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The impact of obesity on health-related quality-of-life in the general adult US population

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Abstract

Background The US Preventive Services Task Force recently recommended screening all adult patients for obesity due in part to the strong association between obesity and numerous chronic diseases. However, how obesity affects health-related quality-of-life (HRQL), particularly for persons without any chronic diseases, is less clear.

Methods The relationship between obesity and HRQL was examined using data from the 2000 Medical Expenditure Panel Survey. Respondents ≥18 years were classified as underweight, normal weight, overweight, class I obesity, and class II obesity based on their BMI. HRQL was measured by the 12-item Short Form physical and mental summary scores (PCS-12 and MCS-12, respectively) and EuroQol EQ-5D index and visual analogue scale (EQ VAS). The impact of obesity on HRQL was examined through multivariate regression, adjusting for sociodemographics and disease status.

Results After adjustment, HRQL decreased with increasing level of obesity. Compared to normal weight respondents, persons with severe obesity had significantly lower scores with scores on the PCS-12, MCS-12, EQ-5D index, and EQ VAS being 4.0, 1.1, 0.073, and 4.8 points lower, respectively. Such decrements of HRQL for severe obesity were similar to the decrements seen for diabetes or hypertension. Persons with moderate obesity or who were overweight also had significantly lower HRQL scores, particularly on the PCS-12 and EQ-5D index. Underweight persons also had lower MCS-12 and EQ VAS scores.

Conclusions Persons with obesity had significantly lower HRQL than those who were normal weight and such lower scores were seen even for persons without chronic diseases known to be linked to obesity.

Keywords: BMI, health-related quality-of-life, MEPS, obesity

Introduction

The United States (US) has been experiencing an 'obesity epidemic'[1,2] and obesity has obtained increasing recognition as a public health concern. From 1990 to 2000 the number of deaths attributable to poor diet and physical inactivity has increased substantially and, if the pattern continues, poor diet and physical inactivity may overtake tobacco as the leading preventable cause of death.[3] The US Preventive Services Task Force recently updated the 1996 recommendations of periodic height and weight measurements[4] and recommended that clinicians screen all adult patients for obesity.[2] Although the Task Force noted that longitudinal data indicate a J-shaped or U-shaped relationship between absolute mortality and body mass index (BMI),[5–7] the Task Force did not address the impact of BMI upon health-related quality-of-life (HRQL).

In both clinical and public health settings, measures of HRQL may be more relevant for function and survival than physiologic and clinical assessments. Numerous investigations have indicated that overweight and obese persons, as well as underweight persons, have impaired HRQL. However, the majority of these investigations in the US were conducted in samples comprised of primary care patients,[8] patients with chronic disease,[8] or patients seeking treatment for obesity.[9, 10] Far fewer studies were conducted in representative samples of the US population[11–14] or in obese persons without any chronic conditions. Because obesity is one cause of many chronic conditions (i.e. diabetes mellitus, hypertension, coronary heart disease, and ischaemic stroke, among others), the impact of obesity on general health or HRQL among persons who have not been diagnosed with any of these conditions remains unclear.

Focusing on analyses from population-based samples, Sturm and Wells examined HRQL using the Community Tracking Study (CTS).[11] Although the CTS was designed to be representative of the US civilian, non-institutionalized population, the sample was clustered within 60 communities, mostly metropolitan areas.[15] After adjusting for chronic conditions, obesity predicted impaired physical HRQL, with an effect size similar to poverty.[11]

Ford and colleagues examined number of recent unhealthy days using data from the 1996 Behavioral Risk Factor Surveillance System (BRFSS), a larger national data set.[12] The mean overall number of unhealthy days was nonlinearly (J- or U-shaped)

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related to self-reported BMI with underweight and obese participants reporting more unhealthy days compared to participants with a normal weight. Being obese also was associated with a decreased probability of reporting excellent health.[12] However, the investigators did not adjust for chronic conditions in these analyses. Because the distributions of unhealthy days are highly skewed, comparison of mean unhealthy days may not be reliable.[16,17] Researchers had addressed this problem by analysing the proportions of persons having 14 or more unhealthy days[12,14,18] but, in dichotomizing the variables, part of the information measured by unhealthy days may be lost.[17]

The impact of obesity on scores of HRQL has been measured with a variety of generic and obesity-specific instruments[19] and one instrument, the Short Form 36 (SF-36), has been one of the most commonly used generic measures in the US. The SF-36 is a health profile that assesses the health status of patients or populations on a comprehensive set of domains. Health profiles have been designed to characterize the particular domain(s) impacted by conditions or treatments, and, therefore, are well-suited to clinical evaluations.[20–22]

By focusing on self-reported functional capacity and perceived health status, profiles do not assess patients' values. In contrast, a health index, such as the EuroQol EQ-5D, incorporates individual values and preferences and generates a single index score of health. The resulting score can be combined with life expectancy in order to create a summary measure of population health that might be used to conduct cost-effectiveness analyses.[23,24]

In 2000 the SF-12 (a health profile and shorter version of the SF-36) and EQ-5D (health index) were administered to a sample of the non-institutionalized, civilian US population as part of the Medical Expenditure Panel Survey (MEPS).[25] We compared the impact of categories of BMI on SF-12 and EQ-5D scores and assessed the performance of the EQ-5D in the general population, paying particular attention to persons who had not been diagnosed with any chronic conditions.

Methods

The MEPS has an overlapping panel design in which any given panel of a random sample of the US non-institutionalized, civilian population is interviewed five times over 30 months.[25,26] The household component of MEPS contains detailed data on sociodemographic characteristics and selected diseases/conditions, among other variables. In 2000, the MEPS included a self-administrated paper questionnaire that was distributed to all participants aged 18 and older and designed to measure HRQL.[25,26]

Data were obtained from 15 438 persons but responses from 1792 persons (12 per cent) were excluded because these persons were not the intended recipients of the questionnaire. The final sample was limited to persons who provided self-reported data (instead of provided by a proxy) and consisted of 13 646 subjects.

Body mass index and obesity

We calculated BMI from self-reported height and weight and created the following five categories of BMI according to the World Health Organization guidelines:[27] underweight ($<18.5\,kg/m^2$), normal weight ($18.5–24.9\,kg/m^2$), preobese (overweight) ($25–29.9\,kg/m^2$), obesity class I/moderate obesity ($30–34.9\,kg/m^2$), and obesity class II/severe obesity ($\geq 35\,kg/m^2$).

Health-related quality-of-life

The Short-Form 12 (SF-12) is comprised of 12 items measuring eight concepts: physical functioning, role limitations due to physical health problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional health, and mental health. These concepts are combined into physical and mental component summary scales (PCS-12 and MCS-12, respectively) that are scored using norm-based methods and transformed so that the general population has a mean of 50 and a standard deviation of 10.[28,29] Higher scores represent better health.

The EuroQol EQ-5D is comprised of a self-classifier and a visual analogue scale. The self-classifier is a descriptive system that enables the respondent to classify his/her health according to five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The data may be used to represent a profile of health status or converted into a single summary index (EQ-5D index) by applying the choice-based method of the time-trade off using the United Kingdom's general population.[30] In addition, the measure captures a self-rating of health status by a visual analogue scale (EQ VAS) which is anchored at 100 (best imaginable health) and 0 (worst imaginable health).[31]

Data on demographic characteristics and self-reported diseases/conditions were obtained by in-person interviews. Income was categorized as <100 per cent poverty, 100–124 per cent poverty, 125–199 per cent poverty, 200–399 per cent poverty, and ≥400 per cent poverty. Regarding health behaviours, participants were asked if they currently smoked and if they engaged in moderate or vigorous physical activity at least three times a week. Participants responded if they had the following chronic clinical conditions: diabetes (excludes gestational diabetes), asthma, high blood pressure, emphysema, stroke (or transient ischaemic attack), and heart disease (includes coronary heart disease, angina, heart attack, and any other heart condition).

Statistical analysis

Data were analysed using SAS (SAS Institute Inc., Gary, NC, 1999). The MEPS data incorporated sampling weights and post-stratification weights. All variance calculations were adjusted for multi-stage cluster design of MEPS data. Descriptive statistics were used to report the distribution of five BMI categories according to sociodemographic and clinical variables and the values of such descriptive statistics were standardized by age and/or gender to the 2000 US population.

The impact of obesity on HRQL scores was examined in two ways. First, using multivariate linear regressions, the HRQL scores were modelled with five BMI categories, smoking, physical activity, clinical conditions, and sociodemographic variables such as age, race/ethnicity, sex, and income as independent variables. The impact of obesity on HRQL scores, adjusted by other covariates, was evaluated through values of the regression coefficient.

Secondly, nonlinear relationships between BMI and HRQL were examined through Spline regression.[32] The predicted values of the SF-12 and EQ-5D were plotted against BMI separately for participants without any conditions and for participants with at least one MEPS condition. The predicted values were calculated by adjusting for sociodemographics.[17] This procedure was also applied to persons without any chronic conditions, separately by smoking status and physical activity.

Results

Table 1 depicts the relationship between BMI and sociodemographic and clinical conditions. In this sample, 2.1 per cent of participants had a self-reported BMI of <18.5 kg/m^2, 39.7 per cent had a BMI of 18.5–24.9 kg/m^2, 35.1 per cent had a BMI of 25–29.9 kg/m^2, 15.0 per cent had a BMI of 30–34.9 kg/m^2, and 8.2 per cent had a BMI of ≥35 kg/m^2. The percentage of participants with a normal weight decreased with increasing category of age until 65 and older and then increased. Females both were

Table 1 Relationship between BMI and Sociodemographics and Clinical Conditions: 2000 MEPS

	n	%	percent underweight n = 219	percent normal weight n = 4437	percent overweight n = 4215	percent class I obesity n = 1907	percent class II obesity n = 1064	association with obesity p-value*
Total	13646	100%	2.1	39.7	35.1	15.0	8.2	
Age								<.0001
18–24	1535	11.25%	5.4	54.1	23.2	12.6	4.7	
25–44	5530	40.50%	1.8	41.2	34.6	13.6	8.9	
45–64	4344	31.80%	1.0	33.2	37.9	18.1	9.8	
65+	2237	16.40%	2.3	37.7	39.8	14.2	6.1	
Sex†								<.0001
Male	5865	43.00%	0.9	31.9	44.2	16.3	6.6	
Female	7781	57.00%	2.9	45.6	28.1	13.9	9.5	
Race/Ethnicity‡								<.0001
White	8679	63.60%	2.0	41.5	34.9	14.1	7.4	
Black	1826	13.40%	1.8	29.7	35.8	18.9	13.8	
Asian/Pacific Islander	289	2.10%	5.2	59.2	26.5	6.8	2.2	
American Indian/Alaskan Native	73	0.50%	2.3	24.7	35.0	22.5	15.5	
Hispanic	2779	20.40%	1.0	32.7	38.6	18.9	8.8	
Income‡								<.0001
<100% poverty	1643	12.00%	2.5	37.9	30.9	16.4	12.3	
100–124% poverty	633	4.60%	2.0	33.8	35.1	17.9	11.1	
125–199% poverty	1977	14.50%	1.9	34.3	35.0	16.5	12.2	
200–399% poverty	4316	31.60%	1.8	38.1	34.9	16.2	9.1	
≥400% poverty	5077	37.20%	2.2	42.9	36.1	13.3	5.5	
Current smoking‡								<.0001
Yes	2953	21.90%	3.4	43.4	34.7	12.5	5.9	
No	10535	78.10%	1.7	38.3	35.5	15.7	8.8	
Physical activity‡								<.0001
Yes	7289	53.70%	1.9	44.0	36.7	12.3	5.0	
No	6292	46.30%	2.2	33.8	33.4	18.7	11.9	
Disease‡								
None	8993	66.10%	2.1	43.8	35.3	12.9	6.0	<.0001
Any of following diseases	4620	33.90%	1.8	31.0	35.2	19.0	13.1	
Asthma	1202	8.80%	1.9	35.0	35.2	16.2	11.6	<.0001
Hypertension	2803	20.60%	0.7	23.4	34.3	21.8	19.8	<.0001
Diabetes	946	7.00%	0.4	20.0	31.5	24.1	24.0	<.0001
Heart disease	1340	9.90%	2.3	37.6	33.5	16.9	9.7	0.0008
Stroke	288	2.10%	3.8	33.6	39.3	11.8	11.5	0.0125
Emphysema	187	1.40%	6.3	49.0	24.2	13.2	7.3	<.0001

†: adjust for age.
‡: adjust for age and sex.
*: Chi-square test or Mantel-Haenszel Chi-square test.

more likely to be of a normal weight as well as to be underweight and severely obese while males were more likely to be overweight and moderately obese. Regarding race/ethnicity, Asian/Pacific Islanders were the most likely to have a normal weight while American Indians/Alaskan Natives were the least likely to have a normal weight. Persons who reported a higher household income and persons who engaged in moderate or vigorous physical activities three or more times a week were more likely to have a normal weight. Compared to nonsmokers, current smokers had a significantly lower BMI. Among the clinical conditions, persons with diabetes were the least likely to have a normal weight and the most likely to have class II obesity.

The overall average PCS-12, MCS-12, EQ-5D index, and EQ VAS scores were 49.4 (SE = 0.13), 51.2 (SE = 0.11), 0.823 (SE = 0.0031) and 79.2 (SE. = 0.22), respectively. Table 2 illustrates the adjusted effect of obesity on SF-12 and EQ-5D scores. Results from multivariate regressions show that scores on both measures decrease with increasing level of obesity. Compared to persons with a normal weight, persons with class II obesity have the greatest decrements in PCS-12, EQ-5D index and EQ VAS scores, and have significant decrements in MCS-12 scores. The average score decrements for the PCS-12, MCS-12, EQ-5D index and VAS were 4.00, 1.07, 0.073 and 4.84 points, respectively. When regression coefficients of class II obesity were compared to regression coefficients of the six clinical conditions, the impact of class II obesity on HRQL scores was similar to the impact of asthma, hypertension and diabetes. Persons with class I obesity had significantly lower, but in smaller magnitude, average PCS-12, EQ-5D index and EQ VAS scores, compared with persons of a normal weight. This trend also was seen in persons who were overweight, as overweight persons had significantly lower average PCS-12 and EQ-5D index scores.

At the lower end of BMI, although only approximately 2 per cent of respondents had a BMI <18.5 kg/m^2, regression analyses showed a strong negative impact of being underweight on HRQL. In particular, when compared to normal weight persons,

Table 2 Multivariate Linear Regression Analyses of SF-12 and EQ-5D

	PCS-12		MCS-12		EQ-5D index		EQ VAS	
Covariates	**beta**	**p-value**	**beta**	**p-value**	**beta**	**p-value**	**beta**	**p-value**
Age								
18–24 (ref)	0.00	.	0.00	.		.	0.00	.
25–44	–1.23	<.0001	0.16	0.6662	–0.026	0.0014	–3.43	<.0001
45–64	–3.79	<.0001	0.67	0.0811	–0.077	<.0001	–0.56	<.0001
65 +	–7.80	<.0001	2.82	<.0001	0.099	<.0001	–6.46	<.0001
Sex								
Male	1.07	<.0001	1.37	<.0001	0.023	<.0001	0.80	0.0117
Female (ref)	0.00	.	0.00		0.000	.	0.00	.
Race/Ethnicity								
White	0.00	.	0.00	.	0.000	.	0.00	.
Black	1.01	0.0002	0.97	0.0035	0.025	0.0006	2.40	0.0007
Asian/Pacific Islander	0.30	0.5056	1.19	0.0566	0.046	<.0001	–1.75	0.2544
American Indian/Alaskan Native	1.69	0.2895	–1.21	0.5236	0.023	0.5039	0.93	0.6918
Hispanic	–0.11	0.6825	0.01	0.9708	0.006	0.4305	–1.00	0.0725
Income								
<100% poverty	–4.65	<.0001	–3.81	<.0001	–0.124	<.0001	–10.79	<.0001
100%–124% poverty	–2.97	<.0001	–3.81	<.0001	–0.093	<.0001	–8.34	<.0001
125–199% poverty	–2.32	<.0001	–2.36	<.0001	–0.061	<.0001	–5.08	<.0001
200–399% poverty	–0.97	<.0001	–0.84	0.001	–0.027	<.0001	–1.68	<.0001
≥400% poverty (ref)	0.00	.	0.00	.	0.000	.	0.00	.
Smoke	–1.35	<.0001	–2.00	<.0001	–0.046	<.0001	–4.02	<.0001
Physical activity	2.26	<.0001	1.54	<.0001	0.046	<.0001	3.49	<.0001
Disease								
Asthma	–1.99	<.0001	–1.49	0.0002	–0.045	<.0001	–3.65	<.0001
Hypertension	–2.69	<.0001	–1.19	<.0001	–0.053	<.0001	–4.38	<.0001
Diabetes	–2.78	<.001	–0.98	0.0749	–0.042	0.0002	–5.47	<.0001
Heart disease	–4.63	<.0001	–2.29	<.0001	–0.083	<.0001	–7.65	<.0001
Stroke	–5.29	<.0001	–1.91	0.0396	–0.080	<.0001	–5.36	<.0001
Emphysema	–8.99	<.0001	–1.83	0.0528	–0.120	<.0001	–11.79	<.0001
Obesity								
Underweight	–0.87	0.227	–1.60	0.0317	–0.029	0.0879	–3.75	0.0109
Normal weight (ref)	0.00	.	0.00	.	0.000	.	0.00	.
Overweight	–0.73	0.001	–0.24	0.3345	–0.013	0.0115	–0.52	0.1931
Class I obesity	–1.86	<.0001	–0.08	0.82	–0.033	<.0001	–3.23	<.0001
Class II obesity	–4.00	<.0001	–1.07	0.0303	–0.073	<.0001	–4.84	<.0001

underweight persons had the greatest decrement in MCS-12 scores and their average EQ VAS score was significantly lower, too.

Additionally, we explored if differences arose in scores of HRQL across sociodemographic groups and categories dichotomized by health behaviours and chronic clinical conditions (Table 2). All of these factors had a significant impact on HRQL scores. For example, current smokers had lower average scores and persons who engaged in moderate to vigorous physical activities had higher average scores. Smoking and physical activity had a similar magnitude of impact on average HRQL scores, and this impact was slightly smaller than that of class II obesity. All six chronic conditions were associated with lower SF-12 and EQ-5D scores.

We calculated predicted HRQL scores, adjusting for sociodemographic variables, using BMI to examine the relationships between these two variables. Figure 1 indicates a nonlinear relationship. The four plots in Figure 1 reveal a strong and significant effect of having at least one condition on HRQL. Each curve shows a similar pattern: the predicted HRQL values start low when BMI values are approximately 15 kg/m^2, the scores increase as BMI increases and peak at a BMI of approximately 20–24.9 kg/m^2, then the HRQL scores decline with further increases of BMI and the decrements continue to their lowest point when the BMI approaches 50 kg/m^2. The impact of BMI on HRQL scores are observed among persons both with and without one or more of the six self-reported chronic conditions. Even for persons without any of the chronic conditions, there are signs of impaired HRQL when their weight increases above the normal range, particularly on the PCS-12, EQ-5D index and EQ VAS.

The four plots in Figure 2 are of predicted HROL scores against BMI values by smoking status and physical activity for persons without any conditions. The plots show the strong negative impact of both smoking and lack of physical activity on HRQL, with the impact of these two factors on HRQL being approximately the same.

Discussion

Our results further strengthen the literature that obesity is associated with impaired HRQL, a finding noted both in the general US population[11,12] and abroad.[33,34] Compared to previous studies, our analyses focused on the impact of obesity on HRQL among the US adults without any of six self-reported chronic conditions, the majority of which are associated with obesity. Even in absence of these conditions, HRQL scores decreased with increasing level of obesity. Compared to persons in other BMI categories, persons with severe obesity had the lowest HRQL scores, as measured by both the SF-12 and EQ-5D.

The HRQL scores also were significantly lower for overweight and moderately obese participants. While participants with severe obesity had the most impaired HRQL, overweight and moderately obese participants might represent the bigger public health problem, given that these persons comprise approximately 50 per cent of total US adults while only 8 per cent of US adults are severely obese. Additionally, compared to severely obese persons, overweight or moderately obese persons may be less likely to seek treatment of obesity or obesity-related conditions.[35]

The relationships between HRQL scores and category of BMI were evident for both measures, although, for the SF-12, the decrements in scores for overweight/obese persons were greater on the PCS-12 than the MCS-12. Other investigations have indicated that obesity is a stronger predictor of poor physical health than mental health[11,12,16,19,33,36] and changes in weight are more strongly associated with changes in physical health.[37] Of note, however, MCS-12 scores were the most impaired at the extremes of BMI and this impairment was comparable to the impairment due to certain chronic conditions. For persons with severe obesity, the decrement in scores on the PCS-12 and EQ-5D index was within the range of what has been considered to be a clinically meaningful difference.[30,38,39]

While obesity negatively impacted HRQL, engaging in moderate or vigorous physical activity had a positive impact on HRQL. Persons who were physically active not only had a lower risk of being obese, but also had higher HRQL scores at all BMI levels. Our results were consistent with previous reports that diet and/or physical activity improves general health and the risks of having 14 or more unhealthy days for persons who report being physically active are at least 20 per cent lower than the risks of persons who are inactive.[12,14]

In previous studies examining HRQL in the US adult population, investigators used data from national surveys such as the BRFSS. In these surveys, HRQL was assessed either by the five-level self-rated health status or by unhealthy days that included poor physical, poor mental, and activity limitation days. These measures have been designed to assess health perceptions as opposed to assessing general health and functional status.[18] Because the 2000 MEPS included both the SF-12 and EQ-5D, measures that have been widely used in the US and abroad and extensively validated in clinical settings and population-based studies, MEPS provides a good way to study HRQL and the impact of obesity on HRQL in the US general population.

Because obesity is associated with many chronic diseases, such as diabetes, hypertension, and heart disease, analyses of obesity's impact on HRQL should consider these potential confounders when making comparisons of HRQL scores, particularly in population-based surveys that include a large number of respondents with one or more of these diseases. Not all previous investigations examined the impact of these conditions in their analyses. Our study provided two types of analyses, i.e. multivariate analysis and stratification, to address this issue and data show consistent results using both methods.

Our study had a number of limitations. First, MEPS data are cross-sectional so we were unable to draw conclusions regarding the causal association between obesity and HRQL. Secondly, only specific chronic conditions were ascertained so

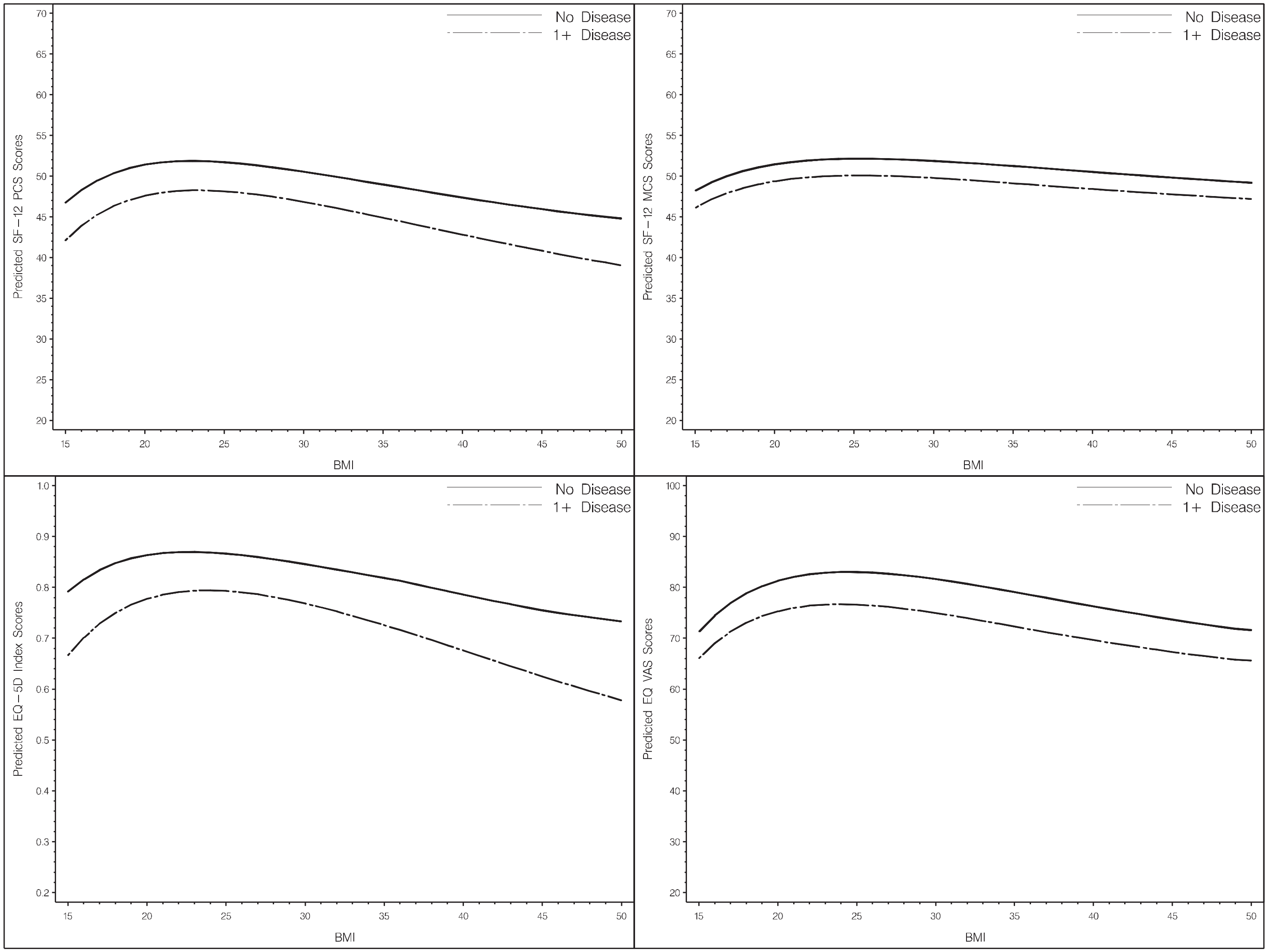

Figure 1 Relationship between HRQL scores and BMI, by disease status: 2000 MEPS

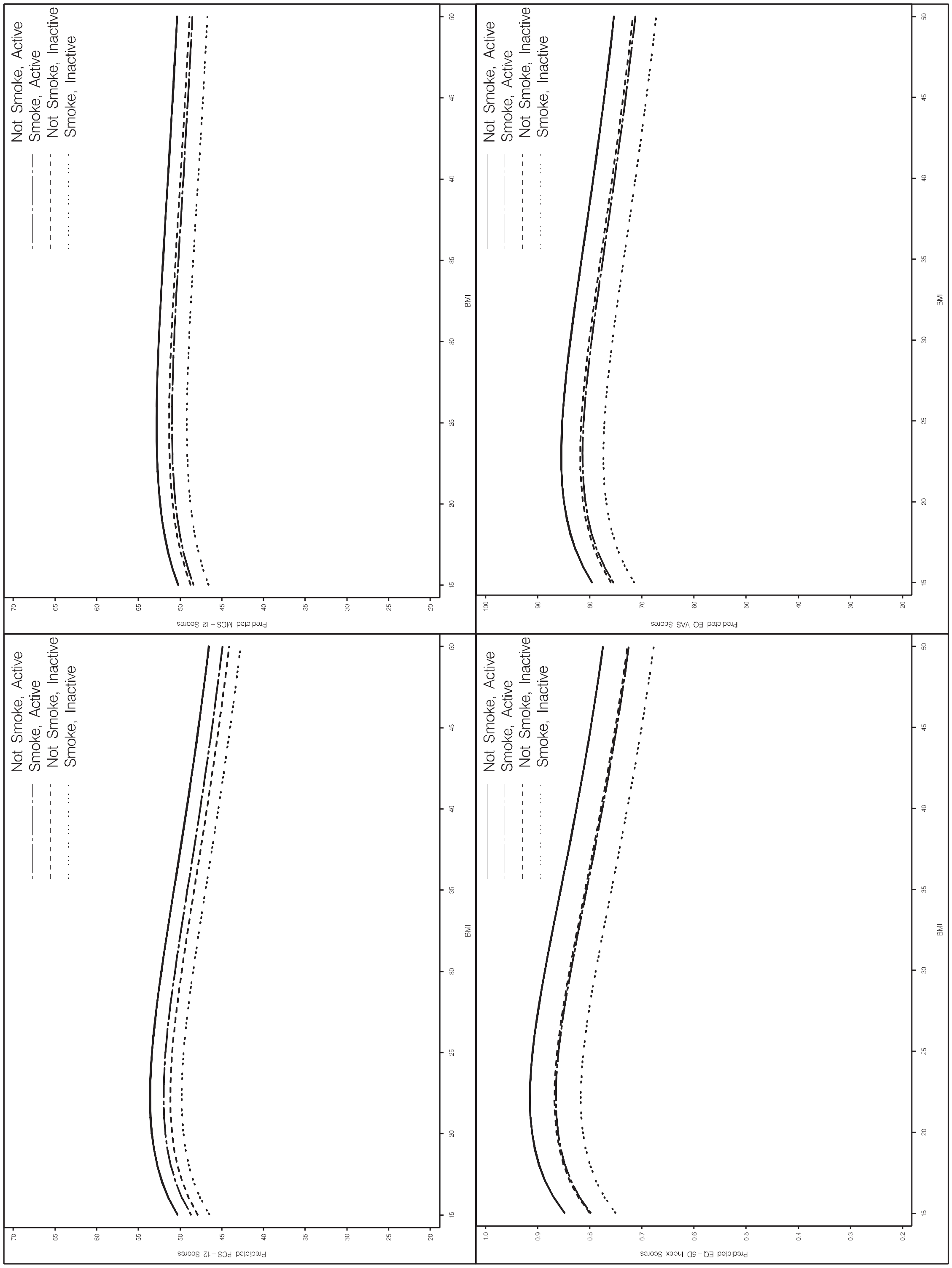

Figure 2 Relationship between HRQL scores and BMI for persons in the absence of diseases, by smoking and physical activities: 2000 MEPS

the association of HRQL with obesity might be due to another unmeasured condition. Thirdly, both the chronic conditions and weight and height were self-reported. Self-reporting conditions might underestimate their prevalence. Obese persons are more likely to under-report their weights and over-report their heights than are non-obese persons and men are more likely to over-report their heights than are women, with both of these reporting patterns resulting in misclassification and leading to decreased calculated BMI.[40,41] Fourth, for the EQ-5D we used weights derived from the general population of the United Kingdom due to the lack of scoring function weights derived in the US at the time the data were analyzed. It is unknown whether such weights represent the preferences of the US general population but evidence suggests that the valuations for a standard set of EuroQol health states are broadly similar from country to country, suggesting cross-national and cross-cultural applicability.[23,38]

In conclusion, the 2000 MEPS containing the SF-12 and EQ-5D serves as the best data set to study HRQL of the US general population. Even in the absence of chronic disease, scores of HRQL decreased with increasing category of weight. The national trends of a greater prevalence of overweight and obesity will impact all sectors of health care, i.e. clinicians, public health officials, employers, payers and policymakers, among others. Screening and implementing interventions for obesity have been associated with modest long-term weight loss. Whether this weight loss, in turn, might improve HRQL for the large percentage of overweight/obese persons in the general population remains to be seen but such a change would have a profound implication both within a managed care panel and a community.

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References

1 Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. *J Am Med Assoc* 2002; **288**: 1723–1727.

2 Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States, 1991–1998. *J Am Med Assoc* 1999; **282**: 1519–1522.

3 Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States, 2000. *J Am Med Assoc* 2004; **291**: 1238–1245.

4 US Preventive Services Task Force. *Guide to clinical preventive services*, 2nd ed. Alexandria, VA: International Medical Publishing; 1996; 219–229.

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**: 933–949.

6 Sorkin JD, Muller D, Andres R. Body mass index and mortality in Seventh-day Adventist men. A critique and re-analysis. *Int J Obes Rel Metab Disord* 1994; **18**: 752–754.

7 Manson JE, Willet WC, Stampfer MJ, *et al*. Body weight and mortality among women. *N Eng J Med* 1995; **333**: 677–685.

8 Katz DA, McHorney CA, Atkinson RL. Impact of obesity on health-related quality of life in patients with chronic illness. *J Gen Intern Med* 2000; **15**: 789–796.

9 Fontaine KR, Cheskin LJ, Barofsky I. Health-related quality of life in obese persons seeking treatment. *J Fam Pract* 1996; **43**: 265–270.

10 Kolotkin RL, Crosby RD, Williams GR. Health-related quality of life varies among obese subgroups. *Obes Res* 2002; **10**: 748–756.

11 Sturm R, Wells KB. Does obesity contribute as much to morbidity as poverty or smoking? *Publ Hlth* 2001; **115**: 229–235.

12 Ford ES, Moriarty DG, Zack MM, Mokdad AH, Chapman DP. Self-reported body mass index and health-related quality of life: findings from the Behavioral Risk Factor Surveillance System. *Obes Res* 2001; **9**: 21–31.

13 Heo M, Allison DB, Faith MS, Zhu S, Fontaine KR. Obesity and quality of life: mediating effects of pain and comorbidities. *Obes Res* 2003; **11**: 209–216.

14 Hassan MK, Joshi AV, Madhavan SS, Amonkar MM. Obesity and health-related quality of life: a cross-sectional analysis of the US population. *Int J Obes Relat Metab Disord* 2003; **27**: 1227–1232.

15 Schoenman JA, Berk ML, Feldman JJ, Singer A. Impact of differential response rates on the quality of data collected in the CTS physician survey. *Eval Hlth Prof* 2003; **26**: 23–42.

16 Moriarty DG, Zack MM, Kobau R. The Centers for Disease Control and Prevention's Healthy Days Measures – Population tracking of perceived physical and mental health over time. *Hlth Qual Life Outcomes* 2003; **1**: 37.

17 Jia H. Muennig P, Lubetkin EI, Gold MR. Predicting geographical variations in behavioural risk factors: an analysis of physical and mental healthy days. *J Epidemiol Commun Hlth* 2004; **58**: 150–155.

18 Centers for Disease Control and Prevention. *Measuring healthy days*. Atlanta, GA: CDC, November 2000.

19 Fontaine KR, Barofsky I. Obesity and health-related quality of life. *Obes Rev* 2001; **2**: 173–182.

20 Coons SJ, Rao S, Keininger DL, Hays R. A comparative review of generic quality-of-life instruments. *Pharmacoeconomics* 2000; **17**: 13–35.

21 Garratt AM, Ruta DA, Abdalla MI, Buckingham JK, Russell IT. The SF36 health survey questionnaire: an outcome measure suitable for routine use within the NHS? *Br Med J* 1993; **306**: 1440–4444.

22 Guyatt GH, Feeny DH, Patrick DL. Measuring health-related quality of life. *Ann Intern Med* 1993; **118**: 622–629.

23 Kind P. The EuroQol instrument: An index of health-related quality of life. In: Spilker B, editor, *Quality of life and pharamcoeconomics in clinical trials*, 2nd Edn. Philadelphia: Lippincott-Raven Publishers, 1996; 191–201.

24 Gold MR, Patrick D, Torrance G, *et al*. *Cost-effectiveness in health and medicine*. New York, NY: Oxford Press, 1996.

25 *MEPS Fact Sheet*. January 2003. Agency for Healthcare Research and Quality, Rockville, MD. Available at http://www. meps. ahrq. gov/whatismeps/bulletin.htm (date last accessed 1 March 2004).

26 Cohen SB. Design strategies and innovations in the Medical Expenditure Panel Survey. *Med Care* 2003; **41**: III-5–III-12.

27 World Health Organization Expert Committee on Physical Status. *The use and interpretation of anthropometry*. Report of a World

Health Organization Expert Committee. Geneva: World Health Organization; 1995. Technical Support, Series 854.

28 Ware J Jr, Kosinksi M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care* 1996; **34**: 220–233.

29 Ware JE, Kosinski M, Keller SD. *SF-12 ®: How to score the SF-12 ® Physical and Mental Health Summary Scales*, 3rd Edn. Lincoln, RI: QualityMetric Incorporated, 1998.

30 Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997; **35**: 1095–1108.

31 Rabin R, de Charro F. EQ-5D: a measure of health status from the EuroQol Group. *Ann Med* 2001; **33**: 337–343.

32 Simonoff JS. *Smoothing methods in statistics*. New York, NY: Springer-Verlag, 1996.

33 Larsson U, Karlsson J, Sullivan M. Impact of overweight and obesity on health-related quality of life – a Swedish population study. *Int J Obes Relat Metab Disord* 2002; **26**: 417–424.

34 Stafford M, Hemingway H, Marmot M. Current obesity, steady weight change and weight fluctuation as predictors of physical functioning in middle-aged office workers: the Whitehall II study. *Int J Obes Relat Metab Disord* 1998; **22**: 23–32.

35 Sciamanna CN, Tate DF, Lang W, Wing RR. Who reports receiving advice to lose weight? Results from a multistate survey. *Arch Intern Med* 2000; **160**: 2334–2339.

36 Doll HA, Peterson SE, Stewart-Brown SL. Obesity and physical and emotional well-being: associations between body mass index, chronic illness, and the physical and mental components of the SF-36 Questionnaire. *Obes Res* 2000; **8**: 160–170.

37 Fine JT, Colditz GA, Coakley EH, et al. A prospective study of weight change and health-related quality of life in women. *J Am Med Assoc* 1999; **282**: 2136–2142.

38 Johnson JA, Coons SJ, Ergo A, Szava-Kovats G. Valuation of EuroQOL (EQ-5D) health states in an adult US sample. *Pharmacoeconomics* 1998; **13**: 421–433.

39 Johnson JA, Pickard AS. Comparison of the EQ-5D and SF-12 health survey in a general population in Alberta, Canada. *Med Care* 2000; **38**: 115–121.

40 Palta M, Prineas RJ, Berman R, Hannan P. Comparison of self-reported and measured height and weight. *Am J Epidemiol* 1982; **115**: 223–230.

41 Rowland ML. Self-reported weight and height. *Am J Clin Nutr* 1990; **52**: 1125–1133.