OBES SURG (2010) 20:1354–1360
DOI 10.1007/s11695-009-0054-x

CLINICAL RESEARCH

Racial, Socioeconomic, and Rural–Urban Disparities in Obesity-Related Bariatric Surgery

Amy E. Wallace · Yinong Young-Xu · David Hartley · William B. Weeks

Received: 23 July 2009 / Accepted: 1 December 2009 / Published online: 6 January 2010

Abstract
Background Morbid obesity is associated with serious health and social consequences, high medical costs and is increasing in the USA, particularly among rural, socioeconomically disadvantaged populations. Bariatric surgery more often provides significant long-term weight loss than traditional weight loss treatments. We examined the likelihood of bariatric surgery among morbidly obese patients across rural/urban locales, racial/ethnic groups, insurance categories, socioeconomic, and comorbidity levels.
Methods We examined 159,116 records representing 774,000 patients with morbid obesity from the 2006 Nationwide Inpatient Sample. We determined the likelihood, expressed in odds ratios, of bariatric surgery associated with each patient characteristic using survey-weighted univariate logistic regression. We also performed multivariate logistic regression, assuming all patient factors were independent.
Results After adjusting for patient-level characteristics, the most rural residents were 23% less likely to receive bariatric surgery than urban residents. Other demographic features associated with significantly lower odds ratios for bariatric surgery included minority status, male gender, lower income, older age, non-private insurance status, and higher comorbidity. Rural-dwelling patients who are non-white, male, poorer, older, sicker, and non-privately insured almost never received bariatric surgery (OR=0.0089).
Conclusions Though obesity is more prevalent among middle-aged, rural, economically disadvantaged, and racial/ethnic minority populations, these patients are unlikely to access bariatric surgery. Because obesity is a leading cause of preventable morbidity and mortality in the USA, effective treatments should be made available to all patients who might benefit. Current Medicare/Medicaid policies that reimburse only high volume centers may effectively deny rural residents who rely on these insurance programs for bariatric surgery.

Keywords Morbid obesity · Bariatric surgery · Rural populations · Disparities

The research reported here was supported by the Veterans Rural Health Resource Center—Eastern Region, Veterans Administration Office of Rural Health. The views expressed in this article do not necessarily represent the views of the Department of Veterans Affairs or of the US government.

A. E. Wallace (✉)
Veterans Rural Health Resource Center-Eastern Region,
VAMC (11Q),
WRJ, VT 05009, USA
e-mail: aew@dartmouth.edu

Y. Young-Xu
National Center for Posttraumatic Stress Disorder, VAMC,
Hanover, NH, USA

D. Hartley
Maine Rural Health Research Center,
Muskie School of Public Service, University of Southern Maine,
Portland, ME, USA

W. B. Weeks
Dartmouth Institute for Policy and Clinical Practice,
Hanover, NH, USA

A. E. Wallace
Department of Psychiatry, Dartmouth Medical School,
Hanover, NH, USA

Introduction

Obesity is increasingly prevalent in the USA and is associated with significant morbidity, mortality, direct, and indirect economic and societal costs [1]. As of 2004, more that 33% of US adults were obese (BMI ≥30) and 6.9% of women and 2.8% of men were morbidly obese (BMI >40) [2]. The 2004 prevalence of obesity was highest among black adults (45%), followed by Hispanics (36.8%), and non-Hispanic whites (30%). Among 20–39 years old, 28.5% were obese, compared with 36.8% of 40–59 years old and 31% of those aged 60 years and older [2]. Rural populations of all ages and racial/ethnic groups are at increased risk for obesity [3].

In general, morbid obesity is refractory to diet, exercise, and drug therapies [4, 5]. Bariatric surgery results in significant and sustained weight loss in 68% of patients and is associated with improvement or resolution of obesity-related conditions including sleep apnea [6], cardiac disease [7], diabetes [8], hypertension, hyperlipidemia, infertility, and arthritis [9, 10], and reduction in obesity-related mortality by almost 30% [11]. Older studies indicate that rates of bariatric surgery do not correspond to the relative prevalence of morbid obesity in various population segments. Specifically, morbid obesity prevalence and bariatric surgery rates are negatively correlated based on age group and region [12], race [13], income level, and insurance status [12]. While 40% of morbidly obese patients are male [11], males receive only about 15% of all bariatric surgeries [15]. Rural residence is also a risk factor for obesity and is associated with many socio-demographic factors that reduce the overall likelihood of receiving bariatric surgery. We sought to examine more current rates of bariatric surgery within socio-demographic, economic, and rural–urban subgroups.

Methods

We conducted our analysis using the 2006 Nationwide Inpatient Sample (NIS) Hospital Discharge Dataset. The NIS is sponsored by the Agency for Healthcare Research and Quality (AHRQ) which obtains data on both clinical discharge diagnoses and resource use for approximately 20% of all US hospital admissions. Community hospitals are the primary sampling units, and all discharges from sampled hospitals are included. Recorded admissions in annual NIS databases range from five to eight million per year. In 2006, the sampling framework had increased to 38 participating states, 1,045 hospitals, and 8,074,825 admissions. Stratification and weighting variables are provided by AHRQ to allow generation of national estimates while taking into account the complex sampling design and expansion of the sampling framework over time. NIS records up to 15 discharge diagnoses according to the International Classification of Diseases Clinical Modification, Ninth Revision (ICD9-CM); first-listed diagnoses are regarded as the primary reason for admission. This study was approved by Dartmouth Medical School's Institutional Review Board (CPHS# 21698).

To identify our study population denominator, we assumed that all patients diagnosed with morbid obesity based on recorded BMI >40 were eligible for bariatric surgery, regardless of other clinical or demographic factors. We did not assess bariatric surgery rates for patients with BMI <40, though bariatric surgery may also be indicated for this population. In addition, we limited our sample to those with an ICD9-CM diagnosis code for morbid obesity (278.01) rather than the non-specific diagnosis code for obesity (278.00–278.8). We believe this improved the sensitivity of the selection and focused on the population most likely to be eligible for bariatric surgery. To identify our study population numerator, we used ICD9-CM procedure codes to identify bariatric procedures (43.0–44.99, 45.50–45.91), and to further focus on obesity-related bariatric surgery, we relied on diagnosis-related group code for obesity surgery (288). We excluded bariatric surgeries that were not likely to have been performed for elective weight loss such as those with diagnosis codes for gastrointestinal track neoplasm (150–159.9), inflammatory bowel disease (555.0–556.9), or noninfectious colitis (557.0–558.9), and emergent admission codes (admission-type variable= emergent or urgent and/or admission-source variable= emergency department or other hospital).

Our primary outcome of interest was the association between patient characteristics and undergoing any obesity-related bariatric surgery, thus we did not categorize bariatric procedures by type. Because Santry et al. noticed that "the overwhelming majority of patients (who underwent bariatric surgery) had private insurance and this proportion increased (from 1998 to 2002) [15], and Livingston and Ko found that that 28% of morbidly obese US adults in 2000 earned less than $20,000 per year and that 12% were in the Medicaid program [16], we wanted to examine these and other factors that we hypothesized might influence the likelihood of receiving bariatric surgery. Therefore, we included the following patient characteristics in our multivariate analysis: age, race/ethnicity, sex, type of insurance, and average annual household income in the patient's ZIP Code of residence as reported in the NIS (four strata: $1–$35,999, $36,000–$44,999, $45,000–$59,999, and $60,000 or more). While NIS does not include patient-level income data, area ZIP code serves as a proxy for socioeconomic status of the patient, particularly for individuals who are retired and may have accumulated wealth but no earned income. NIS uses a four-level Urban–Rural Classification Scheme for counties that was devised by the United States Office of Management and Budget: large metropolitan (at least one million residents), small metropolitan (between 50,000 and one million residents), micropolitan (between 10,000 and 50,000 population with at least one urban cluster), and all else as "rural". We used the same categories in our analysis. We also calculated a comorbidity index based on the 15 diagnosis codes included in the NIS data using the Deyo adaptation [17] of the Charlson Weighted Index of Comorbidity. This method correlates with inhospital morbidity and mortality and was designed and validated for use with administrative datasets

Statistical Analysis

First, we used ANOVA and Chi-square testing to compare underlying morbid obesity rates and characteristics of bariatric surgery patients using the 2006 NIS. Then, we performed univariate logistic regression weighted for survey sampling to determine the likelihood, expressed in odds ratios, of bariatric surgery associated with each patient characteristic. Finally, we performed multivariate logistic regression, and assumed all patient factors were independent in the regression models. For example, we assumed that a man's likelihood to receive bariatric surgery compared to a woman's was independent of their race or insurance status. We adopted this simplification in the model to achieve a clear take-away message. A fuller model could include all interaction terms to all possible orders (e.g. Gender X Race X Income X Age), but it would be less parsimonious, and the interpretation of interactions involving more than two factors would be too complex to the point of being a pure statistical construct. Nevertheless, we explored all interactions involving two factors for two reasons. First, we wanted to check whether these two-term interactions could change the results that we derived from our main, independent models; and second, we believed that meaningful interactions could suggest future areas of fruitful research.

We managed data and performed all analyses using both SAS software (Statistical Analysis System; SAS Institute; Cary, NC) and Stata (Stata Corporation; College Station, TX). Our linear regression procedure accounted for using a sampling variability (SAS Proc Survey; SAS Institute).

Results

In the 2006 NIS sample, we identified 159,116 records representing 774,000 elective hospitalizations for patients with morbid obesity (recorded BMI >40). While rural-dwelling inpatients represented 19.2% of all morbidly obese inpatient admissions, they represented only 15.5% of patient obtaining bariatric surgery (Table 1). Among all patients admitted with morbid obesity, white females aged 40–59 years from urban locales and in low income ZIP code areas were most frequently represented. Three quarters of the sample were covered by private insurance or Medicare and the plurality of patients had two or more comorbidities. Urban dwelling patients who were admitted for morbid obesity were about four times more likely to obtain bariatric surgery than their rural counterparts (9.8% vs. 1.7%, $p<0.001$). In addition, females were also about four times more likely to obtain bariatric surgery than males (9.2% vs. 2.2%, $p<0.001$) and patients aged 40–59 years were 1.5 times more likely than 2039 years old and six times more likely than patients older than 60 years old to obtain bariatric surgery ($p<0.001$). Privately insured patients were over eight times as likely to obtain bariatric surgery as those covered by government insurance programs, self-pay patients, or other insurances ($p<0.001$). Finally, increased comorbidity was associated with lower rates of bariatric surgery.

In our analyses, we encountered a similar problem to that found by Santry et al. [15], 25% of our study population had missing race data. Therefore, we examined whether missing race data were differently distributed among other characteristics, for example, whether those with private insurance were less likely to have missing race data than patients reliant on Medicare/Medicaid. We did not find any differences in missing race data for the characteristics that we studied. In other words, because the missing race information was due to the fact that some NIS participating states did not report race, for the variables that we studied, race data were missing at random and as a result, we could and did carry out analyses regarding racial disparity. Our multivariate logistic regression confirmed that, after controlling for important variables, rural, non-white, male, poorer, older, non-private insurance covered, and sicker patients had substantially lower odds of receiving bariatric surgery, after adjusting for all other factors (Fig. 1).

As to our decision to conduct all two factor-interaction terms, we were satisfied on both accounts. First, we found that inclusion of all two-term interactions did not change the results that we derived from our main, independent models. Second, we did find several meaningful and statistically significant interactions that warrant further exploration. For example, our analysis showed that odds ratio for men (vs. women) receiving bariatric surgery varied by age. For those aged 60 years or older, the OR was 0.75 (CI needed, $p<0.001$); in contrast, for those aged between 40 and 59 years, the OR was 0.42 (CI needed, $p<0.001$).

Our analysis estimated the odds of bariatric surgery by examining the impact of one characteristic at a time while holding other characteristics constant. While this

Table 1 Characteristics of patients undergoing bariatric surgery from the 2006 nationwide inpatient sample

Patient characteristics	Total elective inpatient admission of patients with morbid obesity (*N*)	Morbidly obese patients undergoing bariatric surgery (*N*)	Proportion undergoing bariatric surgery among inpatients within group (%)	Proportion of all admitted morbidly obese patients undergoing bariatric surgery (%)	*P* value
	773,733	88,605		11.5%	
Race					<0.001
White	394,434	50,753	12.9%	8.7%	
Black	111,952	7,770	6.9%	1.3%	
Hispanic	58,200	6,460	11.1%	1.1%	
Asian	3,021	227	7.5%	0.029%	
Native American	3,960	194	4.9%	0.025%	
Not provided	189,535	21,412	11.3%	2.8%	
Other	12,631	1,789	14.2%	0.3%	
Gender					<0.001
Female	525,660	70,996	13.5%	9.2%	
Male	247,652	17,345	7.0%	2.2%	
ZIP code annual income					<0.001
<$36,000	235,337	17,709	7.5%	2.3%	
$36,000-$44,999	204,856	22,218	10.8%	2.9%	
$45,000-$59,999	182,962	24,028	13.1%	3.2%	
≥$60,000	131,945	22,738	17.2%	3.0%	
Age					<0.001
20–39	158,856	32,738	20.6%	4.2%	
40–59	360,337	48,943	13.6%	6.3%	
60+	254,540	6,924	2.7%	0.9%	
Insurance					<0.001
Private (including HMO)	298,306	63,854	21.4%	8.3%	
Medicare	281,036	7,757	2.8%	1.0%	
Medicaid	124,577	6,164	4.9%	0.8%	
Self-pay	38,300	6,172	16.1%	0.8%	
No charge	4,408	252	5.7%	0.03%	
Other insurances	24,833	3,755	15.1%	0.5%	
Comorbidity scores					<0.001
Charlson Index=0	230,223	48,539	21.1%	6.3%	
Charlson Index=1	246,897	32,002	13.0%	4.1%	
Charlson Index ≥2	296,613	8,064	2.7%	1.0%	
Residence locale					<0.001
Urban	623,858	75,501	12.1%	9.8%	
Rural	147,892	12,798	8.7%	1.7%	

provides a general picture of the impact of that particular factor and is helpful to public health officials to make informed decisions, a more realistic picture of the impact on patients might also be helpful to illustrate the hardships faced by people with limited means as race, gender, and socioeconomic forces usually interact and act in consort. To demonstrate this, we temporarily suspended the interaction terms in the model and assumed that all effects were additive (a reasonable assumption based on the effect modifications that we found and presented earlier). For example, we explored the cumulative effects of a patient's likelihood of obtaining bariatric surgery if they were rural-dwelling, non-white, male, poorer, older, sicker, and did not have private insurance (Table 2). Such an individual would be 99 times less likely to obtain bariatric surgery than a person with the opposite combined characteristics (OR=0.0089, 95% CI=0.0079–0.0099).

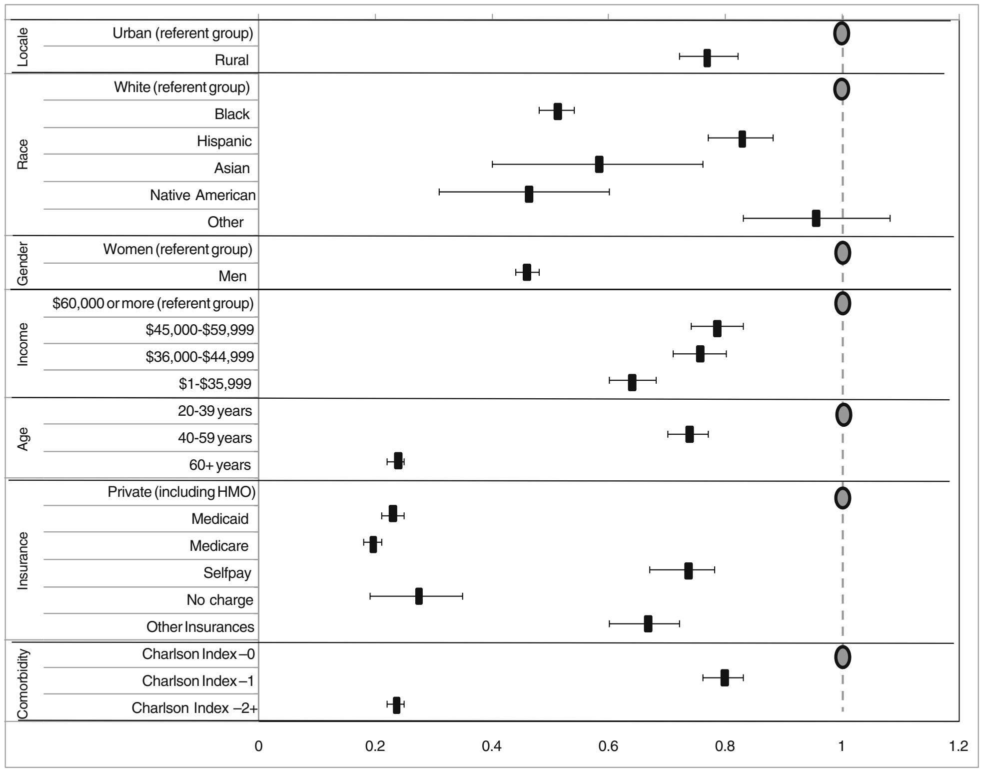

Fig. 1 Odds ratios for patient characteristics associated with obtaining bariatric surgery, each adjusted for all other variables

Discussion

Using AHRQ's national inpatient survey, we estimated that almost 91,000 bariatric surgeries occurred in 2006; 88,605 of those appeared to be electively performed for the purpose of weight loss. Clearly, the number of bariatric surgical procedures has increased substantially in the past decade, from 13,365 in 1998 and 72,177 in 2002 [15]. We found that patient characteristics were strongly associated with the likelihood of obtaining bariatric surgery among those admitted for morbid obesity: male, rural-dwelling, non-white, poorer, older, and non-private insurance covered persons were much less likely to obtain bariatric surgery than their counterparts with the opposite characteristics.

Other studies have also looked at the distribution of bariatric surgeries by patient characteristics. For example, Livingston and Ko [16] found that 36% of US adult population who met BMI criteria for bariatric surgery were male, while fewer than 20% of all bariatric surgeries were received by men. After adjusting for potentially confounding variables, we found that morbidly obese women were twice as likely to receive bariatric surgery as their male counterparts. This contrast could be due to a greater popularity among women, as suggested by Santry et al. [15] but it could be more complicated as the distribution of income, of age, of insurance type, and of race could all be significantly different between men and women.

Table 2 Nested model examining the impact of combined effects of patient characteristics

Model	Odds ratio	Lower 95% CI	Upper 95% CI
Rural-dwelling	0.69	0.66	0.72
Rural-dwelling+non-white race	0.35	0.32	0.37
Rural-dwelling+non-white race+male	0.15	0.14	0.17
Rural-dwelling+non-white race+male+family income <$60,000 per year	0.11	0.10	0.12
Rural-dwelling+non-white race+male+family income <$60,000 per year+older than 40 years old	0.035	0.031	0.038
Rural-dwelling+non-white race+male+family income <$60,000 per year+older than 40 years old+ Charlson score >0	0.021	0.019	0.023
Rural-dwelling+non-white race+male+family income <$60,000 per year+older than 40 years old+ Charlson score >0+without private insurance	0.0089	0.0079	0.0099

Researchers have revealed that African Americans tend to receive less care and lower quality of care than Caucasian American in general [14, 18] and in cardiovascular disease in particular [14]. Our finding suggests that this disparity exists in bariatric surgery as well. Morbid obesity is highly linked to the development of cardiovascular disease [20, 21], thus it is more troubling to see that African Americans are not receiving good preventive care as well as treatment for cardiovascular disease, the most prevalent disease in America and primary cause of death [22]. Although, just like African Americans, Asian and Native Americans also were half as likely to receive bariatric surgery, Hispanic Americans were about 20% less likely.

Our study has several limitations. First, our results are based on a large national survey of administrative data with complex design. While the survey is designed to represent the US population, to the extent that it is not generalizable to the US population, our findings may be flawed. Likewise, obesity is now a global problem and our results, which rely on a US database, cannot be generalized globally. Second, we relied on ICD9-CM codes to identify both the study population and their inpatient treatment (bariatric surgery in this case). As with all administrative coding, mislabeling and a lack of detail are possible. For instance, we may have included patients with BMI <40 if they were given an ICD9-CM diagnosis of morbid obesity but did not have a recorded BMI, or excluded some morbidly obese patients for whom neither a morbid obesity diagnosis or BMI were accurately recorded. Unfortunately, this common coding limitation in administrative data is probably the reason why so many in our sample have Charlson Index equal to zero category, even though the adjustment for comorbidity did not significantly impact our finding regarding the existing disparity among racial, geographical, and socioeconomic groups. Nevertheless, as we utilized existing data, some of our measures are proxies with all the inadequacy of approximations (e.g., urban/rural residence for access to care, local income level as a proxy for personal income, etc.). Specifically, distance to care may be a better predictor of access to bariatric surgery; however, the rural–urban definitions used by the NIS are based on population density rather than proximity to services.

Despite these limitations, our finding that rural-dwelling patients receive bariatric surgery less often than their urban counterparts, despite having higher rates of morbid obesity [3] is concerning. Although federal programs like Medicare and Medicaid cover only a small fraction of bariatric surgeries, the fact that these programs require that bariatric surgeries take place in high volume centers of excellence [23] may account for some of our findings. In addition, that rural-dwelling patients are more likely than their urban counterparts to be poor and uninsured may account for some of the disparities that we found. Nonetheless, after adjusting for such factors, rural-dwelling patients who were admitted for morbid obesity were 23% less likely than their urban counterparts to obtain bariatric surgery. These findings suggest that new efforts to encourage rural-dwelling patients, and physicians, to seek bariatric surgery are warranted. While bariatric surgery will not address the obesity epidemic in isolation, ensuring that even the neediest have access to the best treatments is an important first step.

References

1. Arterburn DE, Maciejewski ML, Tsevat J. Impact of morbid obesity on medical expenditures in adults. Int J Obes (Lond). 2005;29:334–9.
2. Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA. 2006;295:1549–55.
3. Jackson JE, Doescher MP, Jerant AF, et al. A national study of obesity prevalence and trends by type of rural county. J Rural Health. 2005;21:140–8.
4. Glenny AM, O'Meara S, Melville A, et al. The treatment and prevention of obesity: a systematic review of the literature. Int J Obes Relat Metab Disord. 1997;21:715–37.
5. McTigue KM, Harris R, Hemphill B, et al. Screening and interventions for obesity in adults: summary of the evidence for the U.S. preventive services task force. Ann Intern Med. 2003;139:933–49.
6. Grunstein RR, Stenlof K, Hedner JA, et al. Two year reduction in sleep apnea symptoms and associated diabetes incidence after weight loss in severe obesity. Sleep. 2007;30:703–10.
7. Vogel JA, Franklin BA, Zalesin KC, et al. Reduction in predicted coronary heart disease risk after substantial weight reduction after bariatric surgery. Am J Cardiol. 2007;99:222–6.
8. Sjostrom L, Lindroos AK, Peltonen M, et al. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. N Engl J Med. 2004;351:2683–93.
9. Pories WJ, Swanson MS, MacDonald KG, et al. Who would have thought it? An operation proves to be the most effective therapy for adult-onset diabetes mellitus. Ann Surg. 1995;222:339–50. discussion 50-2.
10. Buchwald H, Avidor Y, Braunwald E, et al. Bariatric surgery: a systematic review and meta-analysis. JAMA. 2004;292:1724–37.
11. Sjostrom L, Narbro K, Sjostrom CD, et al. Effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med. 2007;357:741–52.
12. Poulose BK, Holzman MD, Zhu Y, et al. National variations in morbid obesity and bariatric surgery use. J Am Coll Surg. 2005;201:77–84.
13. Shinogle JA, Owings MF, Kozak LJ. Gastric bypass as treatment for obesity: trends, characteristics, and complications. Obes Res. 2005;13:2202–9.
14. Felix-Aaron K, Moy E, Kang M, et al. Variation in quality of men's health care by race/ethnicity and social class. Med Care. 2005;43:I72–81.
15. Santry HP, Gillen DL, Lauderdale DS. Trends in bariatric surgical procedures. JAMA. 2005;294:1909–17.
16. Livingston EH, Ko CY. Socioeconomic characteristics of the population eligible for obesity surgery. Surgery. 2004;135:288–96.

17. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol. 1992;45:613–19.
18. Ayanian JZ, Weissman JS, Chasan-Taber S, et al. Quality of care by race and gender for congestive heart failure and pneumonia. Med Care. 1999;37:1260–9.
19. Epstein AM, Weissman JS, Schneider EC, et al. Race and gender disparities in rates of cardiac revascularization: do they reflect appropriate use of procedures or problems in quality of care? Med Care. 2003;41:1240–55.
20. Rashid MN, Fuentes F, Touchon RC, et al. Obesity and the risk for cardiovascular disease. Prev Cardiol. 2003;6:42–7.
21. Poirier P, Giles TD, Bray GA, et al. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association Scientific Statement on Obesity and Heart Disease from the Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2006;113:898–918.
22. Trend table 30: Leading causes of death. Hyattsville, MD 20782 National Center for Health Statistics 2008.
23. Department of Health and Human Services (2008) Medicare proposes revised coverage policy for bariatric surgery as a diabetes treatment. In: Centers for Medicare and Medicaid Services. Press Releases, Baltimore