Obesity and Incremental Hospital Charges among Patients with and without Diabetes in the United States

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ABSTRACT

Objective: The purpose of this study was to estimate the association between obesity and diabetes among inpatients in the United States as well as to investigate the incremental hospital charges attributable to obesity or morbid obesity.

Methods: We analyzed the Nationwide Inpatient Sample 2005, a nationally representative probability sample that includes nearly 8 million inpatient records from US community hospitals.

Results: During the past decade, the obesity among inpatients has steeply increased. In 2005, nearly 1.87 million hospitalizations were made by obese or morbidly obese patients. Both patients with type 1 and type 2 diabetes were considerably more likely to be obese or morbidly obese compared with inpatients without diabetes ($P < 0.01$). The proportions of hospitalizations with obese or morbidly obese conditions were 4.5% among patients without diabetes, 6.3% among patients with type 1, and 12.2% among patients with type 2 diabetes. The hospital charges for obese and morbidly obese patients were 6.1% ($P < 0.01$) and 18.7% ($P < 0.01$) higher than that of the nonobese patients when diabetes status, sex, age, race, hospital admission type, and length of hospital stays were the same.

Conclusion: Following a parallel rise in obesity among the general population, hospital admissions of obese and morbidly obese inpatients are continuously increasing. Morbidly obese patients consumed substantially more hospital resources regardless of the presence or type of diabetes. Under the current price-per-case reimbursement system, additional hospital resource use by this growing number of morbidly obese inpatients could be a burden to hospital financial systems.

Keywords: burden of illness, cost-of-illness, diabetes, hospital care.

Introduction

The prevalence of obesity, which is defined as having a body mass index (BMI) greater than 30 kg/m², has substantially increased over the past couple of decades within the United States [1,2]. Extreme obesity, which is defined as having a BMI greater than 40 kg/m² [3], is also known as “morbid” obesity because it is associated with various life-threatening diseases. The prevalence of morbid obesity has been increasing at a faster rate than that of obesity over the past 20 years [4]. A study based on the Behavioral Risk Factor Surveillance Survey has reported that, from 2000 to 2005, the prevalence of obesity among adults in the United States increased by 24%. However, the prevalence of morbid obesity increased by 50% [4]. This continually increasing prevalence of obesity and morbid obesity in the US population remain a significant public health concern because of its various negative impacts on health.

It is well documented that obesity is positively associated with type 2 diabetes in the general population [2,5–9]. Type 1 diabetes, known as an autoimmune disease, was also reported to be linked to obesity among adults [10–12]. A more recent study suggested that obesity is a risk factor for the early onset of type 1 diabetes among US youths with reduced β-cell functions [13]. The number of young adults hospitalized with diabetes has increased significantly over the last decade [14], following a parallel rise in obesity among the general population. Although the link between obesity and diabetes is found in the general population, there is little information about the association between obesity and diabetes among inpatients. The aim of our study was to estimate the level of obesity and morbid obesity among hospitalized patients with type 1 or type 2 diabetes.

Moreover, the purpose of this study was to describe the incremental hospital charges attributable to obesity or morbid obesity among inpatients with and without diabetes. Obese patients had a significantly higher number of visits to both primary care and specialty care clinics [15]. The costs of the health services rendered to obese persons also tended to be higher [16]. According to a review study [17], the excess use and cost of medical services are because of obesity-related comorbidity. The above referenced study concluded that the increased health-care expenditure was linked with obesity, largely because the obese patients were more likely to have diseases such as diabetes or hypertension. To our knowledge, however, no study has further reported the hospital resource use by obesity level after controlling for diabetes. A study on pediatric patients reported that obesity is associated with significantly higher charges for the most common reasons for pediatric hospitalizations such as appendicitis, asthma, pneumonia, and affective disorders [18]. Because these pediatric conditions were not necessarily obesity-related diseases, we hypothesized that obesity or morbid obesity also plays a significant role in hospital resource use, regardless of the presence or absence of diabetes. Therefore, we proposed to compare hospital charges by obesity level after controlling for diabetes status. Because the prevalence of obesity and morbid obesity is high in the US population, understanding the hospital resources used by these patients is significant to hospital finance systems.
Research Design and Methods

The Nationwide Inpatient Sample (NIS) was analyzed to study obesity and morbid obesity among inpatients in the United States.

NIS-2005

The NIS-2005, a part of the Healthcare Cost and Utilization Project (HCUP), is a nationally representative database of hospital inpatient stays. The NIS is the only all-payer inpatient care database in the United States [19,20]. The NIS is the principal source for national data concerning characteristics of patients discharged from nonfederal, short-stay community hospitals. This annual cross-sectional survey is conducted under the auspices of the Agency of Health Research and Quality (AHRQ), and the database is available to researchers upon completion of the HCUP data use agreement course. The NIS is a probability sample of 20 percent of the US community hospitals used to produce a nationally representative sample. All inpatient records in the sampled hospitals were then included. In 2005, the NIS contained a probabilistic sample of ~8 million (n = 7,995,048) records from over 1000 hospitals. Details concerning sampling procedures are published elsewhere [21]. Admissions that resulted from childbirth and newborn babies were excluded from this study.

Diagnosis Codes for Obesity, Morbid Obesity, and Diabetes

All primary and secondary diagnosis fields in the inpatient record were evaluated to identify obesity and the type of diabetes. Morbidly obese (or extremely obese) patients may require a different amount of hospital resources compared with obese patients. Therefore, obesity was differentiated into two groups: obesity and morbid obesity. The obesity group was identified by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code = 278.00 which is defined as “an increase in body weight beyond the limitation of skeletal and physical requirements as the result of excessive accumulation of body fat.” In adults, a BMI of 30 or more is considered obese. Morbid obesity (identified by ICD-9-CM code: 278.01) is diagnosed when the patient weighs two or more times the ideal body weight, when the patient is more than 100 lbs above the ideal body weight, or when the BMI is 40 or more. An obese but not morbidly obese condition is referred to as “obesity” hereafter.

The type 1 diabetes condition is identified by ICD-9-CM code 250.X1 or 250.X3 and the type 2 diabetes condition is identified by ICD-9-CM code 250.X0 or 250.X2, where X = 0 to 9. If at least one diagnosis field indicated one type of diabetes, then the inpatient records were selected and named with “hospitalizations with type 1” or “hospitalizations with type 2.” Further, to identify the most common reason of hospitalizations for each type of diabetes group, the primary ICD-9-CM code was studied. The primary diagnosis in the patient record is the condition chiefly responsible for the patient’s admission to the hospital.

Estimation of Hospital Charges and Costs

By the type of obesity, the financial burden of hospitalizations was estimated using hospital charges and hospital costs. Hospital charges refer to the amount the hospital billed alone, and do not include professional (physician) fees. The hospital costs were then estimated by multiplying the average cost-to-charge ratios found from the cost-to-charge ratio file provided by the AHRQ [22]. The AHRQ’s cost-to-charge ratio file is constructed using all-payer, inpatient cost and charge information from the detailed reports by hospitals to the Center for Medicare and Medicaid Services. The term “attributable charges or costs” was used to denote the differences in hospital resource use for obese inpatients compared with that of nonobese inpatients.

Statistical Analysis

HCUPnet, a web-based interactive analytic tool, was used to identify the trend of obesity and morbid obesity among inpatients from 1996–2005 [23]. To evaluate a trend during this time period, a scatter-plot was constructed. Different linear trends in different time periods were modeled using piecewise linear regression. Piecewise regression models are broken-stick models, where two or more lines are joined at breakpoints [24].

Because the NIS is a probabilistic sample survey, the sampling weight and sampling design were considered in calculating total hospitalizations and their standard errors. Sampling weights were used to account for unequal sampling probabilities and to produce estimates for all hospital discharges in the United States. The population estimation was weighted considering: 1) probability of selection; and 2) the nonresponse rate of the hospital.

To evaluate the association between obesity and diabetes among inpatients, we used design-based Pearson chi-square statistics. Although this test is based on Pearson chi-square statistics, it was reported as an F statistic adjusting for effects of survey design used in the NIS. The odds of being obese (or morbidly obese) were then calculated for each group of “with diabetes” and “without diabetes.” For each group of with or without diabetes, the number of admission records that had a diagnosis of obesity (or morbid obesity) was the numerator of the odds, and the remaining admission records that did not include a diagnosis of obesity were classified as the denominator of odds. Finally, the odds ratio of hospitalization was then calculated by dividing the odds of being obese (or morbidly obese) among inpatients with each type of diabetes by that of individuals without diabetes. The statistical significance of the odds ratio was calculated using design-based logistic regression.

The hospital charges to patients were highly skewed, owing to the extremely high charges generated by few very sick patients. After we examined the skewness of the distribution, we used a median test to compare hospital charges among nonobese, obese, and morbidly obese groups. Finally, we compared hospital charges among different obesity levels after controlling for potential confounders (diabetes status, age, sex, race, admission type, and length of hospital stay) using a linear model. To normalize the distribution of hospital charges, these hospital charges were log-transformed before being fitted to the linear model. Details concerning log transformation are published elsewhere [25]. Briefly, the sample arithmetic mean of the log-transformed hospital charges is the log of the geometric mean which is denoted by $\ln$. The geometric mean, found by exponentiating the arithmetic mean of the log-transformed charges, is lower than the arithmetic mean of actual hospital charges and that is a symptom of a positively skewed distribution. The bigger the difference between arithmetic and geometric means, the more the data is positively skewed. If the data is normally distributed, the two values would be almost identical.

The variable of interest was the obesity group which has three levels (not obese, obese, and morbidly obese). Two dummy variables were created using the “not-obese” as a reference group.
The following regression model was fitted to the data to evaluate the role of obesity in hospital charges.

\[ \ln(\text{Hospital Charges}) = \beta_0 + \beta_1 \times \text{obesity} + \beta_2 \times \text{morbid obesity} + \sum \beta_k X_k + \epsilon_i \]  

where \( \ln \) denotes the natural logarithm function and "\( \sum \)" is the number of confounding variables controlled. In the log scale, \( \beta_1 \) is the difference in the log of geometric means of the hospital charges between the obese patients and nonobese patients, although all other variables in the model were held constant.

\[ \beta_1 = \ln(G_{\text{obese}}) - \ln(G_{\text{not obese}}) = \ln \left( \frac{G_{\text{obese}}}{G_{\text{not obese}}} \right) \]

In the original scale of the hospital charges, the exponentiated (or antilog) coefficient for the obesity group, \( \exp(\beta_1) \), represents the ratio of the geometric mean of obese patients compared with nonobese patients after controlling for confounders in the model. By subtracting 1 from both sides of the equation, we calculated relative change in hospital charges.

\[ \exp(\beta_1) - 1 = \frac{G_{\text{obese}} - G_{\text{not obese}}}{G_{\text{not obese}}} \]

Thus, \( 100(\exp(\beta_1) - 1) \)% is the expected percent change in hospital charges for obese patients compared with non-obese patients, although all other variables in the model were held constant. To calculate the 95% confidence interval (CI) on the original scale of hospital charges, the CI for the log scale was obtained. Then, we antilog these limits to give a CI for the hospital charges itself. Therefore, the observed hospital charge is not in the center of the CI because of the asymmetrical nature of the log scale. All analysis of the NIS-2005 was performed using the statistical package, STATA version 10.0 [26].

**Results**

**Hospitalizations made by Obese or Morbidly Obese Patients**

Over the past decade (between 1996 and 2005), the number of hospitalizations by obese and morbidly obese patients have been rapidly on the rise. Figure 1 shows this upward trend with a 95% CI for the number of hospitalizations by obese and morbidly obese patients. The increase in hospitalizations by morbidly obese patients was steeper than that of obese patients; the number of hospitalizations by obese and morbidly obese patients increased by two and four times, respectively. The increase in the number of hospital admissions by obese and morbidly obese patients was noticeably accelerated after the year 2000. The piecewise linear regression line in Figure 1 showed that the number of obese patients increased by 21,000 each year before the year 2000. However, from the year 2000, the number of obese patients increased by 86,000 every year. These changes in the rates (or slopes) were statistically significant \( (P < 0.01) \). In the year 2000, there was not only a change in the rate of increase but there was also a discontinuous jump in the number of hospital admissions by obese patients \( (P < 0.01) \). Likewise, the number of hospitalizations by morbidly obese patients increased at a significantly steeper rate after the year 2000 \( (P < 0.01) \). Until the year 2000, the number of morbidly obese patients increased by 37,000 every year compared with an increase of 80,000 every year after the year 2000. However, there was no discontinuous jump in the number of hospitalizations by morbidly obese patients in the year 2000 \( (P < 0.33) \).

In 2005, ~0.01% of discharge records listed both ICD-9-CM codes of obesity and morbid obesity, and these patients were considered morbidly obese. During 2005, among ~30.8 million (95% CI: 29.6–31.9 million) hospitalizations in the United States, nearly 1.87 million (~6%) hospitalizations listed obesity or morbid obesity as their comorbidity. Among these 1.87 million hospitalizations, ~1,157,000 hospitalizations were made by obese patients and another 708,000 hospitalizations were made by morbidly obese patients. We examined the most common reason for hospitalization by obesity level. The most common reasons for hospitalization were congestive heart failure accounting for 7% of nonobese inpatients, coronary atherosclerosis and other heart disease accounting for 9.4% of obese inpatients, and nutritional endocrine and metabolic disorders accounting for 10.7% of morbidly obese inpatients.

**Diabetes and Obesity among Inpatients**

Among the 6.42 million hospitalizations made by people with diabetes in 2005, ~5.99 million (95% CI: 5,840,000–6,132,000)

![Figure 1](image-url)
hospitalizations were made by patients with type 2 diabetes and ~435,000 (95% CI: 417,000–453,000) hospitalizations were made by patients with type 1 diabetes. There was a significant positive association between obesity and diabetes among inpatients (Pearson chi-square statistics, $P < 0.01$). Explicitly, as shown in Figure 2 among hospitalizations without diabetes, 4.3% were obese or morbidly obese (2.94% obese + 1.59% morbidly obese) compared with 6.5% (3.74% was obese people and 2.77% morbidly obese) among hospitalizations with type 1 diabetes. If the inpatient was obese or morbidly obese, the odds of having type 1 diabetes increased by 1.3 and 1.8 times. Design-based survey logistic regression revealed that these odds ratios were significantly larger than one (both $P < 0.01$). Among hospitalizations with type 2 diabetes, 12.2% were obese or morbidly obese people (7.09% obese + 5.14% was morbidly obese). If the inpatient was obese or morbidly obese, the odds of having type 2 diabetes increased by 2.6 and 3.5 times, respectively. These odds ratios were significantly different than one (both $P < 0.01$).

**Hospital Resources Use by Obesity Adjusting for Diabetes and Age**

We examined the distribution of the hospital charges. Skewness of distribution for all three obesity categories was greater than five. Because of the extreme skewness of the distribution of the hospital charges, the group mean did not represent the center of distribution. The median, typical hospital charge was compared among three groups. The median hospital charge for morbidly obese patients (US$19,425) was higher than that of the hospitalizations of obese (US$16,012) or nonobese (US$14,569) patients (median tests for all three pairs, $P < 0.05$). During the same time period, the average cost-to-charge ratio was calculated to be 0.523 in the nation. That is, approximately 52.3% of hospital charges were actual hospital costs incurred [22]. Therefore, the typical hospital cost incurred for morbidly obese patients was US$2,525 more than nonobese patients as calculated by $0.52 \times (US$19,425–US$14,569)$.

We further compared the median hospital charges by obesity controlling for age and diabetes condition (Table 1). We included the mean hospital charges in Table 1 to illustrate that hospital charges were positively skewed. Note that mean hospital charges were almost double that of the medians. Medians were used for comparison of hospital charges among the three levels of obesity. As shown in Table 1, regardless of the presence or type of diabetes, the median hospital charges were much higher among morbidly obese inpatients. Among hospitalizations without diabetes, the median hospital charges for nonobese, obese, and morbidly obese patients were US$14,147, US$15,623, and US$20,046, respectively. The same pattern of increase was observed among hospitalizations with type 1 diabetes (US$13,569 for nonobese, US$14,412 for obese, and US$17,540 for morbidly obese patients) and type 2 diabetes (US$16,112 for nonobese, US$16,347 for obese, and US$18,360 for morbidly obese patients). In terms of statistical significance, all pairs of three medians were significantly different (median test, all $P$-values <0.01) for patients without diabetes, with type 1 diabetes, or with type 2 diabetes. From the perspective of practical significance, the median hospital charge among morbidly obese patients was much larger than that of obese or nonobese patients. This observation held true for all age groups.

**Hospital Resources Use by Obesity after Controlling for Potential Confounders**

We started with a model with the obesity category alone. All coefficients were statistically significant at an alpha level of 0.05. The fitted regression line was as follows

$$
\ln(\text{Hospital Charges}_i) = 9.630152 + 0.0709302 \times \text{obesity} + 0.2276906 \times \text{morbid obesity} + \epsilon,
$$

The exponentiated coefficient, $\exp(0.0709302) = 1.074$, is the ratio of the expected geometric mean for obese patients over the expected geometric mean for the nonobese patients. Therefore, we
concluded that hospital charges would be 7.4% higher for the obese patients than for the nonobese patients. Because the exponentiated coefficient for morbid obesity, \( \exp(0.22769) \), equals 1.256, we conclude that hospital charges would be 25.6% higher for the morbidly obese patients than for the nonobese patients.

We further compared the hospital charges among obesity groups after controlling for the diabetes status, age (<20, 20–39, 40–59, 60+), sex, race (whites, blacks, Hispanics, others), hospital admission type (emergency, urgent, others), and length of hospital stay in days. The linear model is presented in Table 2. The exponentiated coefficient for the obese group is now \( \exp(0.059087) = 1.061 \). Hospital charges were 6.1% higher for obese patients compared with nonobese patients (95% CI: 5.6 to 6.5) although other variables in the model were held constant.

Likewise, the exponentiated coefficient for morbid obesity is \( \exp(0.171552) = 1.187 \). The hospital charges for morbidly obese patients were 18.7% higher (95% CI; 18.1–19.4%) than that of the nonobese patients when other variables in the model were controlled.

Admitted Primarily Because of Nonhypertensive Congestive Heart Failure

The increased hospital charges for obese or morbidly obese patients were significant, regardless of the diabetes status, sex, age, race, hospital admission type, or length of hospital stay. Therefore, we further evaluated hospital charges among those who had the same primary diagnosis. The most frequent primary

| Table 1 | Median and mean hospital charges in US dollars by different level of obesity among inpatients with or without diabetes |
|---|---|---|---|---|---|---|---|
| | Age in years | Not obese* | Obese, but not morbidly obese † | Morbidly obese‡ |
| | | Median charges | Mean charges* | Median charges | Mean charges | Median charges | Mean charges |
| Total | | 8.546 | 20.819 | 10.226 | 19.418 | 15.201 | 27.925 |
| | 60+ | 14.147 | 23.985 | 15.623 | 24.460 | 20.046 | 29.057 |
| | 60+ | 13.569 | 26.495 | 14.412 | 23.784 | 17.540 | 27.102 |
| | Total | 8.915 | 20.068 | 8.568 | 15.584 | 11.233 | 25.383 |
| Type 2 diabetes | <20 | 11.650 | 20.495 | 11.825 | 18.877 | 16.803 | 25.054 |

*Defined as body mass index (BMI) less than 30.
†ICD-9-CM code 278.00 is defined as BMI of 30 or more.
‡ICD-9-CM code 278.01 is defined as BMI is 40 or more or when patient is more than 100 lbs above the ideal body weight.
Note: Hospital charges reflect only the amount billed by the hospital for the hospital stay and does not include professional physician fees.

| Table 2 | Comparison of log-transformed hospital charges among three obesity categories after controlling for confounders |
|---|---|---|---|---|---|---|
| Variables | Coefficient | P-value | exp(Coefficient) | Percent change in hospital charges* |
| Obesity | Constant | 8.842568 | 8.842568 | 8.842568 | 8.842568 | 8.842568 |
| (ref: Not obese) | | | | | | |
| Obese* | 0.059087 | 0.01 | 1.061 | 6.1 | 5.6 | 6.5 |
| Morbidly obese‡ | 0.171552 | 0.01 | 1.187 | 18.7 | 18.1 | 19.4 |
| Diabetes | Type I diabetes | 0.036901 | 0.01 | 1.038 | 3.8 | 3.1 | 4.5 |
| (ref: No diabetes) | Type 2 diabetes | 0.005794 | 0.01 | 1.006 | 0.6 | 0.4 | 0.8 |
| Sex | Female | –0.091256 | 0.01 | 0.913 | –8.7 | –8.9 | –8.6 |
| Age | 20–39 years old | 0.193102 | 0.01 | 1.213 | 21.3 | 20.9 | 21.7 |
| (ref: 20 or younger) | 40–59 years old | 0.438059 | 0.01 | 1.550 | 55.0 | 54.5 | 55.5 |
| 60 or older | 0.508354 | 0.01 | 1.663 | 66.3 | 65.8 | 66.8 |
| Admission type | Urgent | –0.072273 | 0.01 | 0.930 | –7.0 | –7.2 | –6.8 |
| (ref: Emergency) | Others | 0.213435 | 0.01 | 1.238 | 23.8 | 23.6 | 24.0 |
| Race | Blacks | –0.080123 | 0.01 | 0.992 | –0.8 | –1.1 | –0.6 |
| (ref:Whites) | Hispanics | 0.17706 | 0.01 | 1.189 | 18.9 | 18.5 | 19.2 |
| Others | 0.046332 | 0.01 | 1.048 | 4.8 | 4.4 | 5.2 |
| Length of stay | Hospital stay in days | 0.070476 | 0.01 | 1.073 | 7.3 | 7.3 | 7.3 |

*Percent change in hospital charges given one unit change in covariate. For instance, we expect approximately 18.7% increase in the geometric mean of hospital charges for morbidly obese patients compared with non-obese patients.
†ICD-9-CM code 278.00 is defined as BMI of 30 or more.
‡ICD-9-CM code 278.01 is defined as BMI is 40 or more or when patient is more than 100 lbs above the ideal body weight.
BMI, body mass index; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.
diagnosis among hospitalizations with type 2 diabetes was non-
hypertensive congestive heart failure. Among hospitalizations
with type 2 diabetes—primarily because of nonhypertensive con-
gestive heart failure—the median hospital charges for non-obese,
obe, and morbidly obese were US$14,775, US$14,876, and
US$15,776, respectively (not shown in the table). The difference
in median hospital charges between nonobese and obese patients
was insignificant (median test, \( P < 0.53 \)). However, the median
hospital charge for morbidly obese patients was significantly
higher than that of nonobese or obese patients (median test,
\( P < 0.01 \)).

**Comment**

Following a parallel rise in obesity among the general population
in the United States, our study found a significant growth of
obese inpatients during the same time period. A growing prev-
ance of obesity among Americans seems to continuously con-
tribute to the high demand in hospital care. We cautiously foresee
that obesity may become a frequent comorbidity among inpa-
tients in the United States for many decades to come. Another
noticeable trend is an accelerated increase in the rate of obese or
morbidly obese patients from the year 2000. ICD-9 code 278.0
was split into 278.00 and 278.01 in 1995, and the observed
increase in obese patients in 2000 are unlikely to be explained by
the change in ICD-9 coding. Parallel to the steep rise of morbid
obesity in the US general population [4], the growth of hospital
admissions by morbidly obese patients was significantly steeper
than that of obese patients. A rapid increase in morbid obese
patients may be explained in part by an upward trend in utiliza-
tion of bariatric surgery in the United States [27]. From
1998 to 2004, the total number of bariatric surgeries increased
by ninefold from 13,386 to 121,053 [27]. Our study found that
the total 708,000 hospitalizations were made by morbidly obese
patients during 2005. Although it is rapidly growing, the pro-
portion of bariatric surgery still remains relatively small (~17%) among
morbidly obese patients. Our database does not include
variables to answer why there was acceleration in the increase in
obese patients and it is beyond the scope of this current study.
However, we reflect on an advancement of medicine which made
obese people live longer with chronic conditions in addition to an
increasing prevalence of obesity in the US population.

Obesity is a well-recognized risk factor for type 2 diabetes. Our study found a dose–response association between obesity
level and type 2 diabetes among inpatients in the United States. If
the inpatient had type 2 diabetes, the odds of being obese and
morbidly obese increased by 2.6 and 3.5 times, respectively.
Although the association was not as strong, inpatients with type
1 diabetes were more likely to be obese or morbidly obese com-
pared with inpatients without diabetes. According to the ac-
celerator hypothesis [11,12], excess body weight speeds the onset
of diabetes in children, and this hypothesis views type 1 and type 2
diabetes as the same disorder of insulin resistance. NIS data does
not include the age of onset of diabetes and we could not
contribute to the growing debate of accelerator hypothesis.
However, our study supported that there was a positive relation-
ship between obesity level and type 1 diabetes among inpatients.
That is, if the inpatient was obese or morbidly obese, the odds
of having type 1 diabetes increased by 1.3 and 1.8 times,
respectively.

A previously published study concluded that the higher cost
of medical services among obese people was largely because of
the high prevalence of obesity-related diseases such as diabetes
[17]. Our study supported that high obesity level is also indepen-
dently associated with higher levels of hospital resource use apart
from the patients’ diabetes status. We found that morbidly obese
patients consumed more hospital resources regardless of the pres-
ence or type of diabetes. Even if patients were admitted with the
same primary diagnosis of nonhypertensive congestive heart
failure, morbidly obese patients used more resources than not
morbidly obese patients. NIS data collected for administrative
purposes do not include the breakdowns of hospital charges.
Further study is needed to investigate the reasons that contribute
to the increased use of hospital charges among morbidly obese
patients. Regardless, the incremental use of hospital resources by
morbidly obese patients provides significant information in the
current reimbursement system. The Diagnosis Related Group
(DRG) is a prospective, patient-classification scheme used for the
price-per-case reimbursement. Medicare provides payments to
hospitals for inpatient services through the DRG system rather
than the actual hospital charges incurred. The increasing number
of morbidly obese patients and incremental resource use by these
patients will inevitably become a growing burden to hospital
financial systems.

There are several limitations with this study. A study has
reported that the ratio of diagnosed to undiagnosed diabetes was
different depending on obesity levels in the United States [8].
That is, between National Health and Nutrition Examination
Survey (NHANES) II (1976–1980) and NHANES 1999–2000,
the proportion of total diabetes cases that was diagnosed
increased from 41% to 83% among individuals with BMI ≥ 35.
However, there was no increase in the percent of total diabetes
cases that were diagnosed among individuals with BMI < 35.
Therefore, the association between obesity and diabetes could be
potentially overestimated because of a higher awareness and
detection of diabetes among obese individuals. Each observation
in the NIS is a hospital discharge record rather than a patient.
The patient identifier was not available in the NIS data and some
patients may have had more than one episode of hospitalization.
Multiple hospitalizations are common among patients with dia-
betes [28]. Because all hospital admissions are subject to resource
utilization, the inclusion of multiple hospitalizations is not a
limitation to our main objective of study. However, we could not
describe the characteristics of patients with diabetes who were
repeatedly admitted.

NIS is hospital administrative data which does not include the
body measurements of patients. If available, to reduce a potential
classification bias, BMI would be ideal measurement in identify-
ing obesity. A study has reported an undercoding of obesity in
medical records [29]. If physicians failed to note the obesity or
morbid obesity of patients’ conditions, then the incremental hos-
pital charges of those patients compared with nonobese patients
could be even larger because higher hospital charges of obese
patients may be counted as nonobese patients. Therefore, the
study results we presented should be understood as a “minimum
difference” in hospital charges among different levels of obesity.

**Conclusions**

Obesity has a sizeable economic burden and it is a well estab-
lished risk factor for diabetes. In this study, obesity has been
shown to be a risk factor for both type 1 and type 2 diabetes
inpatients. Patients with diabetes were considerably more likely
to be obese or morbidly obese compared with those inpatients
without diabetes. Additionally, this study found that obesity and
morbid obesity is a risk factor for increased hospital resource
consumption regardless of their types or presence of diabetes and
other characteristics such as sex, age, race, hospital admission
type, or length of hospital stay. Particularly, the hospital charges
among morbidly obese inpatients were considerably higher
compared with their counterparts. Because of high levels of hospital resource consumption, the rapidly increasing prevalence of morbid obesity among inpatients is likely to be a burden to hospital finance systems.

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