Length of Hospital Stays Among Obese Individuals

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Although prevalence rates of obesity have reached epidemic proportions in the United States, the relationship between obesity and health care use has received very little attention.[1,2] An even smaller body of literature has focused on use of hospital care among obese individuals. Obesity has been strongly associated with a range of health problems; however, studies that have examined the association between obesity and hospitalization have failed to provide consistent results. Some of these studies have revealed elevated risks of hospitalization associated with obesity,[3,4] others have shown no association[5–7] or even a decreased risk,[8,9] and still others have shown a gender-specific[10] or age-specific[8] relationship. In most of these studies, data on weight and hospital use were collected concurrently, and in some, information regarding weight was actually collected after information regarding hospitalizations.[3–5,7–10]

In addressing factors that are part of the causal pathway between obesity and hospitalization, prospective studies have included assessments of data on health conditions.[6,8] Statistical control of such health conditions (e.g., type II diabetes) constitutes overadjustment[11]; studies including health conditions in their analyses have shown no effect of obesity, leading to the erroneous inference that obesity is not an important risk factor for hospitalization.[6,8]

Our objective in this study was to estimate, by means of a longitudinal analysis, lengths of hospital stay among individuals categorized according to their weight status. Our data were derived from the First National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Followup Survey (NHEFS).

METHODS

Survey Description

The baseline for the NHEFS was NHANES I, conducted between 1971 and 1975.[12] In NHANES I, data were collected from a national probability sample of the United States

Objectives. We examined lengths of hospital stay among individuals categorized according to weight status.

Methods. We used data from the First National Health and Nutrition Examination Survey Epidemiologic Followup Survey to estimate length-of-stay differences.

Results. Individuals with body mass indexes (BMIs) of 35 kg/m^2 or above, those with BMIs of 30 to 34 kg/m^2, and those with BMIs of 25 to 29 kg/m^2 had crude length-of-stay rates greater than those of normal-weight individuals. Association between BMI and length of stay varied over time.

Conclusions. Obese individuals experience longer hospital stays than normal-weight individuals. (*Am J Public Health.* 2004;94:1587–1591)

civilian noninstitutionalized population, and the survey included a standardized medical examination and questionnaires covering various health-related topics. The NHEFS cohort consisted of 14 407 individuals who were aged 25 years or older at their baseline interview. A series of 4 follow-up surveys was conducted during 1982 through 1984 and in 1986, 1987, and 1992.

Body Mass Index Measurement

Respondents' weight status was classified according to National Heart, Lung and Blood Institute (NHLBI) criteria. Body mass indexes (BMIs; weight in kilograms divided by height in meters squared) were calculated at baseline and categorized as follows: less than 18.5 kg/m^2, 18.5 to 24.9 kg/m^2, 25.0 to 29.9 kg/m^2, 30.0 to 34.9 kg/m^2, and 35 kg/m^2 or above (as described in the NHLBI guidelines).[13] Respondents with a BMI of 18.5 to 24.9 kg/m^2 were the reference group in the analysis. Women who were pregnant at baseline were excluded (n=124).

Hospitalizations

Number of inpatient hospitalization days was the outcome measure of interest. Respondents reported hospital admissions that occurred between their baseline and final interviews. Reports of hospital stays were elicited through a series of questions in the NHEFS interviews. Respondents were asked to report the dates of all overnight facility stays since their most recent interview. With respondents' permission, all reported facilities were

contacted by mail and asked to abstract information from respondents' medical records. We included all hospitalizations for which there were abstracted data, representing 77% of all stays reported in the NHEFS.

Previous studies have evaluated the use of abstract-matched stays versus all stays in analyses of hospitalization risk and concluded that the bias from use of only the former is minimal.[6,14,15] We used only abstracted data for our analysis because information regarding inpatient days was available only from these data. After hospitalizations related to pregnancy and birth (n=809) had been excluded, 29 471 hospitalizations, representing a total of 263 961 inpatient days, were available for analysis.

Statistical Analysis

Longitudinal models, specifically generalized estimating equations,[16,17] were used to explore the association between BMI and length of stay. This technique was used to account for the within-subject correlation among a respondent's repeated observations. Because our outcome of interest, inpatient days, was a count, we assumed a Poisson distribution for the number of inpatient days. We used the exchangeable correlation structure for our working correlation matrix. We obtained rate ratios and 95% confidence intervals by comparing the healthy BMI category (18.5 to 24.9 kg/m^2) for the period 1971 through 1975 and all other BMI categories for all other periods.

Follow-up periods were divided into 4 intervals: 1971 to 1975, 1976 to 1980, 1981 to

1985, and 1986 to 1992. Person-years were calculated for each participant at each interval, and inpatient days were aggregated for each participant within each of the 4 intervals.

On the basis of the conceptual model developed by Andersen and others, which categorizes factors affecting health care utilization, we included age, gender, race, marital status, whether respondents had children, smoking status, socioeconomic status (i.e., poverty status), region of residence, and urban-rural residence in our models.[18–20] With the exception of smoking status and whether respondents had children, we used baseline values for these covariates. Because data on smoking status and presence of children were not collected at baseline, they were derived from the portion of the survey conducted during 1982 through 1984.

Interactions between BMI categories and time intervals were assessed to examine baseline differences among respondents. Also, through the use of interaction terms (in models not imputing income data), we investigated whether the association between overweight or obesity and length of stay varied according to race, smoking status, or region of residence. To evaluate models fitted with interaction terms, we computed Wald tests and used a significance level of $P < .1$.

We analyzed the NHEFS as a cohort study, and we present results from analyses that did not incorporate weights or sample design corrections. (As have other authors, we found that analyses incorporating weights and survey design corrections and analyses not incorporating these features produced similar results.[21])

Missing Covariates

Several authors have recommended the use of multiple imputation to deal with missing covariates; here we used this method to replace missing data on socioeconomic status (poverty status) for 24% of the sample.[22–26] Previous research indicates that income is an important determinant of health care use,[18–20,27] and socioeconomic status has been linked to obesity.[28] In addition, income and health insurance status have been closely linked, and the NHEFS did not provide complete information on insurance coverage.[29]

TABLE 1—Percentage Distribution of Baseline Characteristics According to Body Mass Index Category: First National Health and Nutrition Examination Survey Epidemiologic Follow-up Survey (N = 11 556), 1971–1992

| Characteristic | Body Mass Index (kg/m^2) | | | | |
	< 18.5 (n = 376)	18.5 to < 25.0 (n = 5430)	25.0 to < 30.0 (n = 3809)	30.0 to < 35 (n = 1368)	≥ 35 (n = 573)
Aged ≥ 65 y	20	23	30	30	24
Black	16	10	13	20	26
Female	75	65	48	65	81
Married	70	77	79	74	67
Has children[a]	83	85	86	86	82
Completed high school or beyond	54	62	53	43	43
Smoking status[a]					
Current	56	40	34	26	26
Former	9	14	20	15	15
Never	36	46	47	60	59
Urban residence	63	63	62	58	60
Region					
Northeast	18	22	23	21	22
Midwest	24	25	26	26	28
South	34	27	25	29	28
West	24	27	26	23	22
Physical activity level[b]					
Very active	51	52	47	43	31
Moderately active	40	42	45	48	51
Quite inactive	10	6	8	10	18

Note. Percentages may not sum to 100% owing to rounding.
[a]Information on presence of children and smoking status was obtained from the 1982–1984 survey.
[b]Physical activity level was based on 2 questions asked at baseline about recreational activity and usual activity. Subjects were classified as quite inactive if they reported being the least active for both questions, very active if they reported being very active for either response, and moderately active for all other combinations.

Participants with missing data on a variety of variables other than income were dropped from the analyses (19%). After exclusion of those who did not complete follow-up interviews and those with incomplete data (other than income), the final analytic sample included 11 556 respondents. SAS Version 8.2 (SAS Institute Inc, Cary, NC) was used in conducting all analyses. PROC GENMOD was used to calculate generalized estimating equations, and PROC MI and PROC MIANALYZE were used to carry out multiple imputation.

RESULTS

Table 1 shows baseline characteristics of the analytic sample according to BMI category. In comparison with other groups, higher percentages of Black, female, inactive, and single individuals were categorized in the 35 kg/m^2 or above BMI group. Lower percentages of high school graduates and higher percentages of never smokers were classified in the 30 to 34.9 kg/m^2 and 35 kg/m^2 and above BMI groups.

We also compared respondents reinterviewed at a subsequent wave with respondents lost to follow-up. White respondents accounted for 86% of those reinterviewed and 75% of those lost to follow-up; married respondents accounted for 76% of those reinterviewed and 61% of those lost to follow-up; respondents at an educational level of high school or above accounted for 55% of those reinterviewed and 44% of those lost to follow-up; and rural residents accounted for 37% of those reinterviewed and 18% of those lost to follow-up. In the case of other baseline variables—BMI, age, sex, and region—percentage distributions of those reinterviewed and those
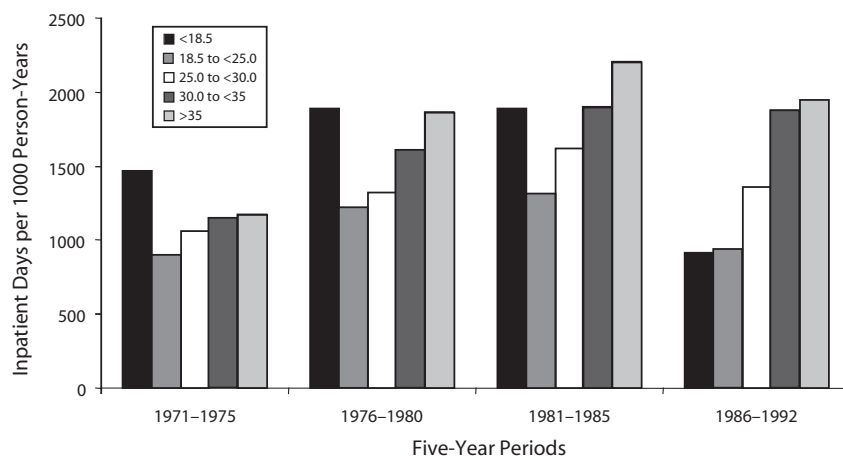
FIGURE 1—Lengths of stay (per 1000 person-years) among individuals classified by body mass index category according to National Heart, Lung and Blood Institute criteria: 1971–1992.

TABLE 2—Length of Stay Rate Ratios and 95% Confidence Intervals: First National Health and Nutrition Examination Survey Epidemiologic Follow-up Survey, 1971–1992

Body Mass Index (kg/m²)	Rate Ratio (95% Confidence Interval)			
	1971–1975	1976–1980	1981–1985	1986–1992
< 18.5	1.94 (1.22, 3.09)	2.21 (1.47, 3.33)	2.17 (1.34, 3.52)	1.01 (0.61, 1.68)
18.5 to < 25.0	1.00	1.47 (1.06, 2.02)	1.61 (1.23, 2.12)	1.09 (0.82, 1.45)
25.0 to < 30.0	1.25 (0.93, 1.67)	1.60 (1.20, 2.12)	1.89 (1.42, 2.51)	1.36 (1.03, 1.79)
30.0 to < 35	1.45 (1.06, 1.98)	1.94 (1.45, 2.61)	2.11 (1.59, 2.81)	1.60 (1.19, 2.16)
≥ 35	1.54 (1.02, 2.31)	2.18 (1.62, 2.91)	2.80 (2.07, 3.78)	2.31 (1.68, 3.18)

Note. Results shown are from a generalized estimating equation model with a Poisson distribution. The model includes Body Mass Index × Time interaction terms. Values were adjusted for age, gender, race, marital status, presence of children, education, height, smoking status, region, urban–rural residence, socioeconomic status (i.e., poverty status), and physical activity level.

lost to follow-up were comparable (differences of 5% or less).

Crude rates of inpatient hospital days for each BMI category are presented in Figure 1. Participants with normal BMIs exhibited the lowest rates in terms of length of stay during 1971 through 1975. In each subsequent period, lengths of stay increased as respondents' adiposity increased. Underweight respondents initially exhibited higher rates but leveled off and actually declined between 1986 and 1992.

Rate ratios for inpatient hospital days are presented in Table 2. Interaction terms between BMI categories and race, smoking status, and region were not significant, indicating that the effect of BMI did not vary according to these characteristics. However, interactions between BMI categories and time period were significant, and thus we present rate ratios for each period.

In the 1971 to 1975 period and thereafter, respondents with BMIs of 30 to 34.9 kg/m² and those with BMIs of 35 kg/m² or above exhibited lengths of stay greater than those observed among normal-weight respondents between 1971 and 1975. In comparison with 1971 to 1975, lengths of stay showed increases among normal-weight respondents during 1976 to 1980 and 1981 to 1985 but decreases between 1986 and 1992. Overweight respondents exhibited rates similar to those observed among normal-weight respondents during 1971 to 1975 but exhibited greater rates thereafter.

With the exception of the final follow-up period (1986–1992), underweight respondents exhibited longer lengths of stay than did normal-weight respondents in the 1971 to 1975 interval. During this final period, respondents with BMIs of 30 to 34.9 kg/m², those with BMIs of 35 kg/m² or above, and those who were overweight continued to exhibit increased lengths of stay (131%, 60%, and 36% higher rates, respectively) than did normal-weight respondents in the baseline period.

DISCUSSION

To our knowledge, this is the first longitudinal study to demonstrate a time trend in associations between weight status and length of stay. We found increases in length of stay among obese individuals throughout the study period and increases among those at BMI levels below 18.5 kg/m² for 3 of the 4 follow-ups. These results suggest a U- or J-shaped relationship between BMI and length of stay because the extreme values of BMI, underweight and obesity, exhibited greater lengths of stays while normal-weight exhibited the shortest length of stay. Previous studies have shown that such a relationship exists between BMI and mortality[30–32] and between BMI and probability of health care expenditures.[33] It is likely that illness-induced weight loss contributed to the elevated risk observed here among individuals with BMIs below 18.5 kg/m².

An advantage of the long follow-up associated with the NHEFS is that we were able to incorporate time trends. A secular trend in length of stay has been previously noted.[34,35] In the present case, the secular trend in length of stay was pronounced among underweight individuals; however, the decline in inpatient days during the 1986 to 1992 period appears not to have been an artifact of sample size: there were approximately 200 hospitalizations among almost 300 underweight respondents during this period.

The analytic approaches used in this study support establishing weight status as a causal factor in the association examined here. Most

of the previous research examining the association between weight status and lengths of hospital stay has been based on cross-sectional designs; however, cross-sectional studies cannot provide evidence regarding the temporal sequence of an association. In the present longitudinal investigation, we measured individuals' hospital use patterns subsequent to measurement of their weight.

We did not control for health conditions in our analyses. As mentioned earlier, because conditions such as type II diabetes are part of the causal pathway between obesity and hospitalization, it is inappropriate to statistically control for these diseases in estimating associations between BMI and health service use. However, on the basis of the model developed by Andersen, we included a large number of covariates that need to be considered in explorations of the effect of weight status on health service use.[19,20,27] For example, we included smoking status, often cited as a confounding factor in associations between underweight status and outcomes such as mortality.[36] We found an association between underweight and hospitalization in models that included smoking status.

Using the NHLBI criteria, we demonstrated that as respondents' adiposity levels (measured via BMI groupings) increased from the normal range, so did their number of inpatient hospital days. This dose–response relationship further supports weight status as a causal factor in the relationship studied here.[11] Another important aspect of the present weight status values is that they were based on precisely measured weight and height data. Researchers have noted that self-reported BMIs exhibit a characteristic pattern of error.[37]

We were able to examine effects of obesity on hospitalization only among Blacks and Whites. Further research is needed to determine whether relationships exist among other racial/ethnic groups. Another drawback involved with our cohort was loss to follow-up, and, because we did not have detailed information on reasons for dropout, we were unable to determine whether any biases existed in our results. A further limitation of the present study is that we examined weight at only 1 point in time.

In addition, because appropriate data were not available, we did not examine fat distribution, which is an important predictor of morbidity and mortality[38] and thus also may play a role in the BMI–hospitalization relationship. Although we did not control for health insurance coverage (since the NHEFS does not include complete health insurance or Medicaid information), we did include income level, which has been closely linked to health insurance status.[29]

Finally, our estimates were based on obesity prevalence rate data from the early 1970s, and rates have increased considerably since that period in every US state; in both genders; and across all age groups, races, educational levels, and categories of tobacco use.[39–41] These increases in obesity have the potential to severely tax the health care system, particularly given our results indicating that obese individuals have longer hospital stays. In all likelihood, treatment and prevention of obesity will reduce use of hospital care and the subsequent health care costs associated with the obesity epidemic. ∎

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