Obesity Affects Nursing-Care Facility Admission among Whites but Not Blacks

Claire A. Zizza, Amy Herring,† June Stevens,*‡ and Barry M. Popkin*§*

Abstract

ZIZZA, CLAIRE A., AMY HERRING, JUNE STEVENS, AND BARRY M. POPKIN. Obesity affects nursing-care facility admission among whites but not blacks. *Obes Res.* 2002;10:816–823.

Objective: This study examines whether obese individuals have a greater rate of nursing care facility admission than normal weight individuals.

Research Methods and Procedures: Data from the National Health and Nutrition Examination Survey Epidemiological Follow-up Survey were analyzed. Cox proportional hazards models were used to examine the relationship between baseline weight status and subsequent time to first nursing home admission while adjusting for sex, age, race, marital status, height, presence of children, smoking status, education, region, urban residence, income, and physical activity.

Results: Of 5960 adults 45 to 74 years old, 989 individuals were admitted to a nursing care facility over the subsequent 20 years. Body mass index (BMI) was studied using five categories: < 18.5, 18.5 to <25, 25.0 to <30, 30.0 to <35, ≥ 35 kg/m^2. The effects of BMI differed by race: compared with those with a BMI of 18.5 to < 25 kg/m^2, adults with a BMI ≥ 30 kg/m^2 or a BMI <18.5 kg/m^2 had a greater rate of nursing home admission in whites, whereas no relationship was found in blacks. The inclusion of time to death with nursing home admission as a joint outcome yielded similar results.

Discussion: The large increase in the prevalence of obesity coupled with the rapid expansion of the number of older Americans will likely increase the demand for nursing facility use. More research is needed to understand differences in factors related to nursing home admission among ethnic groups.

Key words: health care utilization, older adults, weight status

Introduction

Many studies have examined determinants of functional decline, mobility maintenance, and active life expectancy; however, very few have included the influence of body weight (1). Among studies that have included obesity the findings have been inconsistent because measurement issues, sample size, and timing of data collection have varied across studies. Some studies found that obesity is related to impaired function (2–5), whereas others (6,7) found no relationship. Ferraro and Booth (1) found that both underweight and obese individuals exhibited more functional impairment than did normal weight individuals, particularly in younger and middle-aged individuals. Although some researchers have noted this association between obesity and functional status, we know of no studies that examined the long-term effect of obesity on use of nursing care facilities. This study examines the role of obesity in nursing home admissions.

Measures of function describe a syndrome rather than one or more specific diseases. The literature has linked obesity with a series of comorbidities, each of which may affect functioning. Obesity is associated with hypertension, coronary artery disease, type 2 diabetes, and osteoarthritis (8). Furthermore, there is evidence showing that hypertension, stroke or transient ischemic attacks, type 2 diabetes, and osteoarthritis are conditions associated with subsequent functional status decline (9). Heart disease and stroke often create a variety of functional impairments, such as partial paralysis or loss of stamina (10). Excessive weight may promote insulin resistance and hyperglycemia that consequently promote glycation of proteins and DNA in soft connective tissue (11–14). These changes are often associated with inflammatory responses in the connective tissue of the joints and arteries leading to functional impairment

Received for review November 14, 2001.
Accepted for publication in final form May 15, 2002.
Departments of *Nutrition, †Biostatistics, and ‡ Epidemiology, School of Public Health, University of North Carolina; and the §Carolina Population Center, University of North Carolina, Chapel Hill, North Carolina.
Address correspondence to Dr. Barry M. Popkin, Carolina Population Center, University of North Carolina at Chapel Hill, CB 8120 University Square, 123 West Franklin Street, Chapel Hill, NC 27516-3997.
E-mail: popkin@unc.edu

(15,16). In addition, diabetes increases the risk of hypertension and coronary artery disease. Excessive weight may add physical stress to the skeleton and weight bearing joints, increasing the likelihood of osteoarthritis and impaired functioning (17). Although chronic diseases have an important impact on functional status, not all persons with a particular disease exhibit functional impairment (18). In addition, daily functioning and quality of life may be severely diminished in obese individuals without having an impact on the incidence of specific diseases (19).

The consequences of obesity are numerous and diverse, and, thus, estimating the total impact of obesity is challenging. The link between the biological and behavioral consequences of obesity has not been thoroughly examined and may not be as direct as commonly assumed. For example, obesity particularly in women may act as a barrier to health-seeking behavior, particularly preventive health care (20–21). For other types of care measures, such as hospitalizations, medical visits, and medical costs, the majority of studies have found obesity linked to greater use of medical services (22). Black et al. (23) found the probability of health care expenditure was significantly greater for adults with high as well as low body mass indexes (BMIs) when accounting for previous expenditures. One study that followed an elderly (60 to 94 years old) Canadian cohort for 3 to 5 years found weight loss ($\geq$5 kg) but not BMI to be associated with nursing home admissions (24). We know of no research regarding the long-term effect of obesity on the use of nursing care facilities. This article examines the effect of weight status on time to nursing care facility admission in the National Health and Nutrition Examination Survey I (NHANES I) Epidemiological Follow-up Survey (NHEFS).

Research Methods and Procedures

The NHEFS is a longitudinal study that uses as its baseline adults ages 25 to 74 years who were examined in NHANES I. NHANES I collected data from a national probability sample of the U.S. civilian noninstitutionalized population between the ages of 1 and 74 years. The survey, which included a standardized medical examination and questionnaires that covered various health-related topics, took place from 1971 through 1974 and was augmented by an additional national sample in 1974–1975.

The NHEFS is comprised of a series of four follow-up surveys. The first wave of data collection (1982–1984 NHEFS) included all persons who were between 25 and 74 years old at their NHANES I examination. The second wave of data collection (1986 NHEFS) was conducted for members of the NHEFS cohort who were 55 to 74 years old at their baseline examination. The third and fourth waves of data collection (1987 and 1992 NHEFS) were conducted for the entire NHEFS cohort. For this analysis, subjects 45 years and older at baseline were included.

BMI Measurement

In NHANES I, subjects were measured in disposable paper examination gowns and foam rubber slippers, using a Toledo self-balancing scale. We calculated subjects' BMI (kg/m^2) at baseline and categorized it as: $<$18.5, 18.5 to $<$25, 25.0 to $<$30, 30.0 to $<$35, and $\geq$35 kg/m^2 in accordance with the Expert Panel (8). Subjects with a BMI of 18.5 to 24.9 kg/m^2 are the reference group in the modeling.

Nursing Home Admissions

The outcome of interest is the date of the first occurrence of nursing home admission. Discharges back to the community are relatively rare (25,26). For the NHEFS, reports of nursing home facility stays were usually elicited through a series of questions in the interview. Respondents were asked to report the date of all overnight facility stays since they were last surveyed and, thus, time in this analysis can be viewed as continuous. With the respondents' permission, all reported facilities were contacted by mail and asked to abstract information (subsequently referred to as abstract data) from the respondents' medical records on the exact dates of admission.

There were 1092 admissions with complete abstract dates (month, day, and year). Admissions without abstract data were included when there was complete self-reported date information (n = 62). The inclusion of self-reported admissions did not change the hazard ratios for any of the BMI categories.

Mortality

There is some evidence in the literature that blacks might have lower rates of nursing home admissions than whites (10). Thus, we also studied time to death and time to the joint outcome of nursing care facility admission or death. NHEFS collected mortality data throughout the follow-up surveys, 1982–1984, 1986, 1987, and 1992. Deaths were confirmed by a death certificate or proxy interview.

Other Variables

Andersen developed a conceptual framework to study the use of health services among the elderly, which is commonly used (27). Andersen's model and previous research provided the rationale for including other independent variables in the models: age, sex, marital status, education, race, height, region of residence, and urban/rural residence (24,28–33). Racial status was determined by observation; however, if race status was not discernible by the interviewer, the respondent was asked. For this analysis, marital status was defined as married or not married at baseline. Not married included respondents who were widowed, never married, divorced, or separated. Level of education was defined as less than a high school degree or greater than or equal to a high school degree. Region was determined by dividing the United States into four broad geographic re-

gions of approximately equal population and this deviated somewhat from the groups used by the U.S. Bureau of Census (34). For the NHANES I survey, Texas, Oklahoma, Kansas, Nebraska, North Dakota, and South Dakota are considered the West. The Bureau of Census includes Texas and Oklahoma in the South and Kansas, Nebraska, North Dakota, and South Dakota in the Midwest (35). The Midwest region was formerly labeled the North Central region by the Bureau of Census before 1984. Urban areas included areas with populations of 2500 or more. Information on smoking status and the presence of children were obtained from the 1982–1984 survey because these data were not collected for the entire cohort at baseline. Smoking status was defined as current, former, and never.

The baseline survey questions on physical activity were: 1) Do you get much exercise in things you do for recreation (sports or biking or anything like that), or hardly any exercise, or in between?; and 2) In your usual day aside from recreation, are you physically very active, moderately active, or quite inactive? We combined these two questions into one measure with subjects classified as: 1) inactive if they reported being the least active in both questions, 2) very active if they reported being very active for either response, and 3) moderately active for all other combinations. Because BMI and physical activity were both measured at baseline, we are unable to determine the temporal nature of the relationship. However, the coefficients for obesity were not changed by the addition of physical activity and, thus, we present only the results from the models including both terms.

The presence of diseases states, such as hypertension, coronary artery disease, type 2 diabetes, and osteoarthritis, were not included in these models because these states represent potential mediators of obesity and its relationship to nursing care facility admissions (36). That is, these diseases most likely represent intermediate steps in the causal pathway between obesity and nursing care facility admissions.

The degree of association between BMI and fat and fat-free mass is influenced by other factors such as age and sex (37). Using interaction terms, the analysis investigated effect measure modification by sex, education, age, and racial status.

Lost to follow-up and missing values were examined in a number of ways. At the baseline survey, there were 7957 participants 45 years of age and older and of these 7953 had weight and height information available. Of the 7957, 101 participants were lost to follow-up. Baseline BMI of those followed and those lost to follow-up did not differ significantly. In addition, nursing home admission did not predict missing BMI values. Thus, the results from this study seem not to be biased.

Multiple imputation was used to replace missing values for the percentage of poverty in ~25% of the sample (38,39) (Proc Mi and Proc Mianalyze; SAS Institute, Cary, NC). Previous research indicates that income could be an important determinant of health care use (28–33) and socioeconomic status has been linked to obesity (40). Subjects with missing data in variables other than income were excluded from the analyses. When accounting for the availability of all the variables of the analyses (excluding income), there were 989 admissions from a total sample of 6270 subjects.

Statistical Analysis

Nursing care facility admission rates were age-adjusted based on 5-year age groupings by using a STATA Direct procedure (Dstdize; Stata Corporation, College Station, TX). Data were analyzed using Cox proportional hazards models (41) (Proc PHREG; SAS Institute). We used Cox proportional hazards models because we are more interested in the underlying time process rather than the probability or frequency of nursing home admission. In addition, Cox proportional hazards models can account for the varying lengths of follow-up time in the NHEFS. Because logistic results have been shown to produce biased estimates with the NHEFS, the Cox proportional hazards model has been determined to be a more appropriate method than logistic modeling for this data set (42).

The time frame for this analysis was the number of years from the baseline survey to nursing care facility admission. Subjects not admitted to a nursing care facility were censored at the date of their last follow-up survey. We also examined the time until death and time until either admission or death. All of the models included categorized BMI variables as the main exposure and age, sex, marital status, education, race status, height, region of residence, urban/rural residence, smoking status, and the presence of children as covariates.

Assumptions of proportionality were assessed with log-log survival plots and the assumptions appeared to be satisfied. We analyzed the NHEFS as a cohort study and did not incorporate sampling weights because the subsequent follow-up waves (1982–1984, 1986, 1987, and 1992) are not nationally representative samples. Our results do not include survey design corrections because research has shown that design corrections do not appreciably alter results from the NHEFS (42).

Results

Descriptive characteristics are presented in Table 1. In this sample, blacks were more likely to be elderly, single, childless, and an urban resident. Whites were more likely to have a high school degree. Blacks and whites differed in proportions of smokers, region of residence, and activity levels. Regarding nursing care facility admissions, 17% of the sample were admitted. Interaction terms of BMI and racial status were significant ($p < 0.05$) for nursing care

Table 1. Percentage distribution of characteristics of the National Health and Nutrition Examination Survey Epidemiological Follow-up Survey participants 45 years and older at baseline ($n = 6270$)*

	White $n = 5447$	Black $n = 823$
Age, years†		
45–64	55	50
65–75	45	50
Sex†		
Female	54	57
Marital status†		
Married	75	60
Children†§		
Yes	82	74
High school†‡		
Yes	46	18
Smoking status†§		
Current	30	28
Former	20	13
Never	50	59
Urban residence†		
Urban	59	73
Region†		
Northeast	23	13
Midwest	24	20
South	25	51
West	28	17
Activity†		
Very active	44	41
Moderately active	48	45
Quite inactive	8	13

* Proportions between blacks and whites were tested with χ^2 tests.
† Statistical significance at $p \leq 0.05$.
‡ Level of education was defined high school graduate or more.
§ Information on smoking status and presence of children were obtained from the 1982–1984 survey.

facility admissions, whereas interaction terms of sex, education, and age with BMI were not.

Table 2 shows the age standardized rates of nursing care facility admissions in whites and blacks. The overall rate of nursing care facility admission was greater in whites but the 95% confidence interval (CI) for blacks was large and overlapped the white estimate. In whites, those in the 18.5 to 24.9 kg/m^2 BMI category had the lowest rate but the 95% CI overlapped those groups with a BMI between 25 and <30 kg/m^2 and a BMI between 30 and <35 kg/m^2. The 95% CI of the 18.5 to 24.9 kg/m^2 group did not overlap that of the group with a BMI ≥ 35 kg/m^2. All of the rates for blacks overlapped. Most of the BMI-specific admission rates for whites appeared elevated compared with blacks, but the black estimates had large CIs. It is important to note that the number of adjusted admissions for blacks in the lowest and highest BMI categories was very small, potentially hindering our ability to detect significant differences.

Among white subjects, BMI was not associated with nursing care facility admissions in a linear manner (Table 3). Underweight subjects (BMI <18.5 kg/m^2) were at the greatest relative risk followed by those with a BMI ≥ 35 kg/m^2. Those with a BMI between 30.0 and <35 kg/m^2 had a significantly increased relative risk; however, those with a BMI between 25.0 and <30.0 kg/m^2 did not show an increased relative risk of nursing home admission. The relationships between BMI and mortality and BMI and the joint outcome showed the same trend as the BMI–nursing care facility admission relationship. Thus, the inclusion of death did not change the hazard ratios for whites.

Among blacks, there was no significant increased relative risk between BMI and time to nursing facility admission (Table 3). Although most of the coefficients were not significant for blacks, the sign of the coefficients indicated a protective effect of obesity. There were no significant relationships between BMI and mortality except for among underweight blacks. The hazard ratios for the time until death only indicated a trend toward increased relative risk for those with a BMI ≥ 35 kg/m^2 and that trend was not significant (hazard ratio = 1.05, 95% CI: 0.72,1.53). Including death as an outcome with admission also showed no significant associations with obesity but did show a significant association with underweight (BMI < 18.5 kg/m^2; hazard ratio = 3.09, 95% CI: 1.81,5.27).

Discussion

As medical care costs continue to rise, the prevention of expensive components, such as time in nursing care facilities represents an important dimension for research. To date little research has explored how obesity influences nursing home use. This study is the first to find an association between obesity and nursing home admissions. Using longitudinal data derived from a nationally representative sample, we showed that obesity, particularly a BMI above 35 kg/m^2, increased the relative risk of nursing home admissions considerably for white adults. These results indicate, as Heymsfield et al. (37) hypothesized, that the association between BMI and outcomes is nonlinear. For example, many studies showed that a U- or J-shaped relationship exists between BMI and mortality (43–45) or the probability of health care expenditures (23). The increased mortality in individuals with lower BMIs may be due to confounding by preexisting illness and/or smoking (46). We found a similar relationship among whites; both obese and under-

Table 2. Age-adjusted rates* (95% confidence intervals) of nursing care facility admission by race in the National Health and Nutrition Examination Survey Epidemiological Follow-up Survey (NHEFS) participants 45 years and older at baseline

	Whites			Blacks		
Body mass index category, kg/m^2	**Unadjusted admissions**	**Person-years**	**Adjusted rates (per 1000 person-years)**	**Unadjusted admissions**	**Person-years**	**Adjusted rates (per 1000 person-years)**
<18.5	34	2263	14.67 (9.71, 19.62)	5	407	9.53 (1.12, 17.93)
18.5 to <25.0	384	38,965	10.40 (9.37, 11.44)	60	4898	11.84 (8.82, 14.87)
25.0 to <30.0	386	35,464	11.12 (10.02, 12.22)	49	5031	9.14 (6.52, 11.69)
30.0 to <35	152	11,698	12.99 (10.94, 15.04)	23	2608	9.45 (5.58, 13.31)
≥35	47	3,377	16.62 (11.80, 21.44)	13	1448	9.44 (4.26, 14.62)
Overall	969	91,767	11.35 (10.66, 12.05)	150	14,392	10.10 (8.59, 11.70)

* Age-standardized by the direct method, with the person-year distribution in 5-year baseline age strata of the entire NHEFS sample 45 years of age and older.

weight adults are at greater relative risk of nursing home admissions. We also found that as the level of obesity increased, the relative risk of admission increased in a dose–response manner, which provides additional evidence for the existence of an association with obesity.

The NHEFS data provide several important advantages. The NHEFS contains high quality data in that the weight and height data are precisely measured and a majority of the dates of admission are from medical abstracts. Another advantage is the 20 years of follow-up in this dataset. Having such a long follow-up allows the investigation of an outcome of nursing care facility admissions. In addition, the analysis controlled for a large number of variables that are important covariates when exploring the effect of obesity on health and health service use (46–48).

A key finding was the different effects of obesity on nursing care facility admission for blacks and whites. Blacks did not exhibit the same relative risk of nursing care facility admission as whites. We were also unable to adequately explain the relationship between nursing home admission and obesity in blacks by including death as a joint outcome. From our joint analysis, it appears that obese blacks are not dying before they are able to enter a nursing home. The unexpected relationship in blacks may reflect socioeconomic or behavioral factors that we could not control for, such as different health insurance or Medicaid

Table 3. Hazard ratios (95% confidence intervals) for nursing care facility admission, mortality, and joint outcome in the National Health and Nutrition Examination Survey Epidemiological Follow-up Survey participants 45 years and older at baseline ($n = 6270$)*

	Hazard ratio in whites			Hazard ratio in blacks		
Body mass index category, kg/m^2	**Nursing care facility**	**Mortality**	**Joint outcome**	**Nursing care facility**	**Mortality**	**Joint outcome**
<18.5	2.15 (1.46, 3.15)	1.97 (1.57, 2.49)	1.96 (1.56, 2.46)	1.49 (0.46, 4.79)	3.20 (1.87, 5.48)	3.09 (1.81, 5.27)
18.5 to <25.0	1.00 (NA)	1.00 (NA)	1.00 (NA)	1.00 (NA)	1.00 (NA)	1.00 (NA)
25.0 to <30.0	1.09 (0.94, 1.27)	0.99 (0.91, 1.09)	1.02 (0.93, 1.11)	0.63 (0.41, 0.97)	0.85 (0.66, 1.08)	0.84 (0.65, 0.94)
30.0 to <35	1.31 (1.07, 1.61)	1.19 (1.05, 1.36)	1.21 (1.07, 1.37)	0.72 (0.43, 1.21)	0.97 (0.72, 1.30)	0.91 (0.68, 1.21)
≥35	1.69 (1.22, 2.34)	1.59 (1.30, 1.94)	1.52 (1.25, 1.85)	0.63 (0.32, 1.25)	1.05 (0.72, 1.53)	1.05 (0.74, 1.50)

NA indicates not applicable.

* Adjusted for age, sex, marital status, presence of children, education, race, height, smoking status, region of residence, urban-rural residence, income, and activity. Model includes interaction term of BMI and race.

resources, family support, biological responses, or other reasons. One obvious issue might be our inability to control for health insurance coverage for nursing home care. The NHEFS does not have complete health insurance or Medicaid information. In our modeling, we did include income, which is the basis for eligibility in the Medicaid program. Although we examined the presence of family members, particularly spouses and children, there may be other support networks that act differently for disabled black and white citizens.

In the context of health service disparities, several studies have examined the influence of racial status on nursing care facility use. Racial status has been hypothesized to work through one or more social processes, including culture, class, institutionalized discrimination, and geopolitical context (49). To elucidate the process through which race affects the use of nursing care facilities, researchers have examined caregiver burden (50), nursing home bed supply (32), social support, payment source for long-term care (51), and structure and provision of informal care (52). Regardless of all these factors, racial status is consistently a predictor of institutional long-term care.

Other researchers have shown that there are different effects of BMI on blacks and whites. For instance, Stevens et al. (53) found that the association of BMI with mortality was attenuated in blacks compared with whites and was not statistically significant. Others have shown that a relationship between BMI and mortality does exist in blacks; however, the BMI associated with the lowest mortality is slightly higher in blacks (54,55).

When evaluating this black and white difference in nursing home admissions, it is also important to consider the method we used. To create our hazard ratios, the hazard in obese individuals was divided by the hazard in the reference group. According to Stevens (45), it is important to examine both relative rates and rate differences when comparing groups because these two measures can show opposite trends when the risk in the reference categories of the groups are different. Finding a reduced risk or rate of obesity in blacks could be caused by a higher risk or rate in the black reference group. On inspecting the age-standardized admission rates, the rate estimate for the black reference group seems to be only slightly elevated compared with the rate estimate for the white reference group (10.40 vs. 11.84); however, an elevated rate is not evident in overweight and obese blacks. Therefore, a risk difference measure would most likely result in the same conclusion as our relative hazard ratio. Durazo-Arvizu et al. (54,55) showed that the BMI associated with the lowest mortality is slightly higher in blacks. According to the age-adjusted rates, the overweight black group did have the lowest admission rate. Thus, the reference for blacks, consequently, could be set at a higher BMI. However, race-specific guidelines have not been established. When examining the unadjusted nursing care facility admissions, sample size for blacks may be one possible reason for not finding a relationship in this group. The sample sizes for blacks were considerably smaller than for whites and, thus, the CIs for the estimates for blacks were considerably larger. This indicates a greater imprecision for the black estimates. However, the point estimates for blacks were very close to one and some actually indicated a protective effect. Finding the interaction term between race and BMI categories to be significant indicates that the relationship is different between blacks and whites.

A limitation of this study is that we only examined baseline weight status. A measurement of weight one point in time does not reflect one's lifetime exposure. This study is also limited by the lack of waist-to-hip ratio data to include information on fat patterning. Fat patterning is an important predictor of morbidity and mortality (53) and, thus, may also play a role in a nursing home admission–BMI relationship. An added limitation is that baseline data were collected between 1971 and 1975 and nursing home admissions were collected until 1993. During this timeframe, nursing home use rates and the prevalence of obesity were different (56,57). Research with more recent data is needed.

The prevalence of obesity in all age groups in the United States, including older Americans, has increased since these data were collected in the early 1970s. Thus, today this association between nursing care facility use and BMI may be even more relevant. For most individuals admission to a nursing care facility is not voluntary and institutionalization represents a poorer quality of life. In addition, nursing care facility use is an expensive medical cost. Therefore, efforts should be made to prevent the need for long-term care. Obesity treatment and prevention, which may represent modifying a risk factor for institutionalization, is necessary. Another area of concern is the race difference found in this study. Regarding nursing care facility admissions, blacks were significantly different from whites and obesity did not have a significant effect in blacks. More research is needed to understand differences in factors related to nursing care facility admission among races and ethnic groups.

Acknowledgments

Research support funded by NICHD/NIH (HD39183) and the University of North Carolina at Chapel Hill.

References

1. **Ferraro K, Booth T.** Age, body mass index, and functional illness. *J Geront B Psychol Sci Soc Sci.* 1999;54B:S339–S48.
2. **Ferraro K, Farmer M, Wybraniec J.** Health trajectories: Long-term dynamics among white and African Americans. *J Health Soc Behav.* 1997;38:38–54.
3. **Galanos A, Pieper C, Cornoni-Huntley J, Bales C, Fillenbaum G.** Nutrition and function: is there a relationship be-

tween body mass index and the functional capabilities of community-dwelling elderly? *J Am Geriatr Soc.* 1994;42: 368–73.
4. **Keil J, Gazes P, Sutherland S, Rust P, Branch L, Tyroler H.** Predictors of physical disability in elderly blacks and whites of the Charleston heart study. *J Clin Epidemiol.* 1989; 42:521–9.
5. **Launer L, Harris T, Rumpel C, Madans J.** Body mass index, weight change, and risk of mobility disability in middle-aged and older women: the epidemiologic follow-up study of NHANES I. *J Am Med Assoc.* 1994;271:1093–8.
6. **Kaplan G, Strawbridge W, Camacho T, Cohen R.** Factors associated with change in physical functioning in the elderly. *J Aging Health.* 1993;5:140–53.
7. **Lawrence R, Jette A.** Disentangling the disablement process. *J Geront B Psychol Sci Soc Sci.* 1996;51B:S173–S82.
8. **Expert Panel.** Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—the evidence report. *Obes Res.* 1998;6:51–63.
9. **Stuck A, Walthert J, Nikolaus T, Bula C, Hohmann C, Beck J.** Risk factors for functional status decline in community-living people: a systematic literature review. *Soc Sci Med.* 1999;48:445–69.
10. **Wallace S, Levy-Storms L, Kington R, Andersen R.** The persistence of race and ethnicity in the use of long-term care. *J Geront B Psychol Sci Soc Sci.* 1998;53B:S104–S12.
11. **Modan M, Halkin H, Lusky A, Segal P, Fuchs Z, Chetrit A.** Hyperinsulinemia is characterized by jointly distributed plasma VLDL, LDL and HDL levels: a population study. *Arteriosclerosis.* 1988;8:227–36.
12. **Pratley R, Coon P, Rogus E, Goldberg A.** Effects of weight loss on norepinephrine and insulin levels in obese older men. *Metabolism.* 1995;44:438–44.
13. **Reaven G.** Role of insulin resistance in human disease (Banting lecture). *Diabetes.* 1988;34:1595–607.
14. **Supiano M, Hogikyan R, Morrow L, et al.** Aging and insulin sensitivity: role of blood pressure and sympathetic nervous system activity. *J Gerontol A Biol Sci Med Sci.* 1993;48:M237–M43.
15. **Cerami A.** Geriatric bioscience hypotheses: glucose as a mediator of aging. *J Am Geriatr Soc.* 1985;33:626–34.
16. **Walford R, Harris S, Weindruch R.** Dietary restriction and aging: historical phases, mechanisms and current directions. *J Nutr.* 1987;117:626–34.
17. **Hart D, Spector T.** The relationship of obesity, fat distribution and osteoarthritis in women in the general population: the Chingford Study. *J Rheumatol.* 1993;20:331–5.
18. **National Research Council, Panel on a Research Agenda and New Data for an Aging World, Committee on Population and Committee on National Statistics, Division of Behavioral and Social Sciences and Education.** *Preparing for an Aging World: The Case for Cross-National Research*. Washington, DC: National Academy Press; 2001.
19. **Seidell J.** The impact of obesity on health status: some implications for health care costs. *Int J Obes Relat Metab Disord.* 1995;19:S13–S6.
20. **Fountaine K, Faith M, Allison D, Cheskin L.** Body weight and health care among women in the general population. *Arch Fam Med.* 1998;7:381–4.
21. **Olsen CL, Schumaker HD, Yawn BP.** Overweight women delay medical care. *Arch Fam Med.* 1994;3:888–92.
22. **Fountaine K, Barlett S.** Access and use of medical care among obese persons. *Obes Res.* 2000;8:403–6.
23. **Black D, Sciacca J, Coster D.** Extremes in body mass index: probability of healthcare expenditures. *Prev Med.* 1994;23: 385–93.
24. **Payette H, Coulombe C, Boutier B, Gray-Donald K.** Nutrition risk factors for institutionalization in a free-living functionally dependent elderly population. *J Clin Epidemiol.* 2000; 53:579–87.
25. **Cunningham P, Short P, Feinleib S.** Estimating nursing home episodes from a sample of discharges: the importance of adjusting for prior and subsequent stays. *Med Care.* 1995;33: 432–40.
26. **Sekscenki E.** *Discharges from Nursing Homes: 1985 National Nursing Home Survey. Vital and Health Statistics: Series 13 no. 103*. Hyattsville, MD: National Center for Health Statistics; 1990.
27. **Bass D, Noelder L.** The influence of family caregivers on elder's use of in-home services: an expanded conceptual model. *J Health Soc Behav.* 1987;28:184–96.
28. **Andersen R, Newman J.** Societal and individual determinants of medical care utilization in the United States. *Milbank Mem Fund Q.* 1973;51:95–124.
29. **Andersen R.** Revisiting the behavioral model and access to medical care. *J Health Soc Behav.* 1995;36:1–10.
30. **Holden K, McBride T, Perozek M.** Expectations of nursing home use in the Health and Retirement Study: the role of gender, health and family characteristics. *J Geront B Psychol Sci Soc Sci.* 1997;52B:S240–S51.
31. **Phillips KA, Morrison KR, Andersen R, Aday LA.** Understanding the context of healthcare utilization: assessing environmental and provider-related variables in the behavioral model of utilization. *Health Serv Res.* 1998;33:571–96.
32. **Greene V, Ondrich J.** Risk factors for nursing home admissions and exits: a discrete time-hazard function approach. *J Geront B Psychol Sci Soc Sci.* 1990;45:S250–S8.
33. **Aday LA, Andersen R.** A framework for the study of access to medical care. *Health Serv Res.* 1974;9:208–20.
34. **National Center for Health Statistics.** *Plan and Operation of the Health and Nutrition Examination Survey, United States, 1971–1973: Vital and Health Statistics Series1 no. 10a*. Washington, DC: National Center for Health Statistics; 1979.
35. **U.S. Bureau of the Census.** Census Regions and Divisions of the United States 2000. Available at: hhtp://www.census.gov/geo/www/us__regdiv.pdf. Accessed February 5, 2002.
36. **Rothman KSG.** *Modern Epidemiology*. Philadelphia, PA: Lippincott-Raven; 1998.
37. **Heymsfield SB, Allison DB, Wang ZM, Baumgartner RN, Ross R.** Evaluation of total and regional body composition. In: Bray GA, Bouchard C, James WPT, eds. *Handbook of Obesity*. New York, NY: Marcel Dekker, Inc.; 1998, pp. 41–78.
38. **Rubin D.** *Multiple Imputation for Nonresponse in Surveys*. New York, NY: John Wiley & Sons, Inc.; 1987.
39. **Horton N, Lipsitz S.** Multiple imputation in practice: comparison of software packages for regression models with missing variables. *Am Stat.* 2001;55:244–54.

40. **Sobal J.** Obesity and socioeconomic status: a framework for examining relationships between physical and social variables. *Med Anthropol.* 1991;13:231–47.
41. **Cox D.** Regression models and life-tables (with discussion). *J Roy Stat Soc B.* 1972;34:187–220.
42. **Ingram DD, Makuc DM.** *Statistical Issues in Analyzing the NHANES I Epidemiological Follow-up Study.* Hyattsville, MD: National Center for Health Statistics; 1994.
43. **Reubin A, Muller D, Sorkin J.** National Institutes of Health Technology Assessment Conference: long-term effects of change in body weight on all-cause mortality: a review. *Ann Intern Med.* 1993;119:737–43.
44. **Allison DB, Zannolli R, Narayan KMV.** The direct health care costs of obesity in the United States. *Am J Public Health.* 1999;89:1194–9.
45. **Stevens J.** Obesity and mortality in African-Americans. *Nutr Rev.* 2000;58:346–53.
46. **Manson JE, Stampfer MJ, Hennekens CH, Willet WD.** Body weight and longevity. *J Am Med Assoc.* 1987;257:353–8.
47. **Blair SN, Brodney.** Effects of physical inactivity and obesity on morbidity and mortality: current evidence and research issues. *Med Sci Sports Exerc.* 1999;31:S646–S62.
48. **Williamson D.** Descriptive epidemiology of body weight and weight change in U.S. adults. *Ann Intern Med.* 1993;119: 646–9.
49. **Wallace S.** Race versus class in the health care of African-American elderly. *Soc Probl.* 1990;37:517–43.
50. **McFall S, Miller B.** Caregiver burden and nursing home admissions of frail elderly persons. *J Geront B Psychol Sci Soc Sci.* 1992;47:S73–S9.
51. **Falcone D, Broyles R.** Access to long-term care: race as a barrier. *J Health Polit Polic.* 1994;19:583–95.
52. **Burton L, Kasper J, Shore A, et al.** The structure of informal care: are there differences by race? *Gerontologist.* 1995;35: 744–52.
53. **Stevens J, Plankey M, Williamson D, et al.** The body mass index-mortality relationship in white and African American women. *Obes Res.* 1998;6:268–77.
54. **Durazo-Arvizu R, McGee D, Cooper R, Liao Y, Luke A.** Establishing the nadir of the body mass index-mortality relationship: a case study. *J Am Stat.* 1997;92:1312–9.
55. **Durazo-Arvizu R, McGee D, Cooper R, Liao Y, Luke A.** Mortality and optimal body mass index in a sample of the US population. *Am J Epidemiol.* 1998;147:739–49.
56. **Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL.** Increasing prevalence of overweight among U.S. adults. *J Am Med Assoc.* 1994;272:205–11.
57. **Bishop C.** Where are the missing elders? The decline in nursing home use: 1985 and 1995. *Health Aff.* 1995;18:146–55.