Body Mass Index and Likelihood of Health Care Dollar Utilization: Initiatives to Maintain or Promote Health

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Abstract

This study evaluated the relationship between Body Mass Index [BMI, weight(kg)/ height(m)^2] and health care dollars ulitization. Data were analyzed for 383 individuals who were continuously employed and covered by comprehensive health insurance over a 7-year period. A number of experimental and statistical controls were used to control for biases identified in prior studies: data for biophysical measures (height and body weight) and monetary expenditures were observed rather self-reported, medical expenditures were those directly related to weight, and BMI was used as a continuous rather a categorical variable. In addition, age, gender, smoking status, and whether or not dollars were spent for pre-existing health problems 2-years prior to the onset of the study were used as covariates. The logistic regression analysis showed that BMI is significantly related to likelihood of utilizing health care dollars; greater likelihood of expenditure is related to extremes in BMI. The findings underscore the necessity to identify or develop treatment and prevention programs that encourage the maintenance of body weights within moderate ranges.

Key words: Body Mass Index, Quetelet Index, Body Weight, Health Care Dollar Utilization, Health Care Expenditures, Cost-Containment, Cost-Effectiveness, Health Promotion, Logistic Regression

Body Mass Index and Likelihood of Health Care Dollar Utilization: Initiatives to Maintain or Promote Health

Obesity and eating disorders are major medical and public health problems. The National Health and Nutrition Examination Survey estimated that 26%, or 34 million, adult Americans aged 20 to 75 are overweight.[1,2] The prevalence of anorexia nervosa, although less than obesity, is still substantial in actual numbers of cases. Approximately .00125% to .01% women and considerably fewer men are anorexic.[3,4] The prevalence of bulimia nervosa is reported as between 1% to 5% among women and 1% among men.[5-7] Eating disorder symptomatology seems to be increasing,[8] especially among certain subpopulations such as athletes.[9]

Multiple medical sequela are associated with weight status. The major medical complications associated with obesity include heart disease, gall bladder disease, and diabetes mellitus whereas respiratory disease, digestive diseases, and cancer account for the extra mortality associated with lower body weight.[10,11] Problems connected with anorexia nervosa and bulimia nervosa can also be serious and life-threatening. Extensive cardiovascular, gastrointestinal, endocrine, musculosekeletal, and metabolic complications have been noted.[12]

Recidivism rates are high for obesity and eating disorder treatment programs. Recidivism rates for obesity programs are cited as between 75% and 100% one-year or more after treatment terminates, depending on the source.[13,14] Anorexia nervosa appears to be as resistent to treatment as obesity. In fact, following a review of 21 studies published between 1954 and 1982, it was concluded that "there is no evidence that the weight increment attributable to treatment has increased over time. This suggests that the overall treatment outcome of anorexia nervosa, at least as reflected in these data, has not improved over the last 50 years" (p. 195).[15]

Cost-containment and cost-effectiveness are exigent priorities for health care. President Bush in his 1990 State of the Union address indicated that cost-containment and cost-effectiveness are predominant health planning goals and a major concern for the American public.[16] The total cost of individual treatments for the primary disorders of obesity and anorexia nervosa is substantial. For example, "Each year, more than $50 billion is spent on efforts to control weight gain or induce weight loss. More than 50% of the expenditure is for diet foods" (p. 488).[11] Treatments for obesity such as surgery, very low calorie diets, psychoanalysis, and physician-run programs are obviously expensive.[11] The same is true for anorexia nervosa programs that require hospitalization and a vast number of medical staff and technical equipment. Medical costs associated with bulimia nervosa and the secondary medical complications related to weight status can be substantial as well.[17]

A major concern is the validity of findings of prior studies that investigate the relationship of Body Mass Index (BMI) and longevity. A recent review of 25 studies suggested that cigarette smoking, which is a major risk factor for mortality and morbidity, should be included in the study protocol.[18] Important as well is the use of observed rather than self-reported values of height and weight; self-reported measures have been demonstrated to differ enough from "true" assessments to seriously alter conclusions.[19-21] Reliance on actual measures of medical care utilization rather than on subject-reported medical care costs is also prudent. Use of BMI as a continuous rather than a discrete variable is advantageous because of the potential to increase the "statistical power" of the analysis.[22,23] In addition, demographic variables, given their prior know association with other variables, should be taken into consideration. Lastly, medical expenditures should be restricted to those that are strongly weight-related.[24] Excluding health care expenses unrelated or weakly related weight would improve the sensitivity of a study to detect the relationship between BMI and health care utilization expenditures.

The purpose of the study was to investigate the relationship between BMI and health care dollar utilization. Experimental and statistical controls were also implemented as part of the study design to control for extraneous variables that might confound the findings. In addition, to learn more about the association of the expenditure of health care dollars and BMI, subjects were divided into cohorts.

Method

Subjects

The sample consisted of 383 subjects, 263 (68.67%) women and 120 (31.33%) men. Participants were between 21 and 61 years old ($\bar{X}$ = 35.66), weighed 42.18 kg to 123.38 kg ($\bar{X}$ = 72.58), were 1.37 m to 2.01 m ($\bar{X}$ = 1.66) in height, and were between 15.98 to 44.72 ($\bar{X}$ = 26.13) in Body Mass Index [BMI, weight (kg)/height (m)^2]. It was also noted that 80 (20.89%) subjects spent health care dollars for selected "lifestyle-related diseases" during a two-year baseline period and 303 (79.11%) of them did not.

Subjects selection was limited to those who had been employed continuously for a 7-year period. Only 913 people met this criterion. A health risk appraisal (HRA) and limited physical examination, as part of a comprehensive worksite health promotion program, were offered to all employees on company time and at no charge. There were 388 subjects who completed the health risk appraisal and physical examination within the first month these services were available. Of these 388 subjects, complete information was not available for 5 individuals and consequently their data were dropped from the analyses.

Procedure

Independent variables. The physical examination included seven assessments. Only the measurements relevant to the study are presented. Participants were weighed clothed on a calibrated, balance-beam scale under the lightest conditions possible. For example, shoes, jackets, and other heavy apparel were removed. Subjects' heights were measured barefooted or in stocking feet with the rod attached to the balance-beam scale. The observed measures of weight and height were used to compute the Quetelet Index of BMI. BMI is noted to be the most satisfactory measure of relative body weight in the absence of body composition measures.[11]

Participants also completed a Health Risk Appraisal (HRA) questionnaire, developed by the American Health Foundation, which is described in detail elsewhere.[25] One question from the HRA used to assess smoking was, "Are you presently smoking?" which was answered either "yes" or "no." The variables of sex and age were also obtained from the HRA. Respondents checked whether they were male or female and age in years was based on an answer to the following question: "How old were you on your last birthday?"

Dependent variable. The prinical dependent variable was health care utilization dollars. All employees were covered throughout the study period by the same health care insurance plan which was completely paid for by the company. Two years of baseline health care costs, prior to height-weight measures, were obtained from employee health insurance records. The next five years of health care costs were then examined. A computer program was written to prevent counting a particular health insurance payment more than once (even though more than one insurance claim for the same service was made) and to ensure that the correct portion of the health care claim was counted. Included in the analysis were selected health care costs that were related to body weight.[(1)] Health care costs not counted include those related to infective and parasitic diseases, mental disorders, accidents, poisonings and violence, childbirth, symptoms and ill-defined conditions, and congenital anomalies.

An overall measure of annual health care costs was obtained by averaging the health costs for all five post years. The costs for the five-year period were used rather than annual costs because the longer time period provides a more stable and reliable estimate of health care dollar utilization than any single year.

Research design and statistical analyses. An ex post facto retrospective research design was employed with statistical controls for the influence of extraneous variables.[26] The design was selected to examine the relationship between likelihood of health care dollar utilization and BMI. BMI was used as a continuous independent variable, not a categorical variable.[(2)] To adjust for the existence of a prior health care expenditures, a dichotomous variable PRE was used in the model, with PRE = 1, if a subject had positive baseline expenditures, and PRE = 0, otherwise. The five independent variables of primary interest in the analysis were PRE, BMI and its quadratic effect, BMI^2, and the interaction of PRE with BMI as well as BMI^2.

A multiple logistic regression model was fitted to a dichotomous dependent variable, Y, constructed from the measured health care costs for the five post years.[(3)] For each subject, Y = 1, if the subject had positive health care expenditures over the five post years, otherwise Y = 0. Thus, the fitted model provided estimates of the likelihood of health care dollar utilization over the five year time span as a function of BMI and PRE expenditures, after statistically adjusting for the covariates of age, smoking status, and sex. Age was a continuous variable, smoking status was tri-chotomous with each subject either a known smoker, a known non-smoker, or of unknown smoking status.[(4)] Thus, smoking status was modeled with two variables: SM1 represented differences between subjects of known smoking status (SM1 = 0) and those of unknown status (SM1 = 1); and SM2 compared known smokers (SM2 = 1) to known non-smokers (SM2 = -1), with SM2 = 0 for subjects of unknown status. Interactions among the covariates were also investigated.

All statistical modeling was completed with PROC CATMOD within the SAS$^{(TM)}$

statistical package.[27] All analyses were verified by comparing findings to printouts produced by SPSS-X(TM)[28] and BMDP(TM).[29]

Results

Preliminary Evaluation of Covariate Contributions

The logistic regression model for Y regressed on AGE, SEX, smoking status (i.e., SM1 and SM2) and the interaction of age and smoking status was significant, X^2 (5, N = 383) = 12.8, $P < .048$, with SM2, X^2 (1, N = 383) = 4.26, $P < .039$, and AGE*SM2, X^2 (1, N = 383) = 4.64, $P < .031$, significant after adjusting for all other covariate effects. Estimated likelihood of dollar utilization was greater for smokers, and increased with age for non-smokers. After adjusting for the other covariates, there was no significant difference between subjects of known smoking status and those of unknown status at any age. No other interactions among the covariates significantly improved the model.

Contributions of BMI

The five independent variables involving PRE and BMI improved the model significantly, X^2 (5, N = 383) = 18.9, $P < .003$. Adjusting for all other variables in the model, the interactions of PRE with both BMI and BMI^2 were significant ($P < .05$). Table 1 provides the parameter estimates for all the independent variables in the model and their estimated standard errors, along with X^2 statistics and P-values.

Insert Table 1 about here

A heuristic example is now provided for calculating the likelihood of utilizing health care dollars. For example, to estimate the likelihood of dollar utilization for 28-year old, non-smoking women with BMIs of 26.5 and no prior year expenditures, the independent variables would be specified as follows: AGE = 28, SEX = 1, SM1 = 0, SM2 = -1, PRE = 0, and BMI = 26.5. The fitted logit is calculated by using the coefficients in Table 1. The computations would be calculated as follows:

$$2.47667 + 0.012517*28 + 0.125877 - 1.15108 -$$
$$0.0326355*28 - 0.172409*26.5 + 0.003125*26.5^2$$
$$= .34145.$$

This logit leads to an estimated likelihood of 0.5845 (odds = 1.4067).

A similar calculation for women of the same age and smoking status, but with BMIs = 34 and with prior year expenditures, PRE = 1, results in a logit of 4.0536 and a likelihood of 0.9829 (odds = 57.4795). The difference in fitted logits is the log-odds-ratio for the two different cohorts of subjects. This difference is 3.712 and the standard error is 1.33. An approximate 95% confidence ratio for the odds ration is (2.863, 585.23).

<u>Statistical Interpretation</u>

The independent variable of primary interest in this study, BMI, was significant in its interaction with PRE. Most noticeably, the coefficients of both quadratic effects were positive, indicating that the fitted likelihood of dollar utilization increased with extreme values of BMI, high as well as low. The fitted model demonstrates the expected significance ($\underline{P} < .05$) of a pre-existing condition when estimating the likelihood of "future" health care dollar utilization.

Figure 1 illustrates the fitted model for non-smoking men at the quartile ages of 28, 33, and 43 years old, both with and without positive baseline expenditures. The dominant effect of PRE is evident in the rapid rise of the (solid) curves for those with PRE = 1, while the quadratic effect is evident in all six curves. Included on the plot in Figure 1 are fitted probabilities for all the subjects (shown as dots), and a horizontal reference line at .70 was used to define certain cohorts which are explained below.

Insert Figure 1 about here

Cohort Divisions

To better understand the features of the model, six cohorts were defined in terms of each subject's estimated likelihood of dollar utilization and BMI value(2). Subjects were deemed to be "high risk" if their estimated odds of dollar utilization versus non-utilization exceeded .70 (see horizontal reference line on Figure 1). The cutoff of .70 was empirically determined and it falls at (approximately) the midpoint of the fitted values for the data. Based on cutoffs reported by other investigators,[30,31] BMI divisions were made at 22.0 and 30.4, resulting in three levels of BMI: under and normal weight, normal to slightly over weight, and obese. Table 2 presents summary descriptive data for subjects falling into the six cohorts.

Insert Table 2 about here

As expected from the model effects, a subject falls into a "lower risk" cohort primarily because of no existing condition (i.e., no baseline dollars spent, PRE = 0). The subjects in cohort 1 are mostly young women and have the lowest percentage of known smokers among all six cohorts. The subjects in the remaining two "low risk" cohorts (2 and 3) are relatively young, with the percentages of men and women in closer agreement with the entire data set.

Cohort 4 is a "higher risk" group, despite the intermediate BMI levels of the subjects, because of higher age and more subjects with an existing medical condition. Smoking levels are similar to the "low risk" cohorts, however. Cohorts 5 and 6 illustrate the combined effects of extreme BMI, higher existing medical condition percentages and high smoking percentages. Cohort 5 is mostly young women who are "underweight" and who smoke. Cohort 6 are those who are obese, relatively old, and many have an existing medical condition.

Discussion

This paper focuses on the relationship between Body Mass Index and health care expenditures. The results indicate that in spite of other risks, such as age, gender, and smoking status, people with low as well as high Body Mass Indexes are more likely to use health care dollars. In addition to the role of BMI, the major risk level discriminator is whether or not medical dollars were spent during baseline.

One benefit of this paper may be its data analytic features. Using BMI as a continuous rather than a discrete variable has certain advantages. The quadratic contribution of BMI as a significant predictor of health care dollar utilization has created a figure of utility. Practitioners or administrators can estimate patients' likelihood of health care dollar expenditures, simply by knowing a person's age and/or whether the person spent money previously for health care. Not surprisingly, prior behavior is the best predictor of future behavior; prior expenditures during a two-year baseline period seem to be a relatively strong indicator that a person will spend health care dollars in the future.

Another advantage of the study are efforts to ameliorate validity. Analyses were based on observed weights and heights as well as actual measures of medical dollar utilization. The estimate of health care dollar utilization was also relatively stable because of the longitudinal nature of the 7-year timeframe of the study. Demographic factors, "non-weight related" diseases, prior health care dollar expenditures, and smoking status also were statistically controlled. The statistical procedure used seems to adequately model the data. A qualification to these statements, however, is that the stability and generalizability of these, or any, findings, for that matter, awaits replication in order to further verify the relationship between BMI and health care dollar utilization.

There seem to be two primary solutions to reducing the likelihood of health care dollar expenditures and in meeting President Bush's goals of cost-containment and cost-effectiveness. The most obvious solution is to provide treatment for those at both the higher and lower extremes of BMI. The treatment plans would, of course, vary depending on whether the person was on the high or low end of the BMI continuum and whether the person wanted to lose or gain weight. Efficacious treatment intervention identification is an exigent priority especially in light of the numerous attendant medical sequela associated with the extremes in body weight. Addressing the need for medically sound and effective interventions may be timely because obesity is associated with a number of health hazards[32] and also as an independent risk factor for coronary heart disease.[33] In the meantime, further efforts might be taken to encourage "third party" provider payments for treatment programs designed for under- and overweight individuals. Furthermore, comprehensive, cordinated, federal programs that assist people in attaining healthful weight levels should be developed. The physician could also be instrumental in this process by detecting individuals who already fall into or are progressing toward the more extreme BMI ranges.

The best solution, however, for reducing expenditures appears to be prevention. This seems to be especially true in terms of current treatment technology, the refractiveness of the disorders related to body weight, and the fact that most adults gradually increase in weight as they age.[34-36] It might be more prudent, therefore, to concentrate on those individuals who are at lower risk rather than patients with chronic, health problems or degenerative diseases.[37] Although treatment should certainly not be denied, chronic patients represent a very small percentage of the total population, yet are frequent users of the medical system who require the majority of the medical services at the greatest cost. Remaining in the middle BMI ranges may be encouraged by physicians during patient visits and incentives could be offered by third party providers to reduce premiums if a patient's BMI was within the moderate ranges. Third party providers might also offer incentives to individuals who enroll in health promotion programs. Mass media campaigns might be developed that focus on the adverse effects of extreme BMIs and poor nutrition. In addition, The Surgeon General of the United States might identify and endorse methods of healthy lifestyling to promote health and to maintain body weight within "normal" limits. Lastly, the "core" curriculum in elementary, junior and senior high schools, and colleges should include a course that focuses on normal body development and body weight.

In conclusion, this study provides important new information about the relationship between BMI and health care utilization dollars. The likelihood of expenditures increases at both ends of the BMI continuum. Efficacious interventions to alter or maintain body weight and health status need to be developed/ identified for treatment as well as prevention. Efforts to reduce expenditures are an exigent priority in order to continue quality medical care and to further reduce morbidity and mortality.

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Author Notes

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Footnotes

(1)A list of diseases related to obesity can be obtained from the authors.

(2)The continuous nature of BMI allows prediction of subjects' likelihood of dollar utilization at any measured BMI value, given PRE and the easily measured covariates. The fitted values will not change suddenly due to slight shifts in BMI values as might occur with a categorical BMI factor when adjacent categories are, on average, significantly different. Note that it is easy to categorize BMI after fitting the model in the present form and this was done to produce Table 2 above. Note also that AGE was continuous rather than discrete. No improvement was obtained using categorical age effects either.

(3)Note that a prametric multiple regression model for dollars utilized was found to be inappropriate because of the extreme skewness of the dependent variable and the large proportion of subjects with no health care expenditures during both the two PRE and POST years.

(4)The percentage of known smokers is relatively high in comparison to national averages.[38,39] There were 161 (42.04%) subjects who smoked, 85 (22.19%) who did not, and 137 (35.77%) for whom smoking status was unknown. After adjusting for these (possibly) unusual smoking percentages, the independent variables, PRE and BMI still provide significant effects in the overall model.

Table 1

Contribution of Each of the Independent Variables Entered into the Logistic Regression Analysis

Variable	Parameter Estimate	Standard Error	x^2	p
INTERCEPT	2.47667	2.98726	0.69	0.41
AGE	0.01252	0.01533	0.67	0.41
SEX	0.12588	0.25781	0.24	0.63
SM1	-1.18129	0.87494	1.82	0.18
SM2	1.15108	0.57694	3.98	0.04
AGE*SM1	0.02419	0.02453	0.97	0.32
AGE*SM2	-0.03264	0.01512	4.66	0.03
PRE	44.54040	21.10230	4.46	0.03
BMI	-0.17241	0.20939	0.68	0.41
BMI^2	0.00313	0.00360	0.75	0.39
PRE*BMI	-3.36133	1.60931	4.36	0.04
PRE*BMI^2	0.06344	0.03049	4.33	0.04

Note. Age refers to age in years and sex is classified as 0 for men and 1 for women. SM1 is a dichotomous classification of smoking, 0 = subjects of known smoking status and 1 = subjects of unknown smoking status. SM2 is trichotomous classification of smoking status, 1 = known smoker, -1 = known non-smoker, and 0 = a person of unknown smoking status. PRE is a dichotomous classification of baseline expenditures of health care dollars, 1 = positive expenditures, and 0 = no expenditures. BMI is Body Mass Index [weight(kg)/height(m)^2]. BMI^2 is the square of BMI. An asterisk (*) means multiplication.

Table 2

Percentage (Number) of Subjects and Median Age by Cohort and Demographic Variable

	Variables									
	Sex		Smoker			Spent Baseline $		Spent $ 5 Years		Age(Years)
Cohort	Men	Women	Yes	No	Unknown	Yes	No	Yes	No	*Mdn*
1 (n=50)	12.0(6)	88.0(44)	28.0(14)	22.0(11)	50.0(25)	0(0)	100.0(50)	60.0(30)	40.0(20)	28.5
2 (n=152)	44.7(68)	55.3(84)	43.4(66)	15.1(23)	41.5(63)	17.8(27)	82.2(125)	60.5(92)	39.5(60)	33.0
3 (n=45)	31.1(14)	68.9(31)	33.3(15)	17.8(8)	48.9(22)	0(0)	100.0(45)	57.8(26)	42.2(19)	31.0
4 (n=63)	27.0(17)	73.0(46)	34.9(22)	39.7(25)	25.4(16)	33.3(21)	66.7(42)	76.2(48)	23.8(15)	47.0
5 (n=41)	9.8(4)	90.2(37)	73.2(30)	17.1(7)	9.7(4)	41.5(17)	58.5(24)	82.9(34)	17.1(7)	29.0
6 (n=32)	34.4(11)	65.6(21)	43.8(14)	34.3(11)	21.9(7)	46.9(15)	53.1(17)	90.6(29)	9.4(3)	41.0

Note. Cohorts are defined in the following legend:

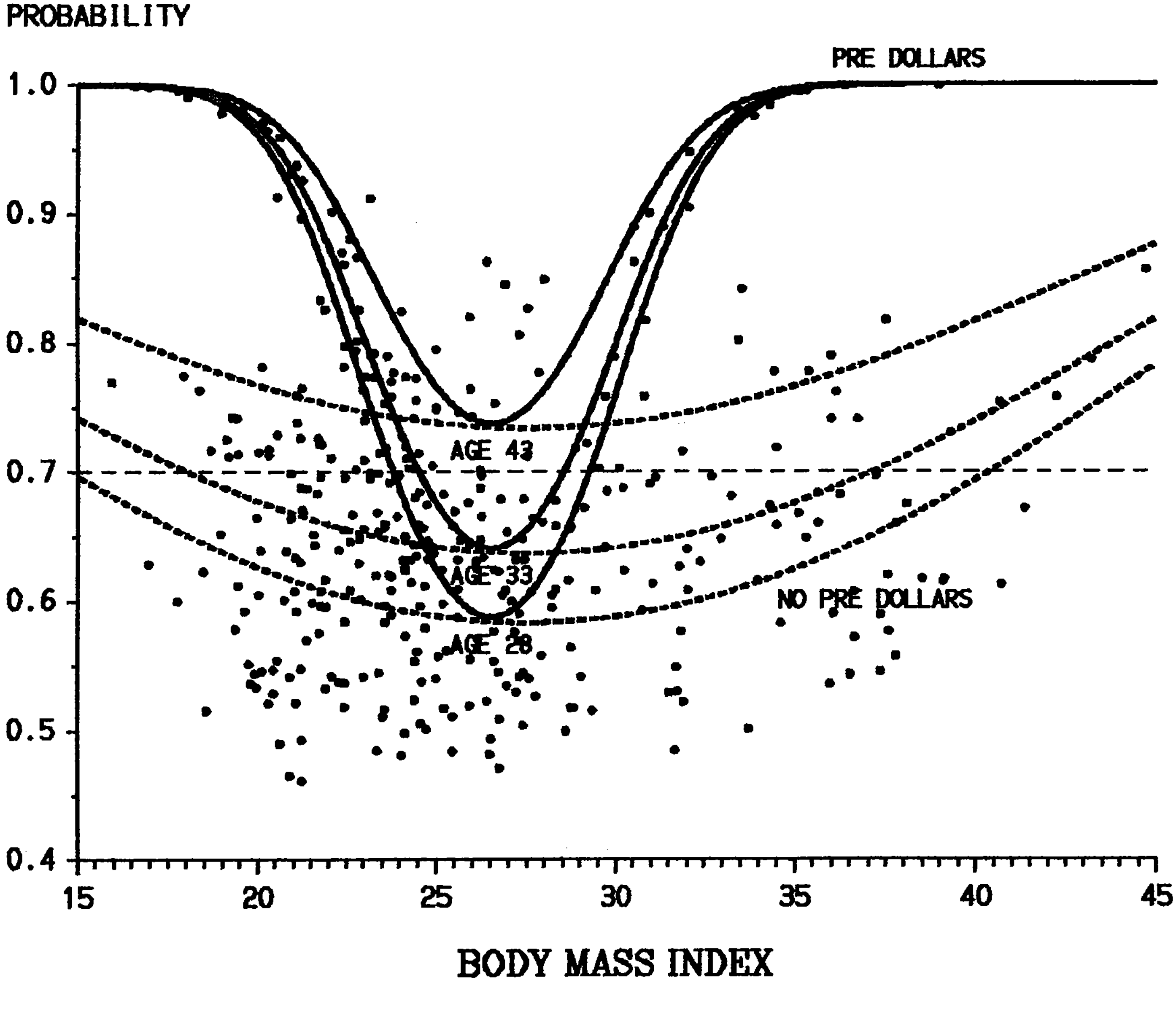
	Estimated Likelihood of Dollar Utilization Versus Non-Utilization	
BMI (W/HT^2)	$\leq .70$*	$> .70$
≤ 22.0	1 = Low Risk, Under & Normal Wt.	5 = High Risk, Under & Normal Wt.
$> 22.0 - \leq 30.4$	2 = Low Risk, Normal to Slightly Overwt.	4 = High Risk, Normal to Slightly Overwt.
> 30.4	3 = Low Risk, Obese	6 = High Risk, Obese

*p = midpoint based on the data of estimated likelihood of utilizing health care dollars.

Figure Caption

Figure 1. Estimated likelihood of 5-year medical dollar utilization.

LIKELIHOOD OF DOLLAR UTILIZATION



NON-SMOKING WOMEN AT QUARTILE AGES 28, 33 AND 43
WITH AND WITHOUT PRE-DOLLAR EXPENDITURES