black	10.5	10.6	11.2	12.1	9.2	10.8	11.2	12.4	11.6	15.5	14.8	11.8	<0.0001
Hispanic	8.9	8.6	10.9	10.4	10.9	11.5	10.7	9.9	11.8	14.9	13.5	11.1	<0.0001
Asian or Pacific Islander	4.1	6.1	5.9	5.3	5.5	5.6	6.8	6.4	7.7	5.9	5.2	5.9	<0.0001
Native American	0.2	0.3	0.1	0.3	0.2	0.4	0.8	0.3	0.6	0.9	0.3	0.4	<0.0001
Others	2.1	2.4	2.2	1.7	2.6	2.3	2.7	2.7	4.0	3.3	3.8	2.7	<0.0001
Region (%)													
Northeast	26.0	23.9	23.2	26.5	24.9	22.3	28.6	24.2	21.7	24.5	22.5	24.4	<0.0001
Midwest	22.0	20.6	19.3	20.1	21.7	19.6	17.6	17.7	21.2	21.6	19.2	20.0	<0.0001
South	33.0	36.3	34.1	34.4	32.1	34.0	33.4	36.6	33.9	33.0	36.2	34.3	0.0074
West	19.1	19.3	23.4	19.0	21.3	24.1	20.4	21.5	23.2	20.9	22.1	21.3	0.0007
Location (%)													
Rural	9.9	10.1	9.7	9.4	7.2	7.7	6.6	6.7	6.7	5.8	5.1	7.7	<0.0001
Urban nonteaching	40.5	38.9	39.3	41.7	41.8	35.6	31.9	36.2	34.3	30.7	33.9	36.8	<0.0001
Urban teaching	49.6	51.0	51.0	48.9	51.0	56.2	61.4	57.0	57.0	62.0	59.4	55.0	<0.0001
Median household income (%)													
Quartile 1	6.4	4.1	25.4	27.3	25.2	26.9	26.4	26.6	25.7	28.0	26.7	22.6	<0.0001
Quartile 2	20.4	20.0	26.3	26.0	23.9	24.0	22.8	24.6	24.3	23.9	23.5	23.6	<0.0001
Quartile 3	27.3	22.6	24.7	20.9	25.9	24.3	22.6	22.5	23.0	22.6	24.5	23.7	0.0016
Quartile 4	44.8	51.1	21.5	23.4	22.6	22.9	25.3	23.5	23.4	22.5	23.9	27.7	<0.0001
Payment (%)													
Medicare	56.6	55.6	56.5	53.7	53.8	55.0	52.2	52.2	51.0	50.4	53.1	53.6	<0.0001
Medicaid	8.0	7.4	8.1	8.5	9.2	10.1	11.4	9.3	10.0	13.1	10.9	9.7	<0.0001
Private insurance	29.6	30.0	29.4	31.3	29.6	27.1	29.6	32.4	31.4	28.9	29.4	29.9	0.1379
Others (includes self-pay)	5.7	7.0	5.9	6.5	7.3	7.6	6.7	6.0	7.4	7.3	6.4	6.7	<0.0001
In-hospital mortality (%)	11.2	10.0	11.0	10.5	9.4	9.8	8.3	7.7	7.5	6.5	6.5	8.9	<0.0001
Cost of care ($)	21,710	22,547	24,414	21,757	24,243	23,737	26,190	24,761	23,361	26,296	24,706	23,975	<0.0001

Table 1 (*continued*)

Table 1 (*continued*)

Variable	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Overall	P value
AHRQ comorbidity measures (%)													
Acquired immunodeficiency syndrome	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.1338
Alcohol abuse	0.0	2.5	2.2	2.6	2.7	3.0	2.5	3.1	2.9	3.5	3.9	2.6	<0.0001
Deficiency anemias	0.0	18.8	20.9	23.2	25.0	25.8	26.0	30.4	30.2	30.7	30.7	23.8	<0.0001
Rheumatic disorders[a]	0.0	0.8	1.1	0.8	1.1	1.0	1.1	1.5	1.3	1.4	1.4	1.1	<0.0001
Chronic blood loss anemia	0.0	9.9	9.2	10.6	9.9	10.5	9.3	8.9	7.7	7.7	7.1	8.3	<0.0001
Congestive heart failure	0.0	7.4	7.2	7.8	7.8	7.7	6.8	7.5	6.2	6.6	7.3	6.6	<0.0001
Chronic pulmonary disease	0.0	14.0	14.0	15.9	15.7	16.5	15.0	15.0	14.3	14.3	15.7	13.7	<0.0001
Coagulopathy	0.0	2.7	3.2	3.3	3.6	3.7	4.0	4.5	5.5	5.6	6.3	3.9	0.0198
Depression	0.0	3.2	3.7	4.4	4.6	5.2	5.3	5.6	6.1	6.3	7.7	4.7	<0.0001
Uncomplicated diabetes	0.0	15.0	14.4	15.1	15.0	17.9	18.3	18.7	18.8	18.1	19.9	15.5	<0.0001
Diabetes with chronic complications	0.0	1.4	1.4	1.3	1.6	1.7	1.8	2.5	2.2	2.0	3.3	1.7	<0.0001
Drug abuse	0.0	0.6	0.4	0.5	0.7	0.7	0.9	0.8	1.3	1.1	1.0	0.7	<0.0001
Hypertension	0.0	33.0	36.7	38.9	40.5	44.1	45.4	50.2	50.1	50.1	54.8	40.3	<0.0001
Hypothyroidism	0.0	4.9	5.2	5.5	5.9	5.6	6.7	7.8	7.5	8.1	8.6	6.0	<0.0001
Liver disease	0.0	1.9	2.1	1.9	2.4	3.0	2.7	3.0	3.4	3.5	3.7	2.5	<0.0001
Lymphoma	0.0	1.1	0.5	0.8	0.6	0.5	0.7	0.6	0.7	0.5	0.7	0.6	<0.0001
Fluid and electrolyte disorders	0.0	24.7	24.7	27.7	29.5	30.2	29.6	29.7	30.8	32.2	34.5	26.7	<0.0001
Metastatic cancer	0.0	26.9	26.7	27.8	25.8	27.1	24.5	24.0	20.8	20.5	19.7	22.2	<0.0001
Neurological disorders[b]	0.0	3.4	3.2	3.7	3.0	3.6	3.7	4.2	3.8	4.5	4.0	3.4	<0.0001
Obesity	0.0	1.7	1.7	2.2	2.1	2.5	3.5	4.9	5.0	4.9	7.1	3.2	<0.0001
Paralysis	0.0	0.9	0.9	1.1	0.7	1.1	0.8	1.1	1.3	1.0	1.5	0.9	<0.0001
Peripheral vascular disorders	0.0	3.0	2.7	2.9	3.3	3.9	3.6	4.6	4.4	4.4	5.3	3.5	<0.0001
Psychiatric disorder[c]	0.0	1.4	0.9	1.7	1.6	1.5	1.8	1.9	1.8	2.2	2.7	1.6	<0.0001
Pulmonary circulation disorders	0.0	0.6	0.5	0.3	0.6	0.5	2.3	2.8	3.0	3.3	3.3	1.6	<0.0001
Renal failure	0.0	2.0	2.3	2.8	3.5	5.2	5.9	6.6	6.4	6.7	8.9	4.6	<0.0001
Solid tumor without metastasis	0.0	2.8	1.1	0.6	1.1	1.0	1.1	0.9	1.5	1.4	1.2	1.1	<0.0001
Peptic ulcer disease excluding bleeding	0.0	4.1	0.5	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.5	1.0	<0.0001
Valvular disease	0.0	3.8	3.7	3.8	4.0	4.3	3.7	4.0	3.9	3.9	3.9	3.6	0.2845
Weight loss	0.0	8.4	10.0	12.1	13.1	14.1	15.3	19.3	21.4	23.3	26.5	14.8	<0.0001

[a], rheumatic disorders include rheumatoid arthritis and other collagen vascular disorders; [b], neurological disorders include hemiplegia, paralysis, and others; [c], psychiatric disorders include depression, psychosis, and others. AHRQ, Agency for Healthcare Research and Quality. Of note, data related to comorbidity measures were available only from 2002 to 2010.

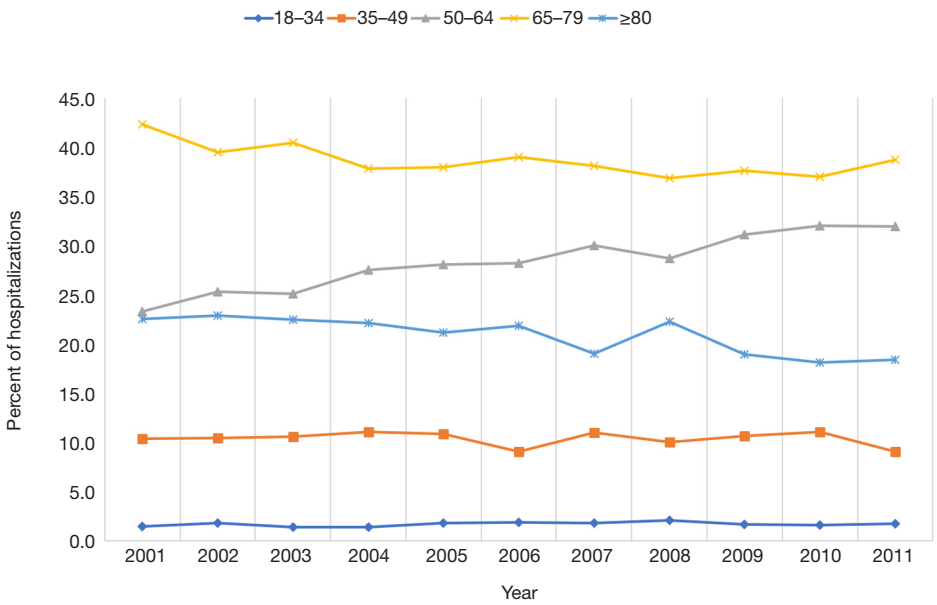

Figure 1 Age-wise distribution of gastric cancer hospitalizations.

Cancer Statistics (USCS), and National Center for Health Statistics (NCHS) (5,21-23).

Worldwide, gastric cancer ranked fifth [2015] for cancer incidence and was the third leading cause of cancer-related mortality worldwide (24,25). It is the second most common cancer in East Asia and accounts for around 50% of all new cases of gastric cancer worldwide. Globally, gastric cancer incidence has decreased steadily over the last 20 years decades. The reasons for downward trends in incidence are not definitively known. However, food refrigeration, falling rates of Helicobacter pylori (*H. pylori*) infection, screening programs, and decreased use of salted and smoked foods may be contributory (26,27). In the U.S., reductions among Asian Americans have paralleled that observed in native countries (28).

In the U.S., gastric cancer is now relatively rare, ranking fifteenth among all of cancer diagnoses (29). Highest rates have been among native Koreans with lowest rates among non-Hispanic whites and Filipino Americans. In 2017, there were 28,000 estimated new cancer cases with 10,960 estimated deaths (22). From 2010 to 2014, the incidence rate was reported as 6.5 per 100,000 population. We found an incidence rate of 60.3 per 100,000 hospitalizations in our study, which was higher as we measured only the inpatient incidence rate (*Table 2*).

The incidence of gastric cancer is decreasing in most countries including the U.S. (30) However, the total number of gastric cancer-related hospitalizations remained stable throughout our study period and did not show a decline. This is likely due to the relatively short time frame (11 years) of our study or re-hospitalizations, perhaps for chemotherapy or palliative care. Early diagnosis, increase in the percent of patients receiving chemotherapy, and improved survival are the factors likely related to increased cost of care in gastric cancer patients as seen in other gastrointestinal cancers like esophageal and pancreatic cancers (31,32).

Of the gastric cancer cases diagnosed between 2010 and 2014 in the U.S., approximately only 1.7% occurred between the ages of 20 and 34 years, whereas 22.9% occurred between 75 and 84 years. The highest incidence was reported between 65 and 74 years with a rate of 25.7% (22). The average age of diagnosis is 69 years and men are at higher risk than women (5). Our findings in the hospitalized group were comparable with highest incidence rates (24%) among those 65 to 79 years of age (*Table 1*).

Siegel *et al.* reported estimated an incidence rate of stomach cancer from 2009 to 2013 at 4.6 and 9.2 for female and males per 100,000 population, respectively (21). It was reported to be 1.7 for female and 7.3 for males per 100,000 population 2010 to 2014 in another study (33). Our findings for inpatient admissions were similar (*Table 1*).

While we found higher incidence rates for inpatient gastric cancer hospitalization for whites compared to

Table 2 Gastric cancer hospitalizations (%) per 100,000 hospitalizations

Variable	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Overall	64.2	63.4	65.3	61.0	63.1	56.9	64.2	61.2	57.8	64.8	60.3	62.0
Age in years												
18–34	0.9	1.2	0.9	0.9	1.2	1.1	1.2	1.3	1.0	1.1	1.1	1.1
35–49	6.7	6.6	6.9	6.8	6.9	5.2	7.1	6.1	6.2	7.2	5.5	6.5
50–64	14.9	16.0	16.4	16.8	17.7	16.0	19.2	17.5	18.0	20.8	19.3	17.5
65–79	27.2	25.0	26.4	23.1	23.9	22.2	24.4	22.6	21.7	24.0	23.3	24.0
≥80	14.5	14.5	14.7	13.5	13.3	12.4	12.2	13.6	10.9	11.8	11.1	13.0
Gender												
Male	39.3	39.3	40.7	38.1	39.8	34.9	40.8	39.2	36.2	41.5	38.0	38.9
Female	24.9	24.0	24.5	22.8	23.2	21.9	23.3	21.9	21.5	23.3	22.3	23.1
Race												
White	32.2	29.8	31.4	29.3	29.8	25.3	29.6	31.9	28.4	33.2	33.8	30.4
Black	6.7	6.7	7.3	7.4	5.8	6.1	7.2	7.6	6.7	10.0	9.0	7.3
Hispanic	5.7	5.4	7.1	6.4	6.9	6.5	6.9	6.0	6.8	9.6	8.1	6.9
Asian or Pacific Islander	2.6	3.9	3.8	3.3	3.5	3.2	4.4	3.9	4.4	3.8	3.2	3.6
Native American	0.1	0.2	0.1	0.2	0.1	0.2	0.5	0.2	0.3	0.6	0.2	0.2
Others	1.3	1.5	1.5	1.0	1.6	1.3	1.7	1.7	2.3	2.2	2.3	1.7
Region												
Northeast	16.7	15.1	15.2	16.2	15.7	12.7	18.4	14.8	12.6	15.9	13.6	15.2
Midwest	14.1	13.1	12.6	12.3	13.7	11.1	11.3	10.8	12.2	14.0	11.6	12.4
South	21.2	23.0	22.3	21.0	20.3	19.4	21.4	22.4	19.6	21.4	21.8	21.3
West	12.2	12.2	15.3	11.6	13.4	13.7	13.1	13.2	13.4	13.6	13.3	13.2
Location												
Rural	6.3	6.4	6.3	5.7	4.5	4.4	4.2	4.1	3.9	3.8	3.1	4.8
Urban nonteaching	26.0	24.7	25.6	25.4	26.4	20.3	20.5	22.2	19.8	19.9	20.4	22.8
Urban teaching	3.2	3.2	3.3	3.0	3.2	3.2	3.9	3.5	3.3	4.0	3.6	3.4
Median household income												
Quartile 1	4.1	2.6	16.6	16.6	15.9	15.3	17.0	16.3	14.9	18.2	16.1	14.0
Quartile 2	13.1	12.7	17.2	15.9	15.1	13.6	14.7	15.1	14.0	15.5	14.2	14.6
Quartile 3	17.6	14.3	16.1	12.8	16.3	13.8	14.5	13.8	13.3	14.7	14.8	14.7
Quartile 4	28.8	32.3	14.1	14.3	14.3	13.0	16.2	14.4	13.5	14.6	14.4	17.3
Payment												
Medicare	36.3	35.2	36.9	32.8	33.9	31.3	33.5	31.9	29.5	32.7	32.0	33.3
Medicaid	5.1	4.7	5.3	5.2	5.8	5.8	7.3	5.7	5.8	8.5	6.6	6.0
Private insurance	19.0	19.0	19.2	19.1	18.7	15.4	19.0	19.8	18.1	18.7	17.7	18.5
Others (includes self-pay)	3.6	4.4	3.8	3.9	4.6	4.3	4.3	3.7	4.3	4.7	3.9	4.1

Table 3 All-cause in-hospital mortality (%) for gastric cancer hospitalizations

Variable	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average	P value
Overall	11.2	10.0	11.0	10.5	9.4	9.8	8.3	7.7	7.5	6.5	6.5	8.9	<0.0001
Age in years													
18–34	14.5	9.6	9.4	7.2	5.3	18.0	7.7	5.4	7.8	7.2	5.8	8.7	0.3261
35–49	10.8	7.5	10.1	7.9	10.2	8.3	7.3	5.2	4.7	5.3	6.5	7.6	<0.0001
50–64	11.7	7.6	9.5	10.4	6.9	9.2	6.9	7.2	7.7	6.6	5.3	8.0	<0.0001
65–79	11.0	11.1	11.2	11.1	10.3	8.8	8.1	7.8	7.1	6.9	6.6	9.1	0.0042
≥80	11.0	12.2	12.9	11.0	11.2	12.4	11.7	9.6	9.5	6.4	7.9	10.6	<0.0001
Gender													
Male	11.8	10.9	10.8	10.4	9.3	9.5	8.1	8.2	7.8	6.4	6.5	9.0	0.0141
Female	10.2	8.7	11.2	10.7	9.7	10.2	8.7	6.8	6.9	6.8	6.4	8.8	Referent
Race													
White	10.6	10.0	10.3	10.6	9.8	9.7	8.4	8.0	6.8	6.3	5.7	8.7	<0.0001
Black	13.1	11.8	13.9	11.5	12.1	9.8	9.9	8.5	9.8	7.8	8.0	10.4	<0.0001
Hispanic	14.0	9.3	11.4	11.1	10.1	9.3	6.6	6.9	7.8	7.2	7.5	9.0	0.4523
Asian or Pacific Islander	9.6	8.8	8.4	8.5	12.0	10.1	8.8	7.9	10.1	5.1	5.1	8.6	0.0331
Native American	17.8	16.8	0.0	5.8	20.0	5.5	10.4	21.1	0.0	2.0	9.3	8.0	0.1405
Others	12.7	8.7	8.3	12.4	11.0	13.2	15.2	9.1	6.3	7.5	6.9	9.7	0.0193
Region													
Northeast	11.5	11.4	14.1	16.4	14.8	11.9	8.1	8.0	9.4	7.1	6.3	10.8	<0.0001
Midwest	10.6	9.7	9.5	9.3	7.0	9.6	8.7	6.8	6.4	5.3	6.7	8.1	<0.0001
South	10.9	10.5	11.0	8.6	7.6	9.1	8.8	7.8	7.8	7.4	7.1	8.8	0.0239
West	11.8	8.0	8.9	7.0	8.4	9.0	7.4	7.9	6.1	5.9	5.5	7.8	<0.0001
Location													
Rural	13.0	10.5	12.0	10.1	7.6	10.3	11.4	12.1	9.3	9.2	8.7	10.6	<0.0001
Urban nonteaching	11.2	10.1	13.5	13.2	12.6	9.2	9.1	9.2	7.7	7.2	6.5	10.2	<0.0001
Urban teaching	10.8	9.9	8.8	8.3	7.1	10.1	7.6	6.2	7.2	6.1	6.4	7.9	<0.0001
Median household income													
Quartile 1	12.7	12.0	12.8	12.8	11.2	11.1	9.1	8.5	8.2	7.5	7.6	10.0	<0.0001
Quartile 2	11.6	9.6	10.0	9.0	8.9	8.6	7.8	7.2	7.3	6.7	6.3	8.4	<0.0001
Quartile 3	11.3	9.5	11.2	10.1	8.0	9.5	8.1	7.6	7.5	6.4	5.9	8.7	0.0022
Quartile 4	10.7	10.0	10.2	10.0	9.9	9.7	8.7	7.7	6.7	5.0	5.9	8.9	0.1051
Payment													
Medicare	10.5	10.6	10.9	9.9	9.6	9.2	9.0	8.3	6.8	6.2	6.4	8.9	0.2804
Medicaid	14.6	8.6	9.6	12.3	8.4	11.7	7.9	10.2	5.2	8.1	7.5	9.2	0.0327
Private insurance	10.8	9.1	10.0	10.3	9.4	9.7	6.7	6.2	8.0	6.2	5.2	8.3	<0.0001
Others (includes self-pay)	14.8	11.2	18.5	14.8	9.0	11.9	10.7	7.2	13.4	6.7	10.9	11.6	<0.0001

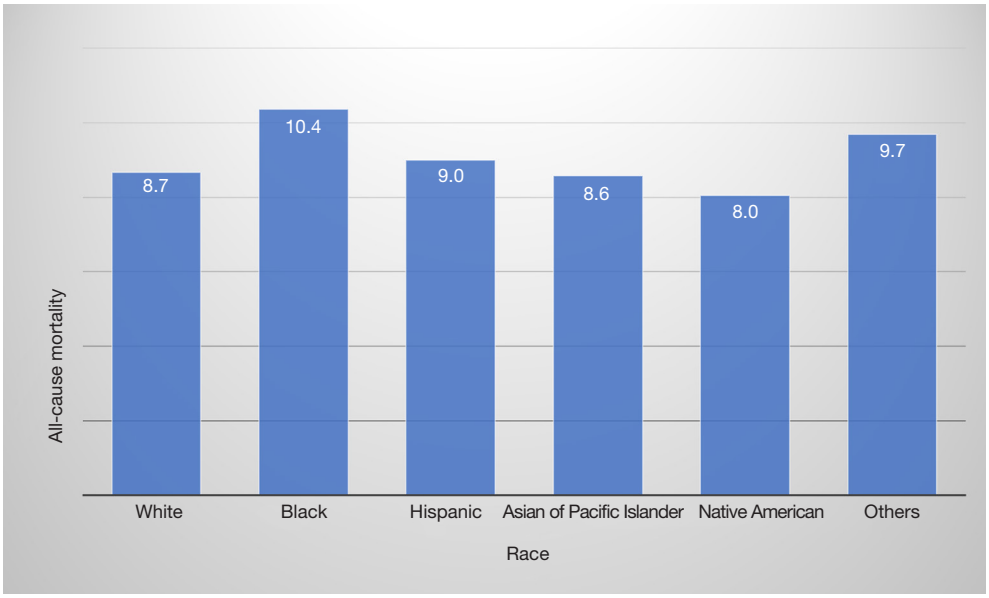

Figure 2 Racial differences in all-cause mortality.

other racial groups, it is important to recognize that rates of hospital admission are not necessarily reflective of the incidence in the population at large. As such our findings are not necessarily inconsistent with earlier studies which have found that the incidence of gastric cancer in the White (non-Hispanic) population was lower (8.2 cases per 100,000 person-years) than values for Asians, Hispanics, and non-Hispanic black persons (respectively: 12.7, 12.7, and 11.8 cases per 100,000 person-years) (34). However, the number of gastric cancer hospitalizations was higher in the White population than any other racial group in our study. This difference is likely due to poor health insurance coverage amongst the non-White races. Kirby and Kaneda reported that Blacks are twice as likely to be uninsured as compared to Whites and Hispanics are thrice as likely (35). In addition, our in-patient results are consistent with earlier studies that mortality is higher in the Black population in the U.S. than the White population (23,36,37).

Our analysis demonstrates that Medicare and Medicaid paid for the highest number of hospitalizations (63.3%) in the U.S. during our study period. Private insurance paid for only 29.4% of the hospitalizations. Together, Medicare and Medicaid represent 39% of national health spending in the U.S (38). One of the highest uninsured rates was seen in patients with stomach cancer (9.7%) by Grant *et al.* between 2007 and 2010 in the U.S. population (39). We postulate that providing these patients with Medicare/Medicaid coverage will further reduce the mortality associated with gastric cancer hospitalizations in the U.S. A Korean study showed that private health insurance only maintains the financial independence of its beneficiaries but does not improve cancer care in patients with gastric cancer (40). Under Japanese national health scheme implemented by the government, the incidence of peptic ulcer decreased dramatically by about 60% over 10 years which in turn is projected to decrease gastric cancer incidence and deaths in Japan in the upcoming decades (41). Such programs can reduce gastric cancer incidence in developing and underdeveloped nations. Also, the model of universal healthcare coverage implemented in the U.S. can be applied in other countries for better coverage of uninsured populations affected by gastric cancer, thus reducing out-of-pocket costs for such populations and reducing the overall all-cause mortality.

Obesity has been associated with elevated cancer risk (42,43). Our analysis also showed a significant association of obesity with risk of mortality in gastric cancer patients (OR 2.0; 95% CI: 1.6 to 2.6; P<0.0001) (*Table 5*). In 2014, a Chinese study with 8,820 participating subjects showed that obesity was significantly and positively associated with H. pylori infection in the Chinese population (44). In 2017, another Chinese study done on 3,039 participants concluded that obesity had no association with H. pylori infection (45). Thus, the association between obesity and H. pylori infection is still unclear. It will be interesting to see if future studies can demonstrate a significant association

Table 4 Cost ($) of care for gastric cancer hospitalizations

Variable	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average	P value
Number of obs. (n)	23,880	23,955	24,950	23,590	24,728	22,430	25,371	24,415	22,793	25,294	23,281	24,062	<0.0001
Average cost	21,710	22,547	24,414	21,757	24,243	23,737	26,190	24,761	23,361	26,296	24,706	23,975	
Total cost per year	518,427,354	540,102,281	609,113,769	513,252,403	599,475,231	532,413,776	664,465,082	604,552,817	532,475,062	665,122,404	575,172,604	577,688,435	
Age in years													
18–34	351	444	358	334	456	418	469	520	381	410	410	414	<0.0001
35–49	2,478	2,508	2,635	2,616	2,691	2,037	2,800	2,445	2,432	2,809	2,119	2,506	0.0068
50–64	5,558	6,061	6,261	6,487	6,939	6,323	7,608	6,999	7,087	8,095	7,430	6,804	<0.0001
65–79	10,104	9,446	10,085	8,923	9,377	8,747	9,657	8,998	8,575	9,349	9,005	9,297	<0.0001
≥80	5,379	5,483	5,600	5,220	5,227	4,904	4,817	5,429	4,313	4,591	4,288	5,023	<0.0001
Gender													
Male	14,611	14,867	15,542	14,735	15,601	13,779	16,141	15,654	14,262	16,179	14,674	15,095	<0.0001
Female	9,269	9,088	9,381	8,829	9,068	8,636	9,212	8,736	8,491	9,105	8,592	8,946	Ref
Race													
White	11,958	11,272	12,010	11,323	11,690	9,964	11,689	12,708	11,199	12,956	13,036	11,800	<0.0001
Black	2,506	2,536	2,797	2,865	2,282	2,425	2,839	3,020	2,642	3,910	3,456	2,843	<0.0001
Hispanic	2,126	2,048	2,722	2,461	2,694	2,570	2,720	2,413	2,687	3,757	3,131	2,666	<0.0001
Asian or Pacific Islander	984	1,459	1,470	1,259	1,353	1,258	1,735	1,557	1,749	1,502	1,219	1,413	
Native American	54	61	34	76	48	87	203	67	137	218	66	96	
Others	498	582	557	405	642	518	687	668	914	845	875	654	<0.0001
Region													
Northeast	6,205	5,714	5,792	6,252	6,160	5,008	7,256	5,918	4,950	6,185	5,247	5,881	<0.0001
Midwest	5,245	4,935	4,814	4,737	5,359	4,387	4,458	4,319	4,829	5,463	4,460	4,819	<0.0001
South	7,876	8,688	8,511	8,120	7,945	7,634	8,472	8,927	7,732	8,356	8,432	8,245	0.0074
West	4,553	4,619	5,832	4,480	5,264	5,401	5,184	5,251	5,282	5,290	5,141	5,118	<0.0001
Location													
Rural	2,357	2,416	2,414	2,213	1,777	1,722	1,667	1,642	1,528	1,478	1,191	1,855	<0.0001
Urban nonteaching	9,680	9,324	9,801	9,831	10,342	7,992	8,101	8,848	7,811	7,762	7,888	8,853	<0.0001
Urban teaching	11,843	12,215	12,735	11,546	12,609	12,611	15,579	13,920	12,989	15,682	13,829	13,233	<0.0001

Table 4 (*continued*)

Table 4 (*continued*)

Variable	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average	P value
Median household income													
Quartile 1	1,523	993	6,348	6,428	6,224	6,026	6,704	6,502	5,867	7,089	6,210	5,447	<0.0001
Quartile 2	4,880	4,794	6,558	6,135	5,912	5,374	5,795	6,012	5,536	6,045	5,478	5,683	<0.0001
Quartile 3	6,529	5,420	6,169	4,938	6,392	5,448	5,720	5,488	5,239	5,720	5,697	5,705	<0.0001
Quartile 4	10,706	12,229	5,373	5,526	5,598	5,125	6,412	5,747	5,330	5,685	5,565	6,663	<0.0001
Payment													
Medicare	13,506	13,312	14,106	12,663	13,293	12,346	13,236	12,739	11,626	12,746	12,366	12,904	<0.0001
Medicaid	1,900	1,779	2,025	1,992	2,286	2,274	2,896	2,261	2,287	3,315	2,532	2,322	<0.0001
Private insurance	7,068	7,174	7,327	7,373	7,316	6,078	7,506	7,909	7,150	7,313	6,844	7,187	0.1379
Others (includes self-pay)	1,349	1,680	1,464	1,521	1,815	1,707	1,698	1,463	1,682	1,849	1,492	1,611	<0.0001

between obesity and H. pylori infection in the U.S. population.

Previous studies have reported age-standardized cancer mortality rates in gastric cancer (46). Siegel *et al.* reported that mortality rate was 2.4 per 100,000 population for females and 4.5 per 100,000 population for males from 2009 to 2013 (21). We found a mortality rate of 2.0 per 100,000 hospitalizations for females and 3.5 per 100,000 hospitalizations for males. In Japan, 5-year (5-YSR) survival rates have been noted to be 69.1% for patients with primary gastric cancer (47). However, the 5-YSR in the U.S. was only 30.6% from 2007 to 2013 (21). Higher survival rates in Japan may be due to effectiveness of mass screening programs leading to early diagnosis (48,49). This led Kim *et al.* to propose multicenter studies to evaluate the effectiveness of gastric cancer screening programs in high-risk individuals (50).

Our literature review did not reveal any studies focusing on the use of endoscopy for gastric cancer screening in the U.S. during the last decade. Also, the guidelines for gastric cancer screening and gastric intestinal metaplasia surveillance are lacking in the U.S. (50). Thus, it is unclear if surveillance and early detection contributed to the decline in mortality rate demonstrated by our study. Nationwide studies designed to determine endoscopy utilization rates in gastric cancer diagnosis are needed to support our findings.

In our study, the average cost of care from 2001 to 2011 was $23,975. In 2009, it was found to be $23,361. Statistical brief #125 provided by AHRQ in 2009 estimated the mean hospital cost for gastric cancer as $22,200 (51). Thus, our estimates for average cost of care for inpatient gastric cancer hospitalization closely reflect AHRQ's cost estimates.

The strength of this study is that analysis of the NIS database permitted us to study a large population, which reduces bias seen in studies that are confined to a single region or hospital. However, our analysis had a number of significant limitations. Administrative databases are susceptible to errors arising from coding inaccuracies. The gastric cancer diagnosis and the presence of comorbidities were based on the presence of administrative codes. ICD-9 CM codes 151.x is validated for gastric cancer in the administrative database. The database did not permit us to determine which patients assigned a code of "gastric cancer" were hospitalized for the new diagnosis, as opposed to patients who had a diagnosis of gastric cancer in the past.

There is a risk that our analysis could underestimate the number of gastric cancer hospitalizations each year. If a gastric cancer diagnosis accompanied other "serious"

Table 5 Predictors of mortality for gastric cancer hospitalizations

Variables	Odds ratio	95% confidence limits		P value
		Lower	Upper	
Age in years				
18–34	Reference			
35–49	1.1	0.9	1.5	0.412
50–64	1.0	0.8	1.3	0.819
65–79	0.8	0.6	1.0	0.050
≥80	0.7	0.5	0.9	0.002
Gender				
Male	Reference			
Female	1.0	1.0	1.0	0.116
Race				
White	Reference			
Black	1.3	1.2	1.4	<0.0001
Hispanic	1.1	1.0	1.3	0.080
Asian or Pacific Islander	1.2	1.0	1.4	0.031
Native American	1.2	0.7	2.1	0.444
Others	1.1	0.9	1.4	0.201
Region				
Northeast	Reference			
Midwest	1.6	1.4	1.7	<0.0001
South	1.4	1.3	1.5	<0.0001
West	1.6	1.4	1.7	<0.0001
AHRQ comorbidity measures				
Alcohol abuse	1.5	1.2	1.9	0.000
Deficiency anemias	1.5	1.4	1.6	<0.0001
Rheumatic disorders	1.7	1.2	2.5	0.006
Chronic blood loss anemia	1.7	1.5	2.0	<0.0001
Congestive heart failure	0.7	0.6	0.8	<0.0001
Coagulopathy	0.4	0.3	0.4	<0.0001
Depression	1.2	1.1	1.5	0.009
Hypertension	1.8	1.7	1.9	<0.0001
Hypothyroidism	1.5	1.3	1.8	<0.0001
Liver disease	0.6	0.5	0.7	<0.0001
Fluid and electrolyte disorders	0.5	0.5	0.5	<0.0001
Metastatic cancer	1.4	1.3	1.5	<0.0001
Neurological disorders	0.8	0.7	1.0	0.028
Obesity	2.0	1.6	2.6	<0.0001
Paralysis	0.7	0.5	0.9	0.008
Peripheral vascular disorders	1.2	1.0	1.5	0.029
Psychiatric disorder	0.7	0.6	0.9	0.008
Pulmonary circulation disorders	0.6	0.5	0.8	<0.0001
Renal failure	0.5	0.5	0.6	<0.0001
Solid tumor without metastasis	2.0	1.3	2.8	0.001
Valvular disease	1.4	1.1	1.7	0.001
Weight loss	0.8	0.8	0.9	<0.0001

conditions—e.g., "gastric perforation"—the latter might be listed as a primary diagnosis, even if a patient's primary diagnosis was gastric cancer.

Our analysis could also overestimate the number of patients with gastric cancer. In fact, the NIS considers each hospitalization as separate entry. Thus, there is no coding method that can separate index cases from readmissions. Further, the design of the database allowed us to examine in-hospital characteristics only and does not permit analysis of long-term follow-up outcomes or health care utilization in out-patient settings or emergency departments.

In conclusion, our review of hospitalization trends over the last decade showed that the number of gastric cancer-related hospitalizations remained stable. There was an increase in the cost of care, but with a substantial reduction in mortality rates over the last decade. It is possible that improved out-patient care and enhanced use of gastric cancer screening may reduce the number of hospitalizations with gastric cancer in the future.

Acknowledgments

None.

Footnote

Conflicts of Interest: Presented at: Digestive Disease Week. Walter E. Washington Convention Center, Washington, DC. May 2018.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was exempted from ethics approval because we did not use personally identifiable information (PII).

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