Adjusting Self-Assessed Health for Potential Bias Using a Random-Effects Generalized Ordered Probit model

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Abstract

We study how socioeconomic conditions, especially relative household income, affect self-assessed health. We use a random effects generalized ordered probit model with data from China Health and Nutrition Survey (CHNS) to test for heterogeneity in how people assess their health. The results show that individuals with high relative income are less likely to report poor health, but they are also less likely to report extremely good healthy. Although SAH capture many aspects of health elements, it might be biased on some socioeconomic features.

Keywords: SAH, Reporting Heterogeneity, relative income

1. Introduction

Self-assessed health (SAH) is a commonly used measure of individual health in a wide range of policy studies. It is often used to analyze how health responds to lifestyle and policy, as well as in distributional studies (Contoyannis and Jones 2004, Balia and Jones 2008, Costa-Font, et al. 2013). But it is often asked how well SAH adequately measures true health.

There is some evidence that SAH may be malleable depending on the survey method. Crossley and Kennedy (2002), using data from the Australian National Health Survey show that 28% of respondents in a random sub-sample which was surveyed twice changed their SAH level after giving answers to additional health related questions. Clarke and Ryan (2006) found a similar variation when SAH was again asked twice of respondents (the first in a personal interview and second in a self-completion survey). Greene at el. (2014) note an inflation of SAH. They found that “the overwhelming majority of responses fall in either the middle category or the one immediately to (its) ‘right’” and such responses are more favorable than should be expected given more objective medical indicators.

Because SAH is a subjective reporting index, there is also an immediate concern about heterogeneity in reporting. Shmueli (2003) show extensive reporting heterogeneity in SAH that depends on a large number of socioeconomic factors, including income. Vaillant and Wolfe (2012) find the difference between SAH and objective measures is more pronounced between individuals than it is within individuals over time. One possible explanation for socioeconomic related heterogeneity is a difference in reference groups or points, depending on their demographic and social-economic characteristics (Kerkhofs and Lindeboom, 1995; Lindeboom and Van Doorslaer, 2004). Lindeboom and Van Doorslaer (2004) proposes a test for differential reporting in ordered response models which enables to distinguish between cut-point shift and index shift using Canadian National Population Health Survey data. They find clear evidence of index shifting and cut-point shifting for age and gender, but not for income, education or language.

The hypothesis underlying the present paper is that individuals' assessment of their own health may depend on one's relative condition in one's subgroup. In research about happiness, Easterlin (1974, 1995) argues that within a country at a given time those with higher incomes are, on average, happier. However, raising the incomes of all does not increase the happiness of all because it is relative income not absolute income which affects happiness. We believe that SAH may have a similar relationship, where the comparison group for an individual might be defined by a localized reference group. To the extent socioeconomic variables like ethnicity and income determine a localized reference group, they would therefore affect SAH, an idea propagated in Wilkinson (1997).

In the research cited above, most papers use traditional Ordered Probit or Logit models, assuming that the coefficients of independent variables do not vary between categories of the dependent variable. This assumption conceals possible heterogeneous effects of some independent variables. In addition, none use relative socioeconomic status in the regression. To fill these gaps in literature, we use a Random-Effects Generalized Ordered Probit Model (Pfarr et al., 2011), to identify the correlation with SAH and how the cut-points in assessing health vary with socioeconomic factors. Most specifically, we are interested in how relative income influences self-assessed health status.

The rest of the paper is organized as follows Section 2 introduces the framework of the random effect generalized ordered probit model; Section 3 introduces the dataset and variables we use in the model, and also the descriptive analysis of the data; The results are discussed in part 4, and part 5 offers conclusions.

2. The Empirical Framework

The World Health Organization (WHO) defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, www.who.int/about/definition/en/print.html). Objective measures of health usually focus on disease or infirmity (the part of this definition that WHO categorically rejects as a whole measure of health) building functional indices founded on diagnostic, prognostic, and evaluative criterion (McDowell, 2006) or the incidence or absence of specific ailments. SAH, on the other hand, is more abstractly defined, with individuals asked to assign themselves to discrete categories that range from poor to excellent, often without much guidance. Underlying both objective measures of health and SAH is true health. Because one component of true health is the presence or absence of disease, it is likely that when people assess their health some objective measures of health go into that assessment. The random effect generalized ordered probit model that follows takes such behavior into account (Pfarr et al., 2010, 2011).

True health H_{it}^{*}, individual i’s health status in time t, is a unobserved latent variable governed by the equation

$$H_{it}^{*} = \alpha_i + X_{it}'\beta + \varepsilon_{it}, \varepsilon_{it} \sim N(0,1)$$

Where $X_{it}^{'}$ is a vector of independent variables which help determine true health (the variable included in $X_{it}^{'}$ will be introduced later). In the random effect panel data model α_i represents an individual effect with a zero mean and variance σ^2 so $\rho = \sigma^2 / (1+\sigma^2)$ is the share of total variability in ${H_{it}}^*$, attributable to the individual effect. The vector β are parameters and ε_{it} is a random term independent of individual characteristics. Included in the vector of independent variables are individuals' demographic and socio-economic features, lifestyle, genetic disposition, current ailments and diseases, and luck. Let ${H_{it}}^S$ be self-assessed health (SAH), an indicator usually got by survey. People are asked a question like "How do you think about your health status". Then they choose from a numerical scale to represent poor, fair, good and excellent health. In our data, SAH is given by a four point scale. We assume underlying the regression is the following decision;

$$
\begin{aligned}
&{H_{it}}^S = 1 \leftrightarrow {H_{it}}^* \le \mu_{i1} \\
&{H_{it}}^S = j \leftrightarrow \mu_{ij-1} < {H_{it}}^* \le \mu_{ij}\ ,\ j = 2, 3 \qquad (1) \\
&{H_{it}}^S = 4 \leftrightarrow {H_i}^* > \mu_{i3} \\
&\mu_{ij} = \mu_j + z_i'\gamma_j \qquad (2)
\end{aligned}
$$

which is a form of censoring. The μ_{ij}'s are unknown individual specific parameters to be estimated with β.

With four categories we have three thresholds; $\mu_{i1} = 0,\ \mu_{i2} = \mu_2 + z_i'\gamma_2,\ \mu_{i3} = \mu_3 + z_i'\gamma_3$ where γ_2 and γ_3 are parameters to be estimated and z_i is a subset of X_{it}. The model is equivalent to three binary logistic regressions where categories of the dependent variables are combined; to find μ_{i1} category ${H_{it}}^S = 1$ is contrasted against categories ${H_{it}}^S = 2,3,4$; for μ_{i2} categories ${H_{it}}^S = 1, 2$ are contrasted with ${H_{it}}^S = 3, 4$; and to find μ_{i3} categories ${H_{it}}^S = 1, 2, 3$ are contrasted against category ${H_{it}}^S = 4$ (Williams 2006). If γ_2 and γ_3 are nonzero, the thresholds are conditional on z_i, unlike the normal probit model where the thresholds are the same for all individuals.[1] Hence a generalized ordered probit model accounts for individual heterogeneity through the thresholds.[2] Imposing our functional forms for the thresholds we have

$$ {H_{it}}^S = 1 \;\; if \;\; {H_{it}}^* \leq 0 $$

$$ {H_{it}}^S = 2 \;\; if \;\; 0 \leq \; {H_{it}}^* \leq \mu_2 + z_i'\gamma_2 $$

$$ {H_{it}}^S = 3 \;\; if \;\; \mu_2 + z_i'\gamma_2 \leq \; {H_{it}}^* \leq \mu_3 + z_i'\gamma_3 $$

$$ {H_{it}}^S = 4 \;\; if \;\; {H_{it}}^* \geq \mu_3 + z_i'\gamma_3 $$

which gives the following probabilities

$$ P_1 = Prob\left({H_{it}}^S = 1 \,|X_i, Z_{it}\right) = \mathrm{F}(-\alpha_i - X_{it}'\beta) $$

$$ P_2 = Prob\left({H_{it}}^S = 2 \,|X_{it}', Z_{it}\right) = \mathrm{F}(\mu_2 + z_{it}'\gamma_2 - (\alpha_i + X_{it}'\beta)) - \mathrm{F}(-\alpha_i - X_{it}'\beta) $$

$$ P_3 = Prob\left({H_{it}}^S = 3 \,|X_{it}', Z_{it}\right) = \mathrm{F}(\mu_3 + z_{it}'\gamma_3 - (\alpha_i + X_{it}'\beta)) - \mathrm{F}(\mu_2 + z_{it}'\gamma_2 - (\alpha_i + X_{it}'\beta)) $$

$$ P_4 = Prob\left({H_{it}}^S = 4 \,|X_{it}', Z_{it}\right) = 1 - \mathrm{F}(\mu_3 + z_{it}'\gamma_3 - (\alpha_i + X_{it}'\beta)) $$

We use MLE and a corresponding log-likelihood function

$$ \begin{aligned} \ln L = & \sum_{H_{it}^S=1} F(-\alpha_i - X_{it}'\beta) + \sum_{H_{it}^S=2} \left[\mathrm{F}\left(\mu_2 + Z_{it}'\gamma_2 - (\alpha_i + X_{it}'\beta)\right) - F(-\alpha_i - X_{it}'\beta)\right] \\ & + \sum_{H_{it}^S=3} \left[\mathrm{F}\left(\mu_3 + Z_{it}'\gamma_3 - (\alpha_i + X_{it}'\beta)\right) - \mathrm{F}\left(\mu_2 + Z_{it}'\gamma_2 - (\alpha_i + X_{it}'\beta)\right)\right] \\ & + \sum_{H_{it}^S=4} \left[1\text{-}\mathrm{F}\left(\mu_3 + Z_{it}'\gamma_3 - (\alpha_i + X_{it}'\beta)\right)\right] \end{aligned} $$

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[1] The traditional ordered probit assumes the categories are "parallel" and differ only by the intercept. The generalized ordered probit does not impose this assumption, which is often violated in practice.

[2] It is common to report the results from Generalized Ordered Probit as (in our case) three different sets of estimates that include the thresholds in the estimates *of* β and then separately report the values of the γ_i. This is how we report our results in Tables 4A and 4B below.

3. Data

We use the data from China Health and Nutrition Survey (CHNS), which is an international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention. This survey was conducted in nine provinces in China for nine waves from year 1989 to year 2011. Among the dataset, there are 4 years of data reporting individual's self-assessed health (1997, 2000, 2004 and 2006) so we use these 4 years of panel data. Since some individuals were not surveyed every year, we use only those observations that have at least 3 years of data. After data cleaning, the effective dataset includes 22055 observations. Among them, 4665 observations are in year 1997, 4983 observations are in year 2000, 6401 observations are in year 2004, and 5997 observations are in year 2006.

3.1 Variables: A production function for SAH

We follow the theoretic framework in Contoyannis and Jones (2004) to choose variables for equations (1) and (2). Table 1 below shows the variables we include. For analytical purposes, we divided the variables into groups representing health behaviors, objective health measures, education, marital status, work status, physical and regional variables. Relative health was kept as its own group.

Health behaviors include variables that measure sleep, smoking, habits on alcohol consumption and exercise. Sleep is a dummy variable which takes a value 1 if an individual sleep 7 to 9 hours and takes value 0 otherwise. For smoking variables, we divide people into three kinds, current smoker, previous smoker and people who never smoked. Current smoker is the excluded category. We use two variables to indicate the alcohol consumption, "Alcohol_freq" and

“Alcohol_occa”. People who don’t drink Alcohol at all is excluded. The “Exercise” variable takes value 1 if the person participates at least one kind of exercise. The exercises in the survey included Kung Fu, Gymnastics, dancing, acrobatics, Track and field (running, etc.), swimming, Soccer, basketball, tennis, Badminton, volleyball and others.

For the objective health measures, the survey asked respondents if a doctor had ever told them they had one of five conditions, high blood pressure, Diabetes, myocardial infarction, Apoplexy, and Fracture.

(Insert Table 1. Independent variable)

Relative income is often considered a substitute for social class (Contoyannis and Jones 2004; Wilkinson 1997). Here we use people’s relative income in the same province[3].

Most other grouped variables are self-expanatory except for “Urban_hukou”. Hukou is a special concept in China for household registration. China has two kinds of Hukou that distinguishe people who live in city or urban area from people who live in rural area. Urban_hukou indicates the respondent is registered in an urban area.

3.2 Descriptive analysis

Table 2 presents the mean values of the variables by the four SAH subgroups. The subgroup reporting SAH=1 feel their health status is “poor”. SAH=2 means health level is “fair”; SAH=3 means health level is “good”; SAH=4 indicates health level “excellent”.

[3] We tried to use relative income within a respondent’s town, but that provided insufficient variability as incomes do not vary much within towns. Moreover, we believe people compare not just within their own community, but also to nearby communities.

Relative income is highly related to SAH status. Both “good” health and “excellent” health subgroups have above average incomes. People who assess their health as poor have income significantly lower than the average. However, the difference between the excellent and good health subgroups is less significant than the difference between other SAH subgroups.

Among the behavior variables, sleep has an ambiguous trend among the four SAH subgroups, while exercise has a clear increasing trend from unhealthy to healthy subgroups. From the exercise and habitat variables, we see people who feel healthy have a better habitat and do exercise more. The poor-health subgroup has a higher proportion of non-smokers and former smokers. People in the healthy subgroup have a higher rate of non-obesity.

Objective healthy measures are highly consistent with people’s SAH. People in the healthy SAH subgroups have lower morbidity rates of all the diseases we use. Especially for the excellent health subgroup, few people are diagnosed of those severe and chronic diseases. Individual’s average number of illness decreases from poor health group to excellent health group.

(Insert Table 2. Means of the variables)

People with higher education level tent to report higher levels of health. For example, the proportion of individuals with middle school, high school and college or university degree (or higher) increases as we move from unhealthy to healthy. However, a higher proportion of divorce and separation are observed in fair and good subgroups. The proportion of single people increases as we move to a higher health level.

A higher proportion of unemployed, house keeper, disable and retired people are observed in the “poor” health subgroup. Most specifically, the rate of unemployed in subgroup SAH=1 is much higher than that in other subgroups. The proportion of people doing agricultural labor work is higher in “poor” and “fair” health subgroup.

Physical condition and living conditions also have a clear trend. Those indicating they have excellent health are more likely to be male, younger and taller. And those indicating poor health and excellent health status are more likely to live in the urban areas.

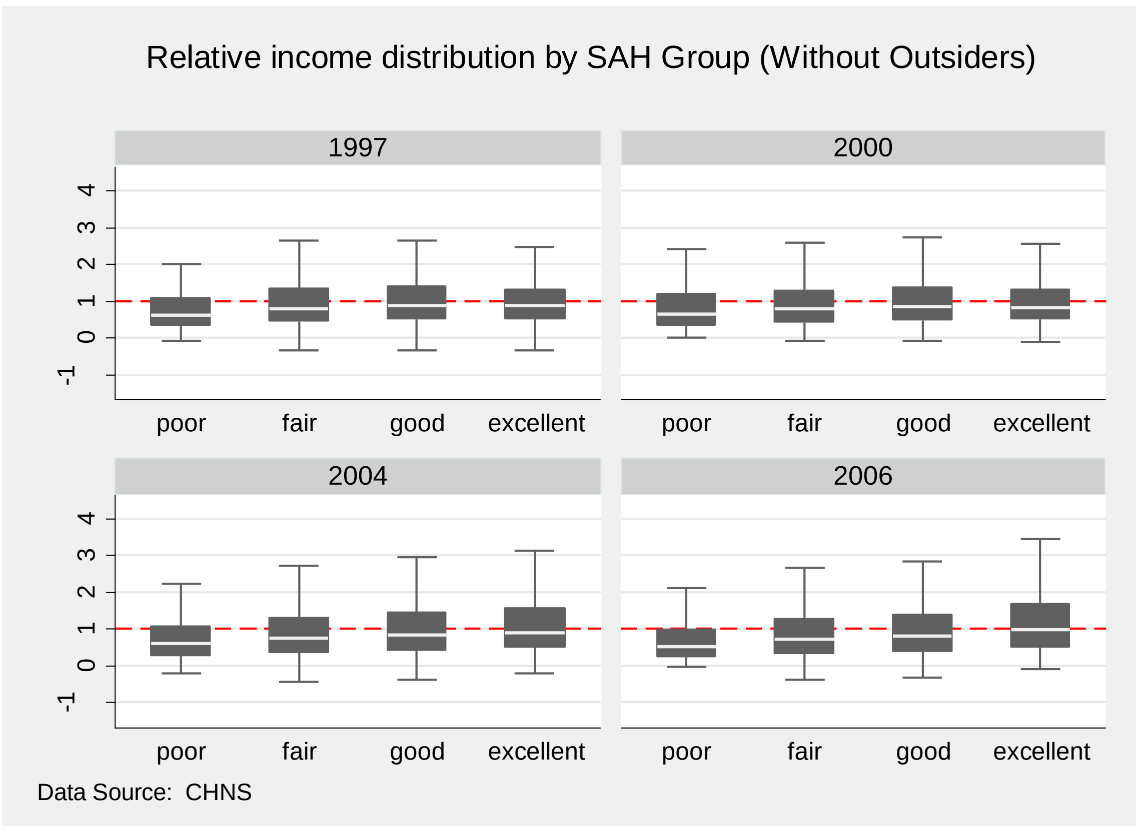

Figure 1. Relative household income distribution by SAH (without outsider)

The figure 1 shows the relative household income distribution by SAH subgroups in different years. The line in the box is the medium of the relative income of every subgroup. And the boxes represent the portion between the 25th percentile and the 75th percentile. In 1997, the box for the poor health subgroup is below the dashed line. It means most people who report poor health earn income below average. Usually, we expect that wealthier people would also be healthier group.

We do find the box of the poor health subgroup is lower than the other subgroups. However, the excellent health subgroup is not as rich as the good health subgroup. The same situation can be observed in year 2000. For year 2004 and 2006, though it's not so obvious in year 2004, a healthier subgroup goes along with a high value of relative household income. And year 2006 shows the most obvious trend. The boxes for the poor health subgroup are comparatively narrow. It means the variation of relative income in this subgroup is smaller than other subgroups.

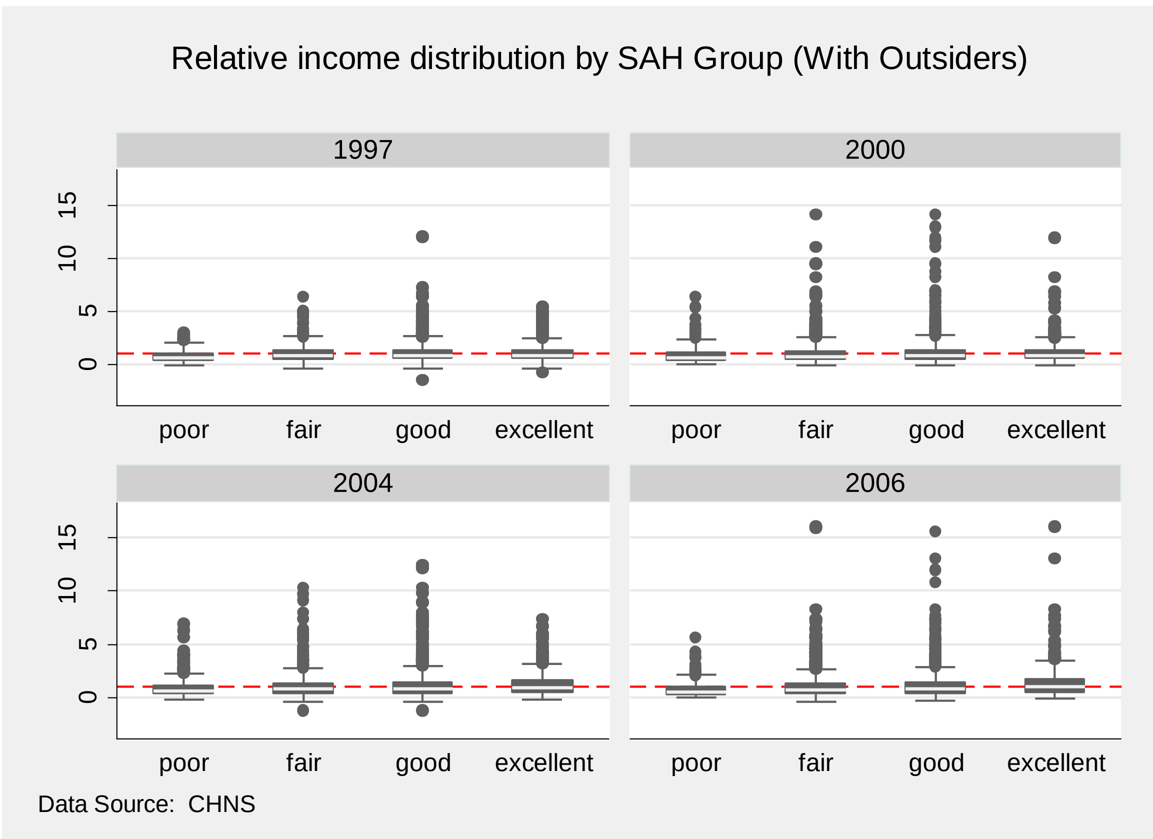

Figure 1. Relative household income distribution by SAH (without outsider)

In figure 1, we drop the outsider point for convenience to see the trend of the major boxes. Figure 2 includes the outsider points. Apparently, fair and good health subgroups show a large spread of relative income. Most people get extremely high relative income cluster in these two subgroups. The good health subgroup shows a largest spread.

Table 3 shows the correlation between the number of diagnosed illness and self-assessed health disaggregated by relative income. People diagnosed with more kinds of diseases are less likely to report good health, although the magnitude of correlation is small. We do note that the correlation becomes strong when relative income increases.

(Insert Table 3. Correlation between number of illness and SAH)

4. Results

Table 4A shows the results from two different regression models, a random effects ordered probit and a random effects generalized ordered probit. SAH is used as a measure of health. As we can see from table 4A, relative income, sleep, education degree of middle and high school, single, widow, unemployment, disable, Urban_Hukou, male, height, diagnosed of hypertension and apoplexy have different coefficients in the three parts of the generalized ordered probit model, i.e., these variables violate the parallel line assumption. Table 4B show the coefficient γ_2 and γ_3 of these variables derived from the estimates in Table 4A.

(Insert Table 4A. Random effect ordered probit and generalized ordered probit model)

We first pay attention to the variables that satisfy the parallel line assumption. The two smoking behavior variables have opposite effect; people who quit smoking are more likely to report poor health, while people who never smoke do not have a significant difference from current smokers.[4] The two alcohol behavior variables also have opposite sign coefficients, although only frequent use is significant at conventional levels. Frequent alcohol users report good health status.

[4] Poor health may lead people to quit smoking, creating an endogeneity problem with this variable that needs further exploration.

People usually doing exercise report better health than people who do not. Generally speaking, people with more education report they are healthier. Divorced and separated people tend to report poorer health than the base group, people who are married. Among the variables about working status, people unemployed, involved in housekeeping and disabled, people who shift work are all have worse self-assessed health than people work normally.

Of primary interest are those variables that violate the parallel assumption, especially relative income. The result suggests that those who have higher relative income tend to report better health. The positive effect of a relative income is especially high among those who report themselves to be poor health as opposed to fair, good, or excellent health. When translated to the γ coefficient (table 4B) it indicates that relative income lowers the threshold that pushes an individual to the next highest level of SAH, so those with higher relative income are more likely to be in the next highest category of SAH. Our interpretation of this is that wealthier people are more likely to say their health is better if their SAH is in the fair or good categories. Relative income is not statistically significant in the run comparing excellent health to the other categories. In sum, these results indicate that being relatively rich lowers the probability that people will self-assess their health as poor, but also does not increase the probability that they will assess their health as excellent.

Similarly, people who have a high-school degree are unlikely to say they are in poor health, but are also unlikely to say they are in excellent health. They tend to feel healthier, but the effect decrease as health level increases. The coefficients of good sleeping behavior are interesting. Generally, it has a positive effect for the individual to choose fair or good health against poor health level, but they are also unlikely to choose excellent health level compare to good, fair and poor. Living in an urban area increases the possibility for people to feel extremely healthy.

Compared to females, males are more conservative about their feeling of health. They tend to report healthy against poor health, but they are also unlikely to report extremely healthy. Tall people tend to feel healthier, and the effect becomes stronger when health level increases. All the disease variables make people feel unhealthy generally.

We also report ρ for both models in Table 4A. In both models, about 22 percent of total variation in SAH can be attributed to individual fixed effects. This translates to a variance of about 0.282 for α_i.

(Insert Table 5. Marginal effect of random effect generalized ordered probit model)

Table 5 provides the marginal effect of the random effect generalized ordered probit model. When relative income increases by 1, the probability of reporting poor health decreases by about 1% while the probability of reporting good health increases by 1.24%. In our dataset, the highest relative income is about 16 (a value of 1 means the respondent earns an average income). At that level the probability of reporting poor health is decreased by 15%, and the probability of reporting good health is increased by 15%. Education, as another important socioeconomic variable, also increases the probability of people reporting good health. Attaining a high school, technical or vocational degree increases the probability of reporting good health by 5%.

5. Conclusion

We use a random effect generalized ordered probit model to test for individual heterogeneity in self-assessed health. While several variables contribute to such heterogeneity, we focus on the influence of relative household income. Using data from the China Health and Nutrition Survey (CHNS), we find that people with high relative income feel better about their health and, more importantly, they have a lower threshold to assess that they have good health. People with high relative income are less likely to report poor health, but they are also less likely to report extremely healthy. The results imply that we should be careful when using SAH as a measurement of health in research, especially when we study the relationship between economic inequality and health. Although SAH capture many aspects of health elements, it might be biased on some socioeconomic features. The results of this study might raise more discussion about bias in SAH and how to adjust SAH as a measurement of individual health in economic and policy research.

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Table 1. Independent variable

Variable	discription
SAH	Self-assessed health
rltv_income	Household net income relative to the average income in the province
behavior	
Sleep	1 if sleep time is between 7 and 9 hours a day, otherwise set 0
Nonsmoker	1 if the person never smoke
Smokerquit	1 if the person smoked before but quit now
Alcohol_freq	1 if have alcohol more than once or twice a week
Alcohol_occa	1 if have alcohol less than once or twice a month
Exercise	1 if the person participate at least one kind of outdoor exercise
Objective	
Hyper	1 if the person is diagnosed of high blood tension
Diabetes	1 if the person is diagnosed of diabetes
MI	1 if the person is diagnosed of myocardial infarction
Apoplexy	1 if the person is diagnosed of apoplexy
Fracture	1 if the person has a history of bone fracture
Work	
unemp	1 if the person is totally unemployed
housekeep	1 if the person is unemployed but is a housekeep
disable	1 if the person is unemployed because he is disable
retired	1 if the person is retired
rehired	1 if the person is rehired after retired
Work shift	1 if the person change works after 2004
Ag_labor	1 if the person participate in one or more agricultural labor work
Education	
Educ_1	Highest level is elementary school
Educ_2	Highest level attained is middle school degree
Educ_3	Highest level attained is high school or technical or vocational degree
Educ_4a	Highest level attained is college and university or above
Marital status	
Single	1 if single and never married
Divorced	1 if get divorced
Widow	1 if the spouse died
Separate	1 if Separate
physical	
Male	1 if the person is male
Height	

Age	
Region	
Urban_hukou	1 if the person's "hukou" is urban

Table 2. Means of the variables

Variable	SAH=1 (obs=1341)	SAH=2 (obs=6905)	SAH=3 (obs=10999)	SAH=4 (obs=2810)
rltv_income	0.8009929	0.9944218	1.092314	1.133842
Behavior				
sleep	0.4198359	0.4764663	0.4164924	0.4320285
exercise	0.0574198	0.0855902	0.0981907	0.1241993
nonsmoker	0.7136465	0.702824	0.6626057	0.6327402
smokerquit	0.049217	0.0291093	0.0199109	0.0185053
alcoholfreq	0.1469053	0.2152064	0.2701155	0.3160142
alcohol_occa	0.0618941	0.0844316	0.0980998	0.0903915
nobese	0.9261745	0.939609	0.951541	0.9409253
Objective				
hyper	0.2281879	0.1229544	0.0466406	0.0270463
diabete	0.0611484	0.0196959	0.0069097	0.0017794
MI	0.0208955	0.0088444	0.0010926	0.0003561
apoplexy	0.0656227	0.0081101	0.0022729	0.0003559
fracture	0.0805369	0.0544533	0.0307301	0.016726
ill_num	0.4563758	0.2140478	0.0876443	0.0462633
Work				
unemp	0.1327368	0.0734251	0.0598236	0.0715302
housekeep	0.2013423	0.1562636	0.1017365	0.0814947
disable	0.0298285	0.0034757	0.0012728	0.0014235
retired	0.1700224	0.1338161	0.0776434	0.058363
rehired	0.00522	0.0060825	0.0084553	0.0081851
workshift	0.0290828	0.039971	0.0473679	0.0483986
ag_labor	0.284862	0.2912382	0.2309301	0.2053381
Education				
educ_1	0.2334079	0.2377987	0.2304755	0.213879
educ_2	0.1715138	0.24895	0.3173925	0.3548043
educ_3	0.1096197	0.1452571	0.1942904	0.2252669

educ_4a	0.01566	0.0267922	0.0337303	0.0466192
Marital status				
single	0.0350485	0.0457639	0.0695518	0.1160142
divorce	0.0067114	0.0098479	0.0084553	0.005694
widow	0.1342282	0.087328	0.0499136	0.0209964
separate	0.0014914	0.0017379	0.0018183	0.0007117
Physical				
age	56.52573	51.64374	45.13801	40.96192
BMI	22.60845	22.8279	22.97065	23.37462
height	157.3863	158.7348	160.6702	163.1306
male	0.3907532	0.422882	0.4969543	0.552669
Region				
urban_hukou	0.2923192	0.2773353	0.2614783	0.3014235

Table 3. Correlation between number of illness and SAH

rltv_income	<=0.5	>0.5 & <=1	>1 & <=2	>2 & <=3	>3
corr	-0.2226	-0.2284	-0.2316	-0.2644	-0.2894

Table 4A. Random Effect Ordered Probit and Generalized Ordered Probit

	Ordered probit	Generalized Ordered probit		
		1 vs. 2-4	1-2 vs. 3-4	1-3 vs. 4
sleep	0.091***	0.212***	0.075**	0.016
	(0.02)	(0.04)	(0.03)	(0.04)
nonsmoker	0.007	0.009	0.009	0.009
	(0.03)	(0.03)	(0.03)	(0.03)
smokerquit	-0.077	-0.072	-0.072	-0.072
	(0.06)	(0.06)	(0.06)	(0.06)
alcoholfreq	0.176***	0.175***	0.175***	0.175***
	(0.02)	(0.03)	(0.03)	(0.03)
alcohol_occa	-0.035	-0.036	-0.036	-0.036
	(0.03)	(0.03)	(0.03)	(0.03)
exercise	0.055	0.056	0.056	0.056
	(0.03)	(0.03)	(0.03)	(0.03)
nobese	-0.150***	-0.147***	-0.147***	-0.147***

	(0.04)	(0.04)	(0.04)	(0.04)
educ_1	0.057*	0.054	0.054	0.054
	(0.03)	(0.03)	(0.03)	(0.03)
educ_2	0.108***	0.217***	0.117***	0.040
	(0.03)	(0.05)	(0.03)	(0.04)
educ_3	0.141***	0.210***	0.175***	0.040
	(0.04)	(0.06)	(0.04)	(0.04)
educ_4a	0.157*	0.132*	0.132*	0.132*
	(0.06)	(0.06)	(0.06)	(0.06)
single	0.024	0.069	-0.049	0.096
	(0.04)	(0.09)	(0.05)	(0.05)
divorce	-0.128	-0.116	-0.116	-0.116
	(0.10)	(0.10)	(0.10)	(0.10)
widow	0.052	0.072	0.105*	-0.100
	(0.04)	(0.06)	(0.05)	(0.08)
separate	-0.122	-0.156	-0.156	-0.156
	(0.21)	(0.21)	(0.21)	(0.21)
unemp	-0.142***	-0.355***	-0.134**	0.006
	(0.03)	(0.06)	(0.04)	(0.05)
housekeep	-0.084**	-0.085**	-0.085**	-0.085**
	(0.03)	(0.03)	(0.03)	(0.03)
disable	-1.100***	-1.383***	-0.810***	-0.270
	(0.15)	(0.16)	(0.18)	(0.28)
retired	-0.014	-0.022	-0.022	-0.022
	(0.04)	(0.04)	(0.04)	(0.04)
rehired	0.262**	0.263**	0.263**	0.263**
	(0.10)	(0.10)	(0.10)	(0.10)
workshift	-0.161***	-0.157***	-0.157***	-0.157***
	(0.04)	(0.04)	(0.04)	(0.04)
ag_labor	-0.084***	-0.082***	-0.082***	-0.082***
	(0.02)	(0.02)	(0.02)	(0.02)
urban_hukou	0.020	-0.032	-0.009	0.088**
	(0.03)	(0.04)	(0.03)	(0.03)
male	-0.029	0.014	0.034	-0.144***
	(0.03)	(0.05)	(0.04)	(0.04)
height	0.016***	0.011***	0.013***	0.024***
	(0.00)	(0.00)	(0.00)	(0.00)
age	-0.019***	-0.015***	-0.021***	-0.017***
	(0.00)	(0.00)	(0.00)	(0.00)
hyper	-0.482***	-0.429***	-0.530***	-0.381***
	(0.03)	(0.05)	(0.04)	(0.07)
diabete	-0.713***	-0.716***	-0.716***	-0.716***
	(0.08)	(0.08)	(0.08)	(0.08)
apoplexy	-1.028***	-1.190***	-0.727***	-0.854*
	(0.10)	(0.12)	(0.14)	(0.39)

fracture	-0.404***	-0.406***	-0.406***	-0.406***
	(0.04)	(0.04)	(0.04)	(0.04)
rltv_income	0.033***	0.121***	0.038***	0.002
	(0.01)	(0.02)	(0.01)	(0.01)
time	-0.065***	-0.089***	-0.097***	0.011
	(0.01)	(0.02)	(0.01)	(0.02)
_cons	0.542*	0.995*	-0.368	-4.220***
	(0.27)	(0.46)	(0.31)	(0.38)
rho	0.219***		0.220***	
	(0.01)		(0.01)	
N	22055		22055	

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4B. Random effect ordered probit and Generalized Ordered probit model

Random Effect Generalized Ordered probit	gamma2	gamma3
sleep	-0.13744	-0.19625
educ_2	-0.10027	-0.17683
educ_3	-0.03429	-0.16947
single	-0.11776	0.027264
widow	0.033152	-0.17204
unemp	0.221356	0.361084
disable	0.573803	1.113395
urban_hukou	0.023093	0.120321
male	0.019478	-0.15827
height	0.001917	0.012777
age	-0.00664	-0.00235
hyper	-0.10078	0.048416
apoplexy	0.462588	0.335501
rltv_income	-0.08239	-0.11891
time	-0.00829	0.099602
_cons	-1.36292	-5.21511

Table 5. Marginal effect of random effect Generalized Ordered probit model

	Marginal effects for p(SAH=1)	Marginal effects for p(SAH=2)	Marginal effects for p(SAH=3)	Marginal effects for p(SAH=4)
sleep	-0.0170***	-0.00778	0.0222*	0.00263
	(0.00328)	(0.00897)	(0.00972)	(0.00612)
nonsmoker	-0.000726	-0.00223	0.00148	0.00147
	(0.00212)	(0.00650)	(0.00434)	(0.00428)
smokerquit	0.00616	0.0179	-0.0126	-0.0115
	(0.00510)	(0.0140)	(0.0104)	(0.00868)
alcoholfreq	-0.0134***	-0.0441***	0.0270***	0.0305***
	(0.00183)	(0.00632)	(0.00359)	(0.00458)
alcohol_occa	0.00303	0.00909	-0.00619	-0.00592
	(0.00268)	(0.00786)	(0.00549)	(0.00504)
exercise	-0.00439	-0.0140	0.00891	0.00946
	(0.00228)	(0.00753)	(0.00460)	(0.00521)
nobese	0.0108***	0.0369***	-0.0216***	-0.0261***
	(0.00271)	(0.0102)	(0.00521)	(0.00770)
educ_1	-0.00433*	-0.0136	0.00882*	0.00914
	(0.00218)	(0.00701)	(0.00442)	(0.00477)
educ_2	-0.0166***	-0.0220*	0.0318***	0.00675
	(0.00352)	(0.00982)	(0.00925)	(0.00643)
educ_3	-0.0155***	-0.0417***	0.0504***	0.00674
	(0.00399)	(0.0115)	(0.0109)	(0.00758)
educ_4a	-0.00979*	-0.0332*	0.0196*	0.0234*
	(0.00414)	(0.0154)	(0.00799)	(0.0116)
single	-0.00537	0.0217	-0.0330*	0.0167
	(0.00654)	(0.0156)	(0.0158)	(0.00921)
divorce	0.0103	0.0289	-0.0211	-0.0181
	(0.00938)	(0.0239)	(0.0191)	(0.0142)
widow	-0.00560	-0.0289*	0.0503**	-0.0158
	(0.00449)	(0.0140)	(0.0161)	(0.0115)
separate	0.0143	0.0387	-0.0292	-0.0238
	(0.0214)	(0.0509)	(0.0433)	(0.0291)
unemp	0.0364***	0.00888	-0.0462***	0.000936
	(0.00701)	(0.0133)	(0.0140)	(0.00859)
housekeep	0.00732**	0.0214**	-0.0150**	-0.0137**
	(0.00263)	(0.00726)	(0.00538)	(0.00451)
disable	0.268***	0.0116	-0.241***	-0.0385
	(0.0512)	(0.0572)	(0.0573)	(0.0340)
retired	0.00181	0.00549	-0.00370	-0.00360
	(0.00314)	(0.00941)	(0.00644)	(0.00611)
rehired	-0.0176***	-0.0658**	0.0335***	0.0499*
	(0.00534)	(0.0243)	(0.00853)	(0.0212)
workshift	0.0143***	0.0390***	-0.0292***	-0.0241***

	(0.00414)	(0.0100)	(0.00837)	(0.00580)
ag_labor	0.00687***	0.0204***	-0.0141***	-0.0132***
	(0.00208)	(0.00598)	(0.00426)	(0.00380)
urban_hukou	0.00264	0.000333	-0.0179*	0.0150*
	(0.00358)	(0.00890)	(0.00888)	(0.00591)
male	-0.00117	-0.0101	0.0350***	-0.0238***
	(0.00410)	(0.0106)	(0.0103)	(0.00692)
height	-0.000896***	-0.00339***	0.000349	0.00394***
	(0.000229)	(0.000580)	(0.000604)	(0.000389)
age	0.00121***	0.00593***	-0.00429***	-0.00285***
	(0.000134)	(0.000344)	(0.000348)	(0.000228)
hyper	0.0458***	0.137***	-0.130***	-0.0528***
	(0.00674)	(0.0136)	(0.0139)	(0.00748)
diabete	0.0957***	0.152***	-0.169***	-0.0793***
	(0.0149)	(0.0114)	(0.0210)	(0.00515)
apoplexy	0.209***	0.0426	-0.165***	-0.0868***
	(0.0330)	(0.0451)	(0.0474)	(0.0197)
fracture	0.0437***	0.0966***	-0.0857***	-0.0545***
	(0.00604)	(0.00955)	(0.0109)	(0.00468)
rltv_income	-0.00984***	-0.00287	0.0124***	0.000283
	(0.00172)	(0.00357)	(0.00359)	(0.00205)
time	0.00726***	0.0251***	-0.0341***	0.00176
	(0.00165)	(0.00423)	(0.00453)	(0.00281)
N	22055	22055	22055	22055

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$