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AN INDEX TO MEASURE HEALTH STATUS

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An Index to Measure Health Status

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Abstract

In this study we developed a health status index using the commonly recorded health measures by doctors and hospitals. This health status index has a minimum possible value of 7 (the least healthy) and a maximum value of 21 (the healthiest). Using the NHANES data, we explored the relationship of this health status index and nutrient intakes, lifestyle, and demographics of the respondent. Regression results showed that as the age of the respondent, being non-Hispanic black, participants of food stamp programs, high percent of calories that came from fat intakes, high percent of calories in beverages that came from soft drinks, smoking, and on special diets are negatively related to the value of the health status index (i.e., the person became less healthy); household income, college education, eating breakfast, and the amount of exercise are positively related value of the health status index (the person became healthier). These results indicate that the health status index developed in this study had the desired properties.

Key words: health status index, NHANES, nutrients

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An Index to Measure Health Status

In the past several decades interest has increased in quality-of-life measures. These measures include the health of population, the benefit of alternative uses of resources, comparing alternative interventions in a clinical trial, and making decisions on treatment for a patient. Simple measures of health status began to appear in the 1940s (Karnofsky and Burchenal 1949; Steinbrocker et al. 1949). More recently, the health utilities index (HUI) have been used to provide a compact but comprehensive framework to describe health status, reporting health-related quality of life, and producing utility scores (Torrance et al. 1982, 1996; Horsman et al. 2003) and the Center for Disease Control and Prevention's (CDC, 2007b) health-related quality-of-life (HRQOL) measures.

Some of these indices or measures require answers to lengthy questionnaires and sometime this becomes an imposition on sick patients and even on healthy ones. Several health status measures of were developed for specific health problems (e.g., Fries et al. 1982; Tugwell et al. 1987) and the HUI and CDC's HRQOL were for respondents subjective evaluation of their health status.

In this study, we used several health-related measures commonly taken in doctors' offices or hospitals and one of the questions asked in the CDC's HRQOL survey to develop an index number for a person's health status. We then examined the relationship between this health index and the number of health problems the person had, nutrient intakes, and demographics. The National Health and Nutrient Examination Survey (NHANES) 2003-04 data were used in this study. The objective of this study was to examine whether the proposed health status index can be explained by the number of health problems the person had, his/her diet and

demographics. The index developed in this study is different from the HUIs and other health status measures in that the proposed health status does not address the quality-of-life issues. The health measurements needed for the derivation of the health status index are readily available, because these measurements are commonly recorded by doctors and hospitals. The only additional piece information that is needed from the respondents/patients is their self-reported general health condition, which is a straightforward question. The construction of the health status index is similar to the healthy eating index (HEI) developed by the USDA (2007). The analytical method used in this study is similar to the one used in the Economist Intelligence Unit's (2005) quality-of-life index study, i.e., we will construct a health status index, then related this index to a set of selected explanatory variables and examine the impacts of these explanatory variables on the index.

Health Measure Components

The health measure components used in this study are the ones commonly taken in doctors' offices, such as body height, body weight, blood pressure, cholesterol level, blood glucose, the number of common health problems the respondent had, and the respondent's subjective judgment of their health condition. The specific definitions of these measures are listed in Table 1.

[Insert table 1 about here]

The classifications for the body mass index (BMI) are the recognized categories established by the Centers for Disease Control and Prevention (CDC 2007a). The classifications for blood pressure are based on the American Heart Association's (2007) recommended blood pressure level for normal, prehypertension, and high blood pressures. The classifications for total cholesterol and HDL are based on the National Institutes of Health's ATP III guidelines for

primary target therapy. LDL was not used due to only selected participants examined in the morning had the LDL measures. The classifications of blood glucose are based on the A1c fraction (American Diabetes Association) and the CDC was contacted to assure the reported glycohemoglobin in the NHANES 2003-04 was indeed the A1c fraction. The general health condition is based on the answer to the question "Would you say your health in general is…" in the NHANES 2003-04. We also compiled a list of 36 common health problems based on the NHANES 2003-04 questionnaires.

Only the NHANES 2003-04 participants of ages equal-to-or-older-than 20 years and had both days of food intake information were used in the analysis. There were 4,043 participants who met these criteria. The detailed problems and the percent of respondents had the health problems are listed in Table 2. Table 3 shows the distribution of the number of these health problems that respondents had. In general, most respondents had only a few health problems, 42% of the respondents had one or less health problems and about 83% of the respondents had five or less health problems. The number of health problems a respondent had was used to classify him/her into three groups.

[Insert table 2 about here]

[Insert table 3 about here]

There are two main approaches have been used to assign weights. Data analytic techniques such as factor analysis provide weights for questions within identified factors (Olschewski and Schumacher 1990). Alternatively, there have been attempts to scale the state according to implicit and explicit personal valuation. Some arbitrary values have been assigned to ordered sets of health states. Past studies show that there is little to be gain by using scales comprising more than five points (Lissitz and Green 1975) and there is no clear advantage to use

the even or odd numbers of points (Remington et al. 1979). We used a scoring method to develop the health status index. We assigned three (3) points for each "Healthy" result, two (2) points for "Less Healthy," and one (1) point for "Unhealthy." The sample distribution of the scores for each of the health status index components are listed in Table 4. Using the health-measure components proposed in this study, about 30% of the participants were unhealthy except for the components general health and glycohemoglobin. As shown in Table 4, 45% of the participants felt they were healthy and 50% felt they were less healthy, and only 5% of the participants felt they were unhealthy. Based on the glycohemoglobin measure (A1c fraction), about 85% of the respondents were healthy and only 10% of them were unhealthy.

[Insert table 4 about here]

The health status index is the sum of the scores of these health-measurement components; with lower scores indicating less healthy and higher scores indicating healthier of the person of interest. The minimum possible points for the health status index are seven (7) and the maximum possible points are 21. As shown in Table 5, more than 50% of the respondents had a score of 16 and higher and the average score is 15.78.

[Insert table 5 about here]

Factors Affecting the Value of Health Status Index

In this section, we relate the proposed health status index in a multivariate regression to various factors that have been shown to be associated with health status in many studies. These factors include dietary habits, genetic makeup, socio-economic status, lifestyle, and quality of diet. Table 6 lists the variables included in the analysis and their definitions.

Socio-economic and demographic variables include household income, race, Hispanic origin, age, gender, education, and marital status. Note that NHANES 2003-04 did not report

household size; therefore, we cannot use per capita household income in the analysis. The dietary variables include the times the participant ate breakfast during the two-day recalls (IFICF 2007), the percent of total calories came from fats and oils, the percent of calories in beverages consumed that came from soft drinks, the percent of total calories that came from away-from-home food consumption, and the number of different vitamin supplements the participant took. In addition to dietary and socio-demographic variables, we also included a variable for smoking and a variable for the amount of exercises the participant did during the past 30 days. Smokers were categorized as "Never," "Light" or "Heavy" (Dye et al.; CDC 2003) according to how long they had currently smoked, or had smoked in the past (former smokers). The variable for smoking has a value from 1 to 3; heavy smoker has a value of 3, light smoker has a value 2, and non-smoker has a value of 1. Detailed definitions for these three groups of smokers are shown in the Appendix.

[Insert table 6 about here]

Previous studies suggest that physical activities are found to associate with significant reduction of excessive adiposity and improve health. NHANES 2003-04 collected leisure-time activity information of the participants. The leisure activity information includes the type of activities, number of times and average duration in minutes of the activity in the past 30 days, and a MET (Ainsworth et al.) score (intensity level) for the activity. To measure the exercise level, we convert leisure activities of exercise into MET scores using the following formula

Exercise = (number of times)*(average duration)*(Met score).

Table 6 shows the definitions and sample statistics of the variables used in the analysis. A multivariate weighted regression model using full sample weight was fitted with the proposed

health status index using the NHANES 2003-04 data. Table 7 presents parameter estimates and associated beta-coefficients (Goldberger 1964) for the regression.

[Insert table 7 about here]

Results show that demographic, dietary, and lifestyle factors are related to the proposed health status index. Gender did not have an impact on the value of the health status index. As respondent gets older, his/her health status index decreases at a decreasing rate. The estimated coefficients show that the influence of age on the health status index turns positive at around 94 years old, this is outside of the range of age in the sample, i.e., [20, 85]; therefore, it should not be a concern. Household income had a positive impact and marital status had no impact on the health status index.

The health status indices for non-Hispanic white respondents and Hispanics were not different from other races (mainly Asians); however, the health status indices for non-Hispanic blacks were lower than other races, an indication that non-Hispanic blacks were less healthy, in general. Respondents who had college education had higher health status index than those who had no college. Respondents whose household participated in the food stamp programs had a lower health status index than those who were not a food stamp participant.

Respondents who had breakfast during the two recall days had a higher health status index than those who did not eat breakfast. Results also show that as the percent of total calories in food consumed that came from fats and the percent of calories in beverages consumed that came from soft drinks increase, respondent's health status index decreases. Respondents who were on special diets either for losing weight or for other health reasons had a lower health status index than those who were not on special diets. As expected, the amount of exercise is

positively related to the health status index and smoking is negatively related to the health status index.

The last column in Table 7 shows the beta coefficients of the coefficient estimates. The beta coefficient is derived from the parameter estimate by multiplying the standard deviation of the associated regressor and dividing by the standard deviation of the response variable. This is usually done to answer the question of which explanatory variables have a greater impact on the dependent variable in multivariate regression analysis, when the variables are measured in different units of measurement. When we rank these beta coefficients by their absolute values, we found that age had the largest impact on the health status index, which is followed by special diets, college education, percent of total calories that came from fats, household income, percent of calories in beverages that came from soft drinks, the amount of exercise, smoking, being non-Hispanic black, and eating breakfast.

Concluding Remarks

In this study we developed a health status index using the commonly recorded health measures by doctors and hospitals. This health status index has a minimum possible value of 7 (the least healthy) and a maximum value of 21 (the healthiest). Using the NHANES 2003-04 data, we explored the relationship between this health status index and dietary habits, genetic makeup, socio-economic status, lifestyle, and quality of diet of the respondent.

A multivariate regression was conducted to explore the factors that influence of the value of the health status index. Regression results showed that as the age of the respondent, being non-Hispanic black, participants of food stamp programs, high percent of calories that came from fat intakes, high percent of calories in beverages that came from soft drinks, smoking, and on special diets are negatively related to the value of the health status index (i.e., the person

became less healthy); household income, college education, eating breakfast, and the amount of exercise are positively related value of the health status index (the person became healthier). These results indicate that the health status index developed in this study had the desired properties.

The health status index proposed in this study can be easily calculated from a set of commonly used health measurements. The higher the index, the healthier the person is. However, the difference between the health index values of two persons can only tell who is healthier than the other, but cannot tell how much healthier. In other words, the magnitude of the difference between the values of two health index for two persons has no direct meaning – the health status index proposed in this study is an ordinal measure. One may want to use the proposed health status index to track the average health status of a population over a period of time. For example, the NHANES data can be used to derive the health status indices and these indices can be used to monitor the general health status of the US population.

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Table 1. Components used in the proposed health status index

Body Mass Index

"Healthy" – normal weight with 18.5-24.9 BMI.
"Less Healthy" – underweight or overweight with <18.5 BMI (underweight) or 25.0-29.9 BMI (overweight).
"Unhealthy" – obese with ≥30 BMI.

Blood Pressure

"Healthy" – "normal" blood pressure, defined as systolic <120 mm HG AND diastolic <80 mm HG.
"Less Healthy" – "pre-hypertension" with a systolic between 120-139 mm HG OR a diastolic between 80-89 mm HG.
"Unhealthy" – "high blood pressure" with a systolic ≥140 mm HG OR a diastolic ≥90 mm HG or if the respondent took medication for blood pressure..

Total Cholesterol

"Healthy" – cholesterol <200 mg/dL (defined by NCEP as desirable).
"Less Healthy" – cholesterol between 200-239 mg/dL (defined by NCEP as borderline high).
"Unhealthy" – cholesterol ≥240 mg/dL (defined by NCEP as high) or if the respondent took medication for cholesterol.

HDL

"Healthy" – HDL cholesterol ≥60 mg/dL (defined by NCEP as high).
"Less Healthy" – HDL cholesterol between 40-59 mg/dL (between low and high NCEP definitions).
"Unhealthy" – HDL cholesterol <40 mg/dL (defined by NCEP as low) or if the respondent took medication for cholesterol..

Blood Glucose

"Healthy" – Glycohemoglobin ≤6.
"Less Healthy" – Glycohemoglobin >6 but <8.
"Unhealthy" – Glycohemoglobin ≥8 or if the respondent tool insulin or diabetic pills.

General Health Condition (Self-Reported)

"Healthy" – code of 1 or 2 (Excellent, Very Good).
"Less Healthy" – code of 3 or 4 (Good, Fair).
"Unhealthy" – code of 5 (Poor).

Health Problems

"Healthy" – had less than two health problems
"Less Healthy" – had two to four health problems
"Unhealthy" – had more than four health problems

Table 2. List of health problem and the percent of positive answers from participants.

Health Problems	%Yes	Age Covered
Receive healthcare over past year (≥ 3 times)	44.0%	0-150
Ever told you had high blood pressure	35.1%	16-150
Doctor told you - high cholesterol level	31.8%	16-150
Doctor said you were overweight	30.3%	20-150
Doctor ever said you had arthritis	28.4%	20-150
Limited in amount of work you can do	23.5%	20-150
SP ever had pain or discomfort in chest	21.1%	40-150
no. of days physical health was not good (≥ 5 days in past 30 days)	20.5%	12-150
Dizzy/balance/falling problems/past year	18.0%	40-150
Wheezing or whistling in chest - past year	14.1%	1-150
Ever been told you have asthma	12.5%	1-150
Overnight hospital patient/last year	11.2%	0-150
Doctor told you have diabetes	10.6%	1-150
Ever told you had a thyroid problem	10.3%	20-150
Ever told you had cancer or malignancy	9.7%	20-150
Leak urine during nonphysical activities	8.6%	20-150
Coughing most days - over 3 mo period	8.2%	12-150
Ever told had osteoporosis/brittle bones	7.6%	20-150
Diagnosed with prostate disease	7.6%	20-150
Do you still have a thyroid problem	7.3%	20-150
Ever told you had chronic bronchitis	6.5%	20-150
Ever told you had heart attack	5.5%	20-150
Ever told you had coronary heart disease	5.2%	20-150
Ever told you had angina/angina pectoris	4.2%	20-150
Ever told you had a stroke	3.9%	20-150
Ever told had congestive heart failure	3.5%	20-150
Ever told you had any liver condition	3.4%	20-150
Do you still have chronic bronchitis	2.9%	20-150
Ever told you had weak/failing kidneys	2.7%	20-150
Ever told you had emphysema	2.3%	20-150
Broken or fractured spine	2.0%	20-150
Broken or fractured a hip	1.7%	20-150
Hepatitis C antibody	1.7%	6-150
Do you still have a liver condition	1.7%	20-150
Ever told by doctor you had melanoma	0.6%	20-59
Received dialysis in past 12 months	0.2%	20-150

Table 3. Distribution of the number of health problems.

# Health Problems	Frequency	Percent	Cumulative	
			Frequency	Percent
0	940	23.25	940	23.25
1	760	18.80	1,700	42.05
2	585	14.47	2,285	56.52
3	460	11.38	2,745	67.90
4	355	8.78	3,100	76.68
5	263	6.51	3,363	83.18
6	210	5.19	3,573	88.37
7	142	3.51	3,715	91.89
8	122	3.02	3,837	94.90
9	81	2.00	3,918	96.91
10	53	1.31	3,971	98.22
11	27	0.67	3,998	98.89
12	22	0.54	4,020	99.43
13	13	0.32	4,033	99.75
14	6	0.15	4,039	99.90
15	1	0.02	4,040	99.93
16	1	0.02	4,041	99.95
17	1	0.02	4,042	99.98
18	1	0.02	4,043	100.00

Table 4. Sample distribution by health index components.

Score	Frequency	Percent	Cumulative	
			Frequency	Percent
BMI				
1 – Unhealthy	1,377	34.06	1,377	34.06
2 – Less Healthy	1,472	36.41	2,849	70.47
3 – Healthy	1,194	29.53	4,043	100.00
Blood Pressure				
1 – Unhealthy	1,677	41.48	1,677	41.48
2 – Less Healthy	802	19.84	2,479	61.32
3 – Healthy	1,564	38.68	4,043	100.00
Total Cholesterol				
1 – Unhealthy	1,205	29.80	1,205	29.80
2 – Less Healthy	1,103	27.28	2,308	57.09
3 – Healthy	1,735	42.91	4,043	100.00
HDL Cholesterol				
1 – Unhealthy	1,746	43.19	1,746	43.19
2 – Less Healthy	1,642	40.61	3,388	83.80
3 – Healthy	655	16.20	4,043	100.00
Glycohemoglobin				
1 – Unhealthy	393	9.72	393	9.72
2 – Less Healthy	208	5.14	601	14.87
3 – Healthy	3,442	85.13	4,043	100.00
General Health Condition				
1 – Unhealthy	205	5.07	205	5.07
2 – Less Healthy	2,032	50.26	2,237	55.33
3 – Healthy	1,806	44.67	4,043	100.00
Health Problems				
1 – Unhealthy	943	23.32	943	23.32
2 – Less Healthy	1,400	34.63	2,343	57.95
3 – Healthy	1,700	42.05	4,043	100.00

Table 5. Distribution of health status index.

Index	Frequency	Percent	Cumulative	
			Frequency	Percent
7	13	0.32	13	0.32
8	69	1.71	82	2.03
9	75	1.86	157	3.88
10	139	3.44	296	7.32
11	235	5.81	531	13.13
12	286	7.07	817	20.21
13	361	8.93	1,178	29.14
14	368	9.10	1,546	38.24
15	472	11.67	2,018	49.91
16	519	12.84	2,537	62.75
17	555	13.73	3,092	76.48
18	467	11.55	3,559	88.03
19	345	8.53	3,904	96.56
20	117	2.89	4,021	99.46
21	22	0.54	4,043	100.00

Table 6. Sample statistics

Variable	Definition	Mean	Std Dev
Health Index		15.149	2.925
Demographics			
Female	Female =1, otherwise=0	0.525	0.499
Age	Age in years	50.604	19.245
Age^2	Age squared	2,931	2,029
Income	Income in $1,000	43.527	27.459
Married	Married = 1, otherwise=0	0.554	0.497
Divorced	Yes = 1, otherwise = 0	0.226	0.418
College	College Ed = 1, otherwise = 0	0.469	0.499
Non-Hispanic White	White = 1, otherwise = 0	0.553	0.497
Non-Hispanic Black	Black =1, otherwise = 0	0.190	0.392
Hispanic	Hispanic = 1, otherwise = 0	0.231	0.421
Food Stamps	Food Stamps for HH = 1, else = 0	0.123	0.329
Dietary and Meal Pattern			
Breakfast	Times ate breakfast (0, 1, 2)	1.712	0.567
%Fat	% of total Kcal from fats	0.333	0.075
%Soft drinks	% of soft drinks in beverages	0.301	0.311
Vitamin	# of different types of vitamins took	1.699	3.824
Special Diets	Any diet either for lose weight or for health reasons (yes = 1; else = 0)	0.151	0.358
Lifestyle			
Exercise (000 MET)	See eq. (2)	3.506	7.524
Smoke	See appendix (1, 2, 3)	1.833	0.904

Table 7. Parameter estimates and β-coefficients

Variable	Parameter Estimate	Standard Error	β Coefficient
Intercept	22.5681*	0.3719	
Female	0.0215	0.0737	0.0038
Age	-0.1886*	0.0134	-1.1058
Age^2	0.0010*	0.0001	0.5686
Household Income	0.0059*	0.0015	0.0580
Married	-0.0311	0.1020	-0.0054
Divorced	0.0645	0.1282	0.0087
Non-Hispanic White	-0.0128	0.1902	-0.0020
Non-Hispanic Black	-0.3390**	0.2176	-0.0368
Hispanic	-0.1289	0.2145	-0.0144
College	0.3967*	0.0781	0.0693
Food Stamps	-0.5790*	0.1340	-0.0586
Breakfast	0.1776*	0.0645	0.0365
% Fat	-2.4005*	0.4742	-0.0645
% soft drinks	-0.4696*	0.1187	-0.0527
Vitamins	0.0090	0.0092	0.0124
Special Diets	-1.1524*	0.0972	-0.1496
Exercise	0.0180*	0.0049	0.0470
Smoking	-0.1264*	0.0426	-0.0396
R^2	0.3770		

*Statistically different zero at $\alpha = 0.05$ level.
**Statistically different zero at $\alpha = 0.10$ level.

Appendix: Definition for Smoking

Smokers were categorized as "Never," "Light" or "Heavy" (Dye et al.; CDC 2003). Taken into account was how long they had currently smoked, or had smoked in the past (former smokers).

- "Never (1)" – someone who has never smoked; answered the questions "Do you now smoke cigarettes" as "no" and "Smoked at least 100 cigarettes in life" as "no."
- "Light (2)" – someone who is a:
  - (1) Current smoker who has smoked <20 years; answered the questions "Do you now smoke cigarettes" as "yes" and "Smoked at least 100 cigarettes in life" as "yes" and "How many years smoked this amount" as "<20;"
  - (2) Former smoker who smoked <20 years; answered the questions "Do you now smoke cigarettes" as "no" and "Smoked at least 100 cigarettes in life" as "yes" and "How many years smoked this amount" as "<20."
- "Heavy (3)" – someone who is a:
  - (1) Current smoker who has smoked ≥20 years; answered the questions "Do you now smoke cigarettes" as "yes" and "Smoked at least 100 cigarettes in life" as "yes" and "How many years smoked this amount" as "≥20;"
  - (2) Former smoker who smoked ≥20 years; answered the questions "Do you now smoke cigarettes" as "no" and "Smoked at least 100 cigarettes in life" as "yes" and "How many years smoked this amount" as "≥20."