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ORIGINAL CONTRIBUTIONS

Stomach

Gastroparesis-Related Hospitalizations in the United States: Trends, Characteristics, and Outcomes, 1995–2004

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OBJECTIVES: Gastroparesis is an increasingly recognized disorder. Its prevalence in the United States is unknown. We examined the trends, characteristics, and outcomes of gastroparesis-related hospitalizations during 1995–2004.

METHODS: The publicly available Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) comprises a nationally representative sample of 5–8 million hospitalizations per year. Gastroparesis-related hospitalizations were identified using the International Classification of Diseases (ICD-9) code 536.3 and compared with other hospitalizations. Multivariate regressions were used to compare for differences in the outcomes including length of stay, total charges, and in-hospital deaths.

RESULTS: Hospitalizations with gastroparesis as the primary diagnosis increased from 3,977 in 1995 to 10,252 in 2004 (+158%) and hospitalizations with gastroparesis as the secondary diagnosis increased from 56,726 to 134,146 (+136%). These compared to smaller changes in diabetes-related hospitalizations (+53%), all hospitalizations (+13%), and hospitalizations with gastroesophageal reflux disease (GERD), gastric ulcer, gastritis, or nonspecific nausea/vomiting as the primary diagnosis (−3% to +76%). Of the five upper gastrointestinal conditions studied as the primary diagnosis, gastroparesis had the longest length of stay (+15.4% to +66.2%, all $P < 0.001$) and the highest or second highest total charges (−7.2% to +60.6%, all $P < 0.01$) in 2004, with similar results in 1995.

CONCLUSIONS: The number of gastroparesis-related hospitalizations has been increasing in the United States, suggesting an increasing prevalence of gastroparesis. The economic impact of gastroparesis-related hospitalizations is significant and increasing.

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INTRODUCTION

Gastroparesis or delayed gastric emptying is a common cause of chronic nausea, vomiting, early satiety, and abdominal discomfort in the absence of mechanical obstruction (1–5). It includes a spectrum of conditions ranging from minimally delayed gastric emptying in functional dyspepsia to profound delay in neurological manifestations of diabetes. Gastroparesis is an increasingly recognized disorder. However, its prevalence in the United States is unknown. The three most common etiologies are diabetes, postsurgical, and idiopathic (unknown) (6). Gastroparesis is estimated to occur in 30–50% of insulin-dependent or type 1 diabetics, 16–30% of noninsulin-dependent or type 2 diabetics, and 20–40% of patients with functional dyspepsia (7–16).

There are reasons to suspect that the prevalence of gastroparesis may be changing. First, the increasing prevalence of diabetes and the improving longevity of diabetic patients may contribute to more patients with diabetic gastroparesis (17). As the number of type 2 diabetics outnumbers that of type 1 diabetics by more than 10 to 1, there may be more type 2 diabetics with gastroparesis than type 1 diabetics. Secondly, although the number of surgeries for peptic ulcer disease has been decreasing, the number of surgeries for gastroesophageal reflux disease (GERD) and morbid obesity has been increasing.

Although health-care expenditures on patients with gastroparesis can be significant, few studies exist on this subject (18). The initial workup of gastroparesis involves the exclusion of mechanical obstruction with either upper endoscopy

or upper gastrointestinal (GI) radiographic series, followed by the establishment of delayed gastric emptying (2–5). Exacerbation of gastroparesis with increased symptoms of vomiting and abdominal pain may prompt emergency department (ED) visits and hospitalizations. Hospitalizations lead to the use of procedures and treatments including intravenous hydration and delivery of medications (prokinetics, antiemetics, and narcotics). More invasive treatments may include total parenteral nutrition surgical procedures including jejunostomy feeding tube and gastric electric stimulation (Enterra, Medtronic Inc., Minneapolis, MN) (2–5).

The aim of this study was to examine the trends of gastroparesis-related hospitalizations in the United States during 1995–2004 and to compare the characteristics and outcomes of hospitalizations with gastroparesis as the primary diagnosis, hospitalizations with gastroparesis as the secondary diagnosis, and hospitalizations with a common upper GI condition as the primary diagnosis.

METHODS

Data Overview

The Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS) sponsored by the Agency for Healthcare Research and Quality (AHRQ) is the largest all-payer inpatient care database that is publicly available in the United States. The NIS was designed to approximate a 20% stratified sample of U.S. hospitals and contains 5–8 million hospital stays from about 1,000 hospitals each year (19). Its large sample size enables the analysis of rare conditions and special populations. Inpatient stay records include clinical and resource use information typically available from discharge abstracts, including up to 15 diagnoses and up to 15 procedures. Information on drug therapy is not available. Hospital and discharge weights were provided to produce national estimates and allow for the analysis of trends over time. A detailed explanation of the year-specific NIS design and sample weights is available online (http://www.hcup-us.ahrq.gov/db/nation/nis/nisrelatedreports.jsp).

Analyses

The first part of this analysis was to examine the national trends of gastroparesis-related hospitalizations during 1995–2004. This was achieved through the HCUPnet Web server sponsored by the AHRQ, which provides projected or weighted national estimates of the number of hospitalizations by either primary diagnosis or all diagnoses (primary or secondary diagnosis) for each year (20). Gastroparesis-related hospitalizations were defined as hospitalizations with a primary or secondary diagnosis of gastroparesis (International Classification of Diseases, Clinical Modification [ICD-9-CM] code 536.3). To control for other unobserved changes over time, the annual trends of gastroparesis-related hospitalizations were first compared with those of diabetes mellitus (ICD-9 code 250) and all hospitalizations in the United States. Diabetes was chosen as a control group because a significant portion of gastroparesis was associated with diabetes, especially type 1 diabetes. We could not separate out type 1 from type 2 diabetes in this analysis, as the latter is combined with unspecified type of diabetes in ICD-9 coding. In addition, the time trend of hospitalizations with gastroparesis as the primary diagnosis was also compared with those of hospitalizations with a common upper GI condition as the primary diagnosis, including GERD (ICD-9 codes 530.11 and 530.81), gastric ulcer (531), gastritis (535.1 to 535.5), and nonspecific nausea/vomiting (536.2 and 787.0). These common upper GI conditions served as the second control group to test the robustness of the time trend of hospitalizations with gastroparesis as the primary diagnosis. Within the HCUPnet Web server, estimates of mean length of stay, mean total charges, and percentage of in-hospital deaths were provided for all hospitalizations in the United States and by the primary diagnosis. We reported the time trends of these outcomes for all hospitalizations in the United States and for the hospitalizations with gastroparesis or a common upper GI condition as the primary diagnosis.

The second and the main part of this analysis consisted of obtaining the microdata of NIS for the years 1995 and 2004 from the AHRQ data distributor and studying the characteristics and outcomes of gastroparesis-related hospitalizations in 1995 and 2004. The characteristics and outcomes of hospitalizations with gastroparesis as the primary diagnosis were compared with those of the hospitalizations with GERD, gastric ulcer, gastritis, or nausea/vomiting as the primary diagnosis. The characteristics of interest included age, sex, type of primary insurance (Medicare, Medicaid, private, self-pay, or unknown), whether the patient was admitted through the ED, the presence and type of diabetes, number of diagnoses (up to 15), and the number of inpatient procedures (up to 15). The outcomes of interest included length of stay, total charges, and whether the patient died in the hospital. Hospitalizations with missing data on any of the above variables (3% in 1995 and 2% in 2004) were excluded from the study sample. In addition, for hospitalizations with GERD, gastric ulcer, gastritis, or nausea/vomiting as the primary diagnosis, those with gastroparesis as the secondary diagnosis (N = 1,312 or 1.9% in 1995, N = 3,371 or 3.9% in 2004) were excluded.

The third and last part of this analysis consisted of estimating the total number of hospital days, total hospital charges, and total number of in-hospital deaths due to gastroparesis as the primary diagnosis, gastroparesis as the secondary diagnosis, or GERD, gastric ulcer, gastritis, or nausea/vomiting as the primary diagnosis in 1995 and in 2004. The 1995 and 2004 NIS microdata were used and sample hospitalizations were weighted in projecting national estimates. Note that some hospitalizations had an upper GI condition as the primary diagnosis and gastroparesis as the secondary diagnosis. These hospitalizations were included in both groups for this analysis.

Statistical Models

Multivariate regressions were used to control for patient characteristics and test the differences in hospitalization outcomes, *i.e.*, length of stay, total charges, and in-hospital

deaths. We are particularly interested in how gastroparesis, as the primary diagnosis, compared with common upper GI conditions in outcomes and whether gastroparesis as the secondary diagnosis led to similar outcomes compared with gastroparesis as the primary diagnosis. Two separate regressions were run to compare: (a) the outcome differences between gastroparesis as the primary diagnosis and GERD, gastric ulcer, gastritis, or nausea/vomiting as the primary diagnosis and (b) the outcome difference between gastroparesis as the primary diagnosis and gastroparesis as the secondary diagnosis.

As the distributions of length of stay (in days) and total charges (in dollars) were highly skewed and approximately log-normal, the log-transformed length of stay (natural log of length of stay plus 1) and total charges (natural log of total charges) were used as the dependent variables in the regressions. Consequently, the estimated coefficients for the explanatory variables represented relative percentage differences in length of stay or total charges. As sensitivity analyses, we used the negative binomial model for length of stay and the generalized linear model with the log-link and gamma distribution for total charges and compared the statistical findings. For the indicator variable of in-hospital deaths, logistic regression was used and odds ratios (OR) are reported for the explanatory variables.

Some patient characteristics, for example, age and sex, are exogenous or unrelated to hospital course. Others, for example, the number of diagnoses or the number of procedures, are possibly endogenous or related to hospital course. A good example is a patient who did respond to initial therapy, developed complications, and required additional procedures. Because of the complications, while in the hospital, this patient had more diagnoses, more procedures, and worse outcomes (a longer length of stay, higher total charges, and/or a higher chance of in-hospital death). To address the potential bias associated with endogenous variables, three distinctive regression specifications were constructed to explain the differences in the hospitalization outcomes. The first specification controlled for only age and sex and was therefore called the age-sex-adjusted model. The second specification controlled for age, sex, type of primary insurance, whether the patient was admitted through the ED, the comorbidity of diabetes, and the number of diagnoses. It was called the diagnosis-adjusted model. The third and most complete specification included all explanatory variables in the diagnosis-adjusted model plus number of procedures. It was called the procedure-adjusted model. The same set of three specifications was used for each outcome variable in 1995 and 2004. Similar results from the three specifications would add confidence to the finding. All regressions were analyzed using SAS statistical software, version 8.2 (SAS Institute Inc., Cary, NC).

RESULTS

Time Trends

Gastroparesis-related hospitalizations increased by 138% in the United States during 1995–2004, of which hospitalizations with gastroparesis as the primary diagnosis increased by 158% and hospitalizations with gastroparesis as the secondary diagnosis increased by 136% (Table 1, Fig. 1). Notably, the number of hospitalizations with gastroparesis as the primary diagnosis increased dramatically after 2000.

There were smaller percentage increases in all diabetes-related hospitalizations (+53%) and all hospitalizations in the United States (+13%) during the same period (Table 1, Fig. 2). There were also smaller percentage changes in hospitalizations with a common upper GI condition as the primary diagnosis, including GERD (+32%), gastric ulcer (−3%), gastritis (+4%), and nausea/vomiting (+76%) (Table 1, Fig. 3).

In general, the mean length of stay decreased for all hospitalizations and for hospitalizations with gastroparesis or a common upper GI condition as the primary diagnosis during 1995–2004, while the mean total charges for these hospitalization categories increased over time (Table 1). Interestingly, for gastroparesis, most of the increases in mean total charges occurred after 2000, when the number of hospitalizations with gastroparesis as the primary diagnosis markedly increased. The percentage of in-hospital deaths generally decreased over time across the hospitalization categories (Table 1).

Hospitalization Characteristics

The HCUP NIS contained 11,955 gastroparesis-related hospitalizations in 1995 and 29,737 gastroparesis-related hospitalizations in 2004. After the exclusion of observations with missing data, the final study sample included 11,571 and 29,083 gastroparesis-related hospitalizations in 1995 and 2004, respectively, with approximately 7% having gastroparesis as the primary diagnosis. For those with gastroparesis as the secondary diagnosis, the top three primary diagnoses (based on 4-digit ICD-9 codes) were the same in both years—diabetes with neurological manifestations (18% in 1995, 24% in 2004), diabetes with ketoacidosis (5% in 1995, 6% in 2004), and congestive heart failure (4% in 1995, 3% in 2004).

Differences between patients hospitalized with gastroparesis as the primary diagnosis and those hospitalized with a common upper GI condition as the primary diagnosis (GERD, gastric ulcer, gastritis, and nausea/vomiting) remained similar in 1995 and 2004 (Tables 2 and 3). As compared with patients hospitalized with gastroparesis as the primary diagnosis, those hospitalized with a common upper GI condition were much less likely to have diabetes as a comorbidity (10.0–14.5% for upper GI conditions *vs* 21.0% for gastroparesis in 1995, 14.2–21.0% for upper GI conditions *vs* 26.7% for gastroparesis in 2004). Differences between patients hospitalized with gastroparesis as the primary diagnosis and those hospitalized with gastroparesis as the secondary diagnosis also remained similar in both years (Tables 2 and 3). The former group of patients were younger, more likely to be female, less likely to have Medicare or Medicaid as the primary insurance, less likely to be admitted through the ED, and much less likely to have diabetes as a comorbidity (21.0–26.7%

Table 1. National Estimates of Gastroparesis-Related Hospitalizations, Diabetes-Related Hospitalizations, All Hospitalizations, and Hospitalization With a Common Upper GI Condition as the Primary Diagnosis in the United States, 1995–2004

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Number of hospitalizations										
Gastroparesis-related	60,703	83,371	90,189	97,366	99,342	103,220	106,992	122,307	131,948	144,398
Primary diagnosis	3,977	4,448	4,192	4,817	4,703	4,872	6,236	7,968	9,430	10,252
Secondary diagnosis	56,726	78,923	85,997	92,549	94,639	98,348	100,756	114,339	122,518	134,146
Diabetes-related	4,357,932	4,591,597	4,836,112	5,112,932	5,242,840	5,583,512	5,917,981	6,246,563	6,557,563	6,665,597
All hospitalizations in the USA	34,236,838	34,219,850	34,678,665	34,874,001	35,467,673	36,417,565	37,187,641	37,804,021	38,220,659	38,661,786
Other upper GI conditions as primary diagnosis										
GERD	80,506	86,401	95,143	92,447	108,589	112,752	113,594	107,139	104,379	106,111
Gastric ulcer	100,544	100,363	98,652	100,703	94,900	95,322	98,716	95,174	94,289	97,684
Gastritis	137,811	133,420	133,464	142,459	129,798	130,308	140,465	134,099	138,710	143,087
Nausea/vomiting	36,886	36,315	40,282	43,355	46,478	50,239	54,242	59,517	59,753	64,958
Length of stay (days, mean)										
All hospitalizations in the USA	5.2	5	4.8	4.8	4.7	4.6	4.6	4.6	4.6	4.6
Upper GI conditions as primary diagnosis										
Gastroparesis	7.3	6.1	6.4	6.5	5.8	6.0	6.0	6.1	6.4	6.1
GERD	3.3	3.1	3.0	2.9	2.7	2.5	2.5	2.7	2.6	2.4
Gastric ulcer	6.0	5.6	5.3	5.2	5.1	5.0	5.0	5.0	5.0	4.9
Gastritis	4.4	4.1	3.9	3.7	3.6	3.7	3.7	3.8	3.8	3.6
Nausea/vomiting	3.6	3.3	3.3	3.2	3.2	3.2	3.3	3.3	3.2	3.2
Total charges ($, mean)										
All hospitalizations in the USA	10,321	10,646	11,281	11,800	12,473	13,733	14,957	17,260	19,729	20,455
Upper GI conditions as primary diagnosis										
Gastroparesis	12,091	10,608	12,607	12,943	13,209	13,201	15,786	17,261	22,466	20,481
GERD	7,208	7,324	7,775	8,256	9,252	9,573	10,014	11,611	13,049	12,168
Gastric ulcer	13,079	12,979	13,157	14,064	14,409	15,810	17,175	20,131	22,686	23,291
Gastritis	7,622	7,687	8,001	8,403	8,688	9,797	10,993	13,214	14,864	14,993
Nausea/vomiting	5,518	5,456	5,669	5,999	6,545	7,159	8,484	9,225	10,613	10,696
In-hospital deaths (%)										
All hospitalizations in the USA	2.58	2.53	2.46	2.50	2.46	2.37	2.32	2.24	2.22	2.13
Upper GI conditions as primary diagnosis										
Gastroparesis	1.52	1.07	1.37	0.99	0.97	0.95	0.77	0.83	0.57	0.56
GERD	0.15	0.12	0.11	0.13	0.11	0.11	0.11	0.09	0.13	0.05
Gastric ulcer	3.08	2.98	2.69	2.98	2.69	2.54	2.71	2.43	2.52	2.17
Gastritis	0.95	0.88	0.86	0.75	0.92	0.84	0.63	0.77	0.72	0.60
Nausea/vomiting	0.76	0.76	0.71	0.78	0.62	0.94	0.70	0.71	0.60	0.47

GI = gastrointestinal; GERD = gastroesophageal reflux disease.

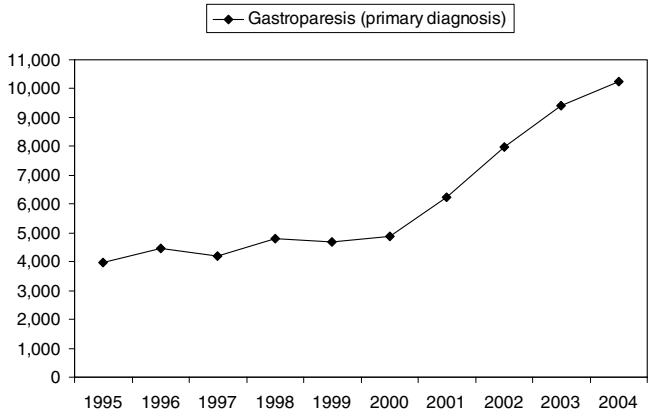

Figure 1. Time trend of the national estimate of hospitalizations with gastroparesis as the primary diagnosis in the United States, 1995–2004.

for primary gastroparesis *vs* 72.9–79.4% for secondary gastroparesis). Also noticeable are the increases in diabetes as comorbidity, the percentage of admissions through the ED, and the number of diagnoses per hospitalization over time.

Hospitalization Outcomes

Patients hospitalized with gastroparesis as the primary diagnosis were similar to those hospitalized with nonspecific nausea/vomiting as the primary diagnosis in age, sex, and percentage of admissions through the ED, but experienced more inpatient procedures, a longer length of stay, and higher total charges (Tables 2 and 3). In fact, gastroparesis had the longest length of stay and the second highest total charges among the upper GI conditions studied as the primary diagnosis, while gastric ulcer had the oldest patients, the most diagnoses, the most inpatient procedures, the highest total charges, and the highest percentage of in-hospital deaths. Compared with

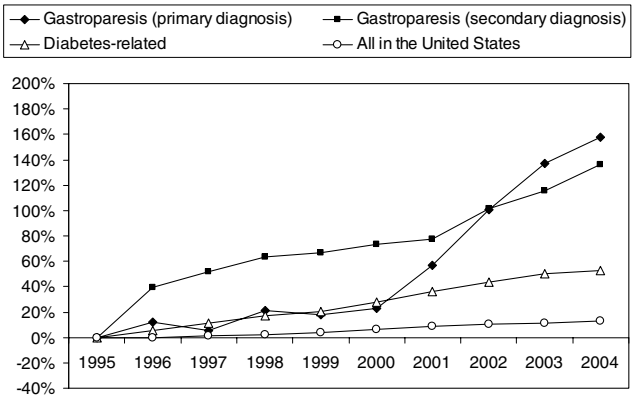

Figure 2. Percentage changes in the national estimates of gastroparesis-related, diabetes-related, and all hospitalizations in the United States, 1995–2004. For each category of hospitalization, the % change in a specific year is defined as the relative percentage change compared with its baseline value in 1995. Gastroparesis (primary) = gastroparesis as the primary diagnosis; gastroparesis (secondary) = gastroparesis as the secondary diagnosis.

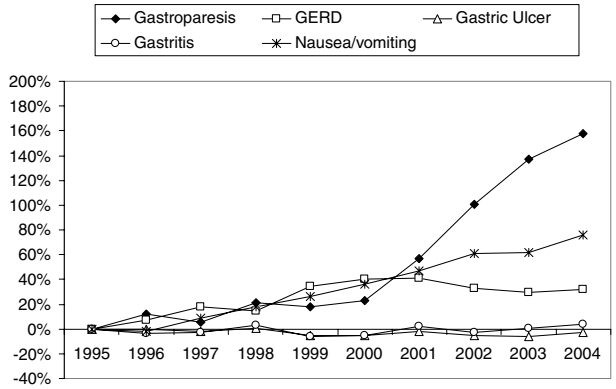

Figure 3. Percentage changes in the national estimates of hospitalizations with gastroparesis or a common upper GI condition as the primary diagnosis in the United States, 1995–2004. For each category of hospitalization, the % change in a specific year is defined as the relative percentage change compared with its baseline value in 1995. GERD = gastroesophageal reflux disease.

patients with gastroparesis as the primary diagnosis, those with gastroparesis as the secondary diagnosis had more diagnoses, more inpatient procedures, a longer length of stay, higher total charges, and a higher percentage of in-hospital deaths.

Results from the multivariate regressions generally confirmed the above findings. Compared with hospitalizations with gastroparesis as the primary diagnosis, hospitalizations with GERD, gastric ulcer, gastritis, or nonspecific nausea/vomiting as the primary diagnosis had a significantly shorter length of stay in 1995 and 2004, with the relative difference ranging from −15.1% to −6.2% (all $P < 0.001$) (Table 4). In both years, total charges for hospitalizations with GERD, gastric ulcer, gastritis, or nonspecific nausea/vomiting as the primary diagnosis were significantly lower compared with gastroparesis in the procedure-adjusted model (−66.4% to −18.7%, all $P < 0.001$). Without controlling for the number of procedures, total charges were significantly higher for gastric ulcer in 2004 (+6.4% to +7.6%, both $P < 0.01$). Results on the likelihood of in-hospital death were less consistent. Compared with hospitalizations with gastroparesis as the primary diagnosis, the likelihood of in-hospital death was similar for hospitalizations with nausea/vomiting as the primary diagnosis but was significantly lower for hospitalizations with GERD as the primary diagnosis in both years (OR 0.085–0.164, all $P < 0.001$). The differences in in-hospital deaths between gastroparesis and gastric ulcer or gastritis varied by year or model specification, for example, both were insignificant in the procedure-adjusted model in 2004.

Including hospitalizations with a common upper GI condition as the primary diagnosis and gastroparesis as the secondary diagnosis (N = 1,312 in 1995, N = 3,371 in 2004) in the regression sample led to similar results in both years (not reported in Table 4). However, having gastroparesis as the secondary diagnosis led to a significantly longer length of

Table 2. Characteristics and Outcomes of Sample Hospitalizations in the 1995 HCUP NIS Database

Condition Diagnosis	Gastroparesis Primary	Gastroparesis Secondary	GERD Primary†	Gastric Ulcer Primary†	Gastritis Primary†	Nausea/Vomiting Primary†
N	765	10,806	15,007	18,798	25,272	6,932
Age (yr)*	52.8 (19.6)	55.9 (17.7)	49.4 (25.4)	66.6 (16.8)	58.1 (21.6)	53.1 (25.3)
Female (%)	69.8	63.4	55.6	53.9	56.9	68.9
Primary insurance (%)						
Medicare	49.0	55.3	35.3	59.8	47.7	43.5
Medicaid	8.8	13.0	14.8	7.0	12.9	13.5
Private	37.8	26.8	42.9	25.6	29.4	36.0
Self-pay	2.5	2.4	3.7	5.0	6.7	3.6
Unknown	2.0	2.5	3.2	2.6	3.3	3.4
Admitted through ED (%)	46.4	52.6	51.1	63.6	62.0	45.7
Diabetes (%)	21.0	72.9	10.0	13.4	14.9	14.5
Number of diagnoses*	5.6 (2.7)	8.4 (2.7)	4.4 (2.5)	6.2 (2.8)	5.6 (2.8)	5.5 (2.6)
Number of procedures*	1.3 (1.6)	1.6 (2.0)	1.1 (1.4)	2.2 (1.8)	1.3 (1.4)	0.6 (1.1)
Length of stay (days)*	7.4 (10.3)	8.0 (9.7)	3.3 (5.2)	6.0 (7.3)	4.3 (5.2)	3.6 (4.3)
Total charges ($)*	12,311 (22,036)	15,506 (30,073)	7,214 (9,687)	13,063 (23,366)	7,441 (10,728)	5,590 (8,486)
In-hospital death (%)	1.4	2.6	0.1	3.1	0.9	0.9

*Numbers in a cell represent mean (standard deviation).
†Hospitalizations with gastroparesis as the secondary diagnosis were excluded.
GERD = gastroesophageal reflux disease.

stay (+9.8% to +31.1%, all $P < 0.001$), significantly higher total charges (+8.1% to +35.4%, all $P < 0.001$), but no changes in the likelihood of in-hospital death.

While there was no significant difference in the length of stay between hospitalizations with gastroparesis as the primary diagnosis and those with gastroparesis as the secondary diagnosis (with the exception of the age-sex-adjusted model in 1995), the latter had significantly higher total charges in both 1995 and 2004 (+6.2% to +18.6%, all $P < 0.05$) and a significantly larger likelihood of in-hospital death in 2004 (OR 2.005–2.083, all $P < 0.05$) (Table 5). Notably, the above differences remained significant but narrowed after controlling for the number of diagnoses and procedures.

Sensitivity analyses using the negative binomial model for length of stay and the generalized linear model with the log-link and gamma distribution for total charges led to similar results in both years (not reported in Table 4 or Table 5). The only exception is that the difference in the length of stay between gastroparesis as the primary diagnosis and gastroparesis as the secondary diagnosis was no longer significant in the age-sex-adjusted specification.

National Estimates of Outcomes

In 1995, gastroparesis as the primary diagnosis resulted in 29,187 hospital days, 48 million dollars of hospital charges, and 60 in-hospital deaths; gastroparesis as the secondary diagnosis resulted in 455,234 hospital days, 863 million dollars of hospital charges, and 1,454 in-hospital deaths (Table 6). In 2004, gastroparesis as the primary diagnosis

Table 3. Characteristics and Outcomes of Sample Hospitalizations in the 2004 HCUP NIS Database

Condition Diagnosis	Gastroparesis Primary	Gastroparesis Secondary	GERD Primary†	Gastric Ulcer Primary†	Gastritis Primary†	Nausea/Vomiting Primary†
N	2,105	26,978	21,355	19,630	28,758	12,848
Age (yr)*	50.6 (18.9)	53.5 (17.3)	47.9 (26.4)	66.7 (16.8)	57.7 (21.4)	50.0 (25.3)
Female (%)	71.8	65.4	58.6	56.9	59.1	68.5
Primary insurance (%)						
Medicare	41.7	51.5	33.6	59.2	47.4	39.7
Medicaid	13.3	16.6	16.7	7.2	13.2	16.9
Private	38.3	25.0	41.5	24.6	28.4	34.5
Self-pay	4.3	4.2	5.3	6.0	7.8	5.7
Unknown	2.4	2.7	2.9	3.0	3.2	3.1
Admitted through ED (%)	63.5	67.9	58.9	74.6	68.5	63.6
Diabetes (%)	26.7	79.4	14.2	20.3	21.0	18.0
Number of diagnoses*	7.2 (3.2)	9.6 (3.3)	5.6 (3.0)	7.8 (3.1)	7.0 (3.1)	6.4 (3.0)
Number of procedures*	1.2 (1.6)	1.4 (1.9)	1.0 (1.3)	2.3 (1.6)	1.4 (1.3)	0.5 (1.0)
Length of stay (days)*	6.1 (8.8)	6.3 (7.4)	2.4 (3.3)	4.9 (5.4)	3.5 (3.6)	3.2 (3.3)
Total charges ($)*	20,573 (28,483)	24,965 (37,891)	12,051 (17,066)	23,259 (37,121)	14,570 (18,658)	10,638 (14,938)
In-hospital death (%)	0.6	1.3	0.05	2.2	0.6	0.5

*Numbers in a cell represent mean (standard deviation).
†Hospitalizations with gastroparesis as the secondary diagnosis were excluded. GERD = gastroesophageal reflux disease.

Table 4. Multivariate Regression Results on the Differences in Outcomes Between Hospitalizations With Gastroparesis as the Primary Diagnosis and Those With a Common Upper GI Condition as the Primary Diagnosis in the 1995 and 2004 HCUP NIS Databases

Year (Sample Size)	1995 (N = 66,774)			2004 (N = 84,696)		
Outcome Variable	Length of Stay	Total Charges	In-Hospital Death	Length of Stay	Total Charges	In-Hospital Death
Regression Model	Log-Linear	Log-Linear	Logistic	Logistic	Log-Linear	Logistic
GERD *vs* gastroparesis						
Age-sex-adjusted difference/OR	−0.543 (−0.585 to −0.501)‡	−0.361 (−0.418 to −0.304)‡	0.092 (0.044–0.194)‡	−0.662 (−0.688 to −0.635)‡	−0.465 (−0.504 to −0.427)‡	0.085 (0.037–0.193)‡
Diagnosis-adjusted difference/OR	−0.465 (−0.504 to −0.426)‡	−0.274 (−0.327 to −0.220)‡	0.114 (0.054–0.241)‡	−0.562 (−0.586 to −0.538)‡	−0.328 (−0.365 to −0.291)‡	0.114 (0.050–0.260)‡
Procedure-adjusted difference/OR	−0.464 (−0.501 to −0.428)‡	−0.273 (−0.320 to −0.226)‡	0.117 (0.055–0.250)‡	−0.551 (−0.574 to −0.528)‡	−0.308 (−0.341 to −0.274)‡	0.164 (0.069–0.392)‡
Gastric ulcer *vs* gastroparesis						
Age-sex-adjusted difference/OR	−0.163 (−0.205 to −0.122)‡	0.024 (−0.033–0.081)	1.423 (0.777–2.605)	−0.170 (−0.196 to −0.144)‡	0.064 (0.026–0.103)†	2.202 (1.233–3.931)†
Diagnosis-adjusted difference/OR	−0.151 (−0.190 to −0.112)‡	0.019 (−0.035–0.072)	1.279 (0.694–2.358)	−0.154 (−0.179 to −0.130)‡	0.072 (0.035–0.109)‡	2.226 (1.242–3.990)†
Procedure-adjusted difference/OR	−0.268 (−0.304 to −0.232)‡	−0.187 (−0.235 to −0.140)‡	0.896 (0.480–1.673)	−0.307 (−0.331 to −0.284)‡	−0.206 (0.240 to −0.173)‡	1.611 (0.840–3.088)
Gastritis *vs* gastroparesis						
Age-sex-adjusted difference/OR	−0.374 (−0.416 to −0.333)‡	−0.359 (−0.415 to −0.303)‡	0.519 (0.281–0.956)*	−0.406 (−0.432 to −0.380)‡	−0.330 (0.368 to −0.291)‡	0.741 (0.411–1.338)
Diagnosis-adjusted difference/OR	−0.349 (−0.387 to −0.310)‡	−0.342 (−0.395 to −0.289)‡	0.491 (0.265–0.912)*	−0.368 (−0.392 to −0.344)‡	−0.281 (−0.318 to −0.245)‡	0.798 (0.441–1.445)
Procedure-adjusted difference/OR	−0.359 (−0.395 to −0.324)‡	−0.361 (−0.408 to −0.314)‡	0.458 (0.244–0.860)*	−0.405 (−0.428 to −0.382)‡	−0.349 (−0.382 to −0.316)‡	0.891 (0.461–1.725)
Nausea/vomiting *vs* gastroparesis						
Age-sex-adjusted difference/OR	−0.504 (−0.547 to −0.461)‡	−0.664 (−0.722 to −0,605)‡	0.568 (0.298–1.085)	−0.454 (−0.481 to −0.427)‡	−0.606 (−0.646 to −0.566)‡	0.713 (0.382–1.331)
Diagnosis-adjusted difference/OR	−0.499 (−0.539 to −0.459)‡	−0.663 (−0.719 to −0.608)‡	0.563 (0.293–1.082)	−0.406 (−0.431 to −0.381)‡	−0.537 (−0.574 to −0.499)‡	0.841 (0.449–1.575)
Procedure-adjusted difference/OR	−0.404 (−0.441 to −0.367)‡	−0.496 (−0.544 to −0.447)‡	0.761 (0.392–1.479)	−0.320 (−0.343 to −0.296)‡	−0.380 (−0.414 to −0.346)‡	1.644 (0.822–3.288)

The explanatory variables in the age-sex-adjusted model included age and sex. The explanatory variables in the diagnosis-adjusted model included age, sex, type of primary insurance, whether the patient was admitted through the ED, the comorbidity of diabetes, and the number of diagnoses. The explanatory variables in the procedure-adjusted model included age, sex, type of primary insurance, whether the patient was admitted through the ED, the comorbidity of diabetes, number of diagnoses, and the number of procedures.

For the log-linear model (length of stay or total charges), the numbers in a cell represent relative percentage difference (95% confidence interval). For the logistic model (in-hospital deaths), the numbers in a cell represent odds ratio (95% confidence interval).

*$P < 0.05$

†$P < 0.01$.

‡$P < 0.001$.

GERD = gastroesophageal reflux disease; OR = odds ratio.

Table 5. Multivariate Regression Results on the Differences in Outcomes Between Hospitalizations With Gastroparesis as the Primary Diagnosis and Those With Gastroparesis as the Secondary Diagnosis in the 1995 and 2004 HCUP NIS Databases

Year (Sample Size)	1995 (N = 11,571)			2004 (N = 29,083)		
Outcome Variable	Length of Stay	Total Charges	In-Hospital Death	Length of Stay	Total Charges	In-Hospital Death
Regression Model	Log-Linear	Log-Linear	Logistic	Log-Linear	Log-Linear	Logistic
Secondary *vs* primary diagnosis of gastroparesis						
Age-sex-adjusted difference/OR	0.068 (0.017–0.120)†	0.186 (0.117–0.254)‡	1.682 (0.914–3.094)	0.005 (−0.025–0.035)	0.115 (0.073–0.156)‡	2.083 (1.167–3.718)*
Diagnosis-adjusted difference/OR	0.014 (−0.038–0.066)	0.084 (0.016–0.153)*	1.294 (0.691–2.424)	0.010 (−0.020–0.040)	0.099 (0.057–0.141)‡	2.047 (1.132–3.700)*
Procedure-adjusted difference/OR	0.007 (−0.040–0.054)	0.073 (0.015–0.131)*	1.203 (0.641–2.258)	−0.012 (−0.039–0.016)	0.062 (0.026–0.098)‡	2.005 (1.097–3.666)*

The explanatory variables in the age-sex-adjusted model included age and sex. The explanatory variables in the diagnosis-adjusted model included age, sex, type of primary insurance, whether the patient was admitted through the ED, the comorbidity of diabetes, and the number of diagnoses. The explanatory variables in the procedure-adjusted model included age, sex, type of primary insurance, whether the patient was admitted through the ED, the comorbidity of diabetes, number of diagnoses, and the number of procedures.
For the log-linear model (length of stay or total charges), the numbers in a cell represent relative percentage difference (95% confidence interval). For the logistic model (in-hospital deaths), the numbers in a cell represent odds ratio (95% confidence interval).
*$P < 0.05$.
†$P < 0.01$.
‡$P < 0.001$.
OR = odds ratio.

resulted in 62,296 hospital days, 208 million dollars of hospital charges, and 57 in-hospital deaths; gastroparesis as the secondary diagnosis resulted in 849,667 hospital days, 3,292 million dollars of hospital charges, and 1,709 in-hospital deaths.

Compared with common upper GI conditions, including GERD, gastric ulcer, gastritis, and nausea/vomiting, gastroparesis was a relatively uncommon primary diagnosis in both 1995 and 2004 (Table 1). Therefore, it is not surprising that gastroparesis as the primary diagnosis resulted in fewer total hospital days, smaller total hospital charges, and fewer in-hospital deaths in the United States in both years (with the exception of GERD in 2004) (Table 6). What is noteworthy is that the relative percentage increases in total hospital days and total hospital charges were the largest for gastroparesis and that the total number of in-hospital deaths was relatively stable for gastroparesis but decreased dramatically for GERD, gastric ulcer, and gastritis in 2004.

DISCUSSION

To the best of our knowledge, this is the first study to demonstrate that the number of gastroparesis-related hospitalizations has been increasing in the United States. The annual number of gastroparesis-related hospitalizations was estimated using the HCUP NIS, which was designed to approximate a 20% stratified sample of U.S. hospitals and comprises 5–8 million hospital stays from about 1,000 hospitals each year. Its large sample size enables the analysis of rare conditions, such as gastroparesis in this study. The findings that both the hospitalizations with gastroparesis as the primary diagnosis and those with gastroparesis as the secondary diagnosis increased during 1995–2004 and that the gastroparesis-related hospitalizations increased at a faster rate compared with the control groups of hospitalizations including common upper GI conditions added further confidence to this conclusion.

The cause for the increase in gastroparesis-related hospitalizations is not clear. It may reflect an increasing prevalence of gastroparesis, the increasing prevalence of diabetes, changes in gastroparesis diagnostic criteria, severity, and treatment, or better recognition/diagnosis of this disorder. More gastroparesis-related hospitalizations had diabetes as a comorbidity in 2004 than in 1995. The prevalence of gastroparesis may be increasing due to the increasing prevalence of diabetes, the improving longevity of diabetics, and the minimal impact of gastroparesis on mortality. In our study, although diabetes-related hospitalizations increased at a slower rate, diabetes-related admissions increased in absolute numbers well above the number of gastroparesis-related admissions. Prior studies on the natural history of gastroparesis have been limited, but they indicated that the symptoms were generally stable and that gastroparesis was not associated with mortality after adjusting for comorbidities over 9 or more years (21, 22). The slower increase shown for

Table 6. National Estimates of Length of Stay, Total Charges, and Number of In-Hospital Deaths Due to Gastroparesis as the Primary Diagnosis, Gastroparesis as the Secondary Diagnosis, or a Common Upper GI Condition as the Primary Diagnosis in the United States, 1995 and 2004

Year	1995			2004		
Outcome	Length of Stay	Total Charges	In-Hospital Death	Length of Stay	Total Charges	In-Hospital Death
Gastroparesis-related hospitalizations						
Primary diagnosis	29,187	47,726,558	60	62,296	208,263,570	57
Secondary diagnosis*	455,234	863,291,147	1,454	849,667	3,291,756,583	1,709
Other upper GI conditions as primary diagnosis*						
GERD	268,302	569,048,424	122	258,741	1,266,554,967	53
Gastric ulcer	604,436	1,295,370,569	3,096	478,210	2,233,560,923	2120
Gastritis	592,254	1,008,033,754	1,269	507,760	2,078,923,132	839
Nausea/vomiting	132,182	200,905,164	326	208,139	685,351,009	304

*Some hospitalizations had GERD, gastric ulcer, gastritis, or nausea/vomiting as the primary diagnosis and gastroparesis as the secondary diagnosis. These hospitalizations were included in both groups.
GERD = gastroesophageal reflux disease.

hospitalizations with nonspecific nausea/vomiting as the primary diagnosis might be in part due to better recognition/diagnosis of gastroparesis. Noticeably, there was a marked increase in hospitalizations with gastroparesis as the primary diagnosis after 2000, with a concomitant, marked increase in its mean total charges. Several important events took place around that time. First, the prokinetic agent cisapride was taken off the market, and this might have increased the number of symptomatic patients. Secondly, gastric electric stimulation received U.S. Food and Drug Administration (FDA) approval through a humanitarian device exemption around that time. This treatment often entails hospitalization for surgical placement of the stimulator (23). There could have been an increased recognition of this disorder and possibly a change in hospital coding practice. Thirdly, there was an increase in utilization of the 4-h gastric emptying scintigraphic study, which was shown to increase the diagnostic yield of gastroparesis (24). Further studies are needed to determine whether these or any other changes contributed to the marked increase in hospitalizations with gastroparesis as the primary diagnosis after 2000.

Note that of the upper GI conditions studied as the primary diagnosis, gastroparesis had the longest length of stay and the highest or second highest total charges. It is somewhat surprising to find that patients hospitalized with gastroparesis as the primary diagnosis differed significantly from those with gastroparesis as the secondary diagnosis. The latter were much more likely to be diabetic and had more diagnoses, more procedures, higher hospital charges, and more in-hospital deaths. The reasons for these differences are unclear. One possible explanation is that patients with idiopathic gastroparesis might be more likely to be admitted and treated under the primary diagnosis of gastroparesis, whereas more complicated cases, such as diabetic patients with multiple complications including gastroparesis, might be admitted and treated under a more serious or life-threatening primary diagnosis such as diabetic ketoacidosis. The differences between gastroparesis as the primary diagnosis and gastroparesis as the secondary diagnosis may reflect different disease state or severity.

Although this study provides important information about gastroparesis-related hospitalizations in the United States, it has several limitations associated with the use of the HCUP NIS database. Patients with more severe forms of gastroparesis are likely to be overrepresented in this inpatient database. The diagnosis of gastroparesis could not be truly validated, as is the case in any retrospective study. The lack of a patient identifier made it impossible to differentiate multiple hospitalizations of the same patient. Even though the NIS recorded up to 15 diagnoses, it is unknown which were prehospitalization or existing diagnoses. In addition, past surgical history is not available. Consequently, the etiology of gastroparesis, whether due to diabetes, past surgery, or idiopathic, could not be ascertained. The database also failed to adjust for hospital coding changes over time, which might be driven by reimbursement changes. Finally, total charges instead of the actual reimbursement data were reported, with the caveat that the reimbursement ratios might have dropped over time.

In summary, the number of gastroparesis-related hospitalizations has been increasing in the United States. This may suggest an increasing prevalence of gastroparesis. The economic impact of gastroparesis-related hospitalizations, as the primary diagnosis and even more so as the secondary diagnosis, is significant and increasing. More studies are needed to better understand the prevalence of gastroparesis, its etiologies including the relationship with type 2 diabetes, its natural history, and its incremental effect on the use of medical care.

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STUDY HIGHLIGHTS

What Is Current Knowledge

- Gastroparesis is a common cause of nausea, vomiting, bloating, and abdominal discomfort in the absence of mechanical obstruction.
- The common etiologies of gastroparesis are diabetes, postsurgical, and idiopathic.
- The prevalence of gastroparesis in the United States is unknown.

What Is New Here

- Hospitalizations with gastroparesis as the primary or secondary diagnosis increased 138% during 1995–2004, suggesting an increasing prevalence of gastroparesis.
- Of the five upper gastrointestinal conditions studied as the primary diagnosis, gastroparesis had the longest length of stay and the highest or second highest total charges in 2004.
- The economic impact of gastroparesis-related hospitalizations is significant and increasing in the United States.

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CONFLICT OF INTEREST

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