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THE APPROPRIATE EMPIRICAL MEASUREMENT OF HEALTH STATUS

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Abstract

The present paper presents a methodological essay demonstrating how a person's health status can be ascertained empirically from the types of survey data available to economists. The main econometric problem is that health status is a latent variable, neither directly observable nor directly measurable. Analysts attempt to deal with this problem by using health proxies such as various mortality rates or morbidity measures including days-in-bed, work-loss-days, etc. But there is no indication of why the chosen proxies are adequate or are superior to their alternatives. The method introduced in this essay extends the concept of morbidity by conceptualizing health status in terms of illness. Illness itself can be measured by a real number that represents the illness severity. Empirically, actual diagnostic conditions, symptoms, as well as the limiting and debilitating effects of illness are incorporated in a multipleindicators-multiple-causes (MIMIC) structural equation model of the latent variable, severity-of-illness. For example, whether or not a person can climb a flight of stairs without help can be combined with knowledge of the person's age, etc. to learn something useful about the person's health status; so also are medical histories useful. A hindering problem in Nigeria is the nonavailability of appropriate data. For that reason, the present methodological essay uses data from the United States National Medical Care Utilization and Expenditures Survey for illustration.

[The previous version of this paper published in Eze and Uwakwe (2015) is an abridged version of this empirical study. This paper was published earlier in vol.4 #2 of 2016 pp.157-162 of this journal. The previous version had some production errors.]

INTRODUCTION

Most models of demand for health care include health status as an explanatory variable. But because health status is a latent variable, many empirical models simply use health proxies such as mortality rates (as regressors). Most models do not indicate the conceptual bases for their choices of proxies. This paper suggests a direct method of measuring health status from the types of survey data available to economists. The model depends on conceptualizing health status in terms of illness (see Eze 2013 reprinted with corrections as Eze 2016).

The present empirical model follows the practice of health professions who commonly consider diagnostic conditions, illness symptoms and other indicators of disease, disability or well-being in their effort to diagnose an illness (that is, to ascertain how ill a person is). The model uses actual diagnostic conditions, symptoms, as well as the limiting and debilitating effects of illness incorporated in a multiple-indicators-multiple-causes (MIMIC, Jöreskog and Goldberger, 1975) structural model. The empirical model employs Linear Structural Model for Latent Variables (LISREL, Jöreskog and Sörbom, 1989) regressions. The estimated coefficients can be used to predict the severity of illness for each person in the sample which can then be used compute aggregate illness severities of different hospitals, communities, etc.

Section 2 reviews the relevant health economics literature on measures of health status. Section 3 presents an empirical construction of severity of illness in a

MIMIC framework and describes the National Medical Care Utilization and Expenditures Survey (NMCUES, 1980) data set used in the empirical analysis. Results are presented in section 4 and the conclusion is in section 5. References are in section 6.

OVERVIEW OF THE ECONOMICS LITERATURE ON SEVERITY OF ILLNESS

In the health economics literature, there are models that use mortality rates to measure heath status. Examples include Riman and Akpan (2012), Onisanwan(2014), Yacub, Ojapinwa and Yussuf (2012), Eneji et al. (2013), etc. On the other hand, there an even many more models that measure health status in terms of morbidity. These include Manning et al. (1987), Newhouse and Phelps (1974), van de Ven and Hooijmans (1991), van de Ven and van der Gaag (1982), Wolfe and van der Gaag (1991, 1981), Kiiskinen (2002), Ataguba (2008), etc. The distinction is between morbidity and mortality measures of health status. Arrow (1963) advocated the applicability of individual optimization, common in neoclassical economics; thereby implicitly distinguishing between population health status (the object of public health programmes) and personal health status. Morbidity measures of health status are more useful because they can be applied to both individual and population analyses. For example, physiological indicators, functional limitations, etc. can take into account the quality of life of either the population or the individual. Mortality measures have little meaning for the individual consumer. Morbidity measures are also more meaningful because of the relevance to utilization of medical resources which is related to the severity of the person's illness. This includes the role of illness in determining a person's budget constraint through its effects on productivity and absenteeism, (see, for example, Horn and Sharkey, 1983). But regardless of whether health status is measured in terms of mortality or morbidity, most previous models follow Grossman (1972) to conceptualize health status as a health capital stock. The present paper conceptualizes health status differently, in terms of illness.

Explanatory variables in empirical models of medical care utilization have included such morbidity proxies for health status as work-loss days, number of sick days in bed, activity limitations and the person's perception of his own health (Wedig, 1988). Van de Ven and van Praag (1981) use an 'index of unhealthiness'. Manning et al., (1987); and Ataguba (2008) use of 'good, fair, poor' health. In using these morbidity proxies, Weisbrod (1991) cautions that a person is not sick if his or her health status cannot be improved or controlled with medical care (compare this with Williams 1981, p.273-4). This would be correct only if there were no other reasons (than medical care utilization) for wanting to ascertain the health status. Following a suggestion by Phelps (2013, p.35) that a typical person's health stock could decline from 'random events of illness and injury,' these ideas are expanded and formalized in this paper by conceptualizing illness and injury as a single health variable (Eze 2016, Dardanoni and Wagstaff, 1987).

THE EMPIRICAL MODEL: MEASUREMENT OF SEVERITY OF ILLNESS

Visualize a measure of the level of a person's health which assumes a particular value if the person is healthy and assumes a relatively lower value when the person is sick. The level of a person's health when he or she is healthy is denoted by the symbol

H^*, and is a datum that incorporates personal characteristics including age, gender, chronic health and genetic conditions, and 'characteristics existing prior to the onset of a specific illness but which are, per se, no reason for seeking health care' (van de Ven and van der Gaag 1982, p.173). H_i^* is a personal health benchmark. Also, let H denote person i's $_i$ actual level of health whether he is healthy or sick. Given these definitions, illness is defined as the fall of person i's health H_i from its benchmark H_i^*. The severity of person i's illness S_i is defined as the magnitude of this health deviation (see Eze, 2016). Symbolically,

1.1 $S_i \equiv H_{i^*} - H_i \geq 0.$

severity of illness S entails measuring the two levels of health H^* and H in Equation 3.1. The empirical problem is that all three health variables (S, H, and H^*) are latent variables. This section presents an empirical method of estimating S. The model is a multiple indicator, multiple causes model with observed proxies used as effects or indicators, as causes or as both causes and effects of the latent variables (Joreskog and Goldberger, 1975 p. 631). There do not seem to be established criteria (other than intuition) for sorting proxies into causes and effects. In this paper, the person's benchmark level of health H^* is represented with such proxies as the person's age, permanent income, gender, lifestyle, education, and chronic health and genetic conditions, etc. The person's actual level of health H has proxies similar to those for H^* except that H depends also on the presence and intensity of the person's
illness. That is,

3.2. $H^* = g(CHRONIC, AGE, PI, GENDER, EDUC, LIFEST) + e_1$

3.3. $H = g(CHRONIC, AGE, PI, GENDER, EDUC, LIFEST, DIAGN) + e_2$

where g(.) is a health function. CHRONIC is a vector of dummies for the presence of chronic health conditions. All chronic conditions reduce health, especially H^*. As for the current health condition H, some chronic conditions, such as diabetes, increase the probability of worsened conditions. Some medical care, such as insulin, is taken to prevent the worsening of conditions. According to Weisbrod (1991), medical care usage of this form by a person with incurable but controllable illnesses (for example, diabetes mellitus) is often thought to be truly inelastic; it is medical care above and beyond this fixed amount that is of policy relevance. Permanent income PI is intended to measure how easy a person's life is. Permanent income is itself a latent variable and may be a function of age, H^*, education, social class, family size, source of income, etc. (see van de Ven and van der Gaag, 1982). LIFEST is a vector of measures of the person's lifestyle including health habits such as smoking and body weight (Lillard et al. 1986). LIFEST also includes marital status, urban versus rural residence, number of full-time jobs, etc. Education EDUC is interpreted as an index of access – access to better jobs, better medical information, better athletic facilities, etc.; whereas in Grossman's (1972) model, education measures efficiency of health production. DIAGN is a vector of indicators of the presence and intensity of disease. The terms e_1 and e_2 are residuals with appropriate distributional assumptions.

Having derived the actual level of health H and the benchmark level of health H^* in equations 3.2 and 3.3 respectively, the severity of illness Scan be obtained from equation 3.1.

3.4. $S \equiv H^{*} - H = g(DIAGN) + e$

where equation 3.4 implies distributional and separability assumptions. Assume $e \equiv (e_2 - e_1) = N(0,)$, where is a positive definite matrix. Note that the normality assumption contradicts the assumption that $S \geq 0$ in Equation 3.1.

Imagine (following equation 3.4) that the severity of illness S is 'caused' by diagnostic conditions and those personal characteristics such as age, genetic and gender that are relevant to disease. Imagine also that the effects of illness as well as a person's self-assessment of his own health are the 'indicators' of severity of illness. For example, whether or not a person can climb a flight of stairs without help may indicate how ill or how old the person is, but the response to the question 'how do you feel' may depend on ill-health rather than age. Consider the following structural model:

3.5. $S = \alpha_1 C1 + \alpha_2 C2 + \alpha_3 C3 + \alpha_4 C4 + \alpha_5 C5 + \alpha_6 A1 + \alpha_7 A2 + \alpha_8 A3 + \alpha_9 A4 + \alpha_{10} A5 + \alpha_{11} A6 + \alpha_{12} AGE + \alpha_{13} HED + \alpha_{14} MCARAGE + \alpha_{15} MCAID + \omega$

3.6. $PH = \beta_1 S + u_1$

3.7. $DEAD = \beta_2 S + u_2$

3.8. $L1 = \beta_3 S + u_3$

3.9. $L2 = \beta_4 S + u_4$

3.10. $PEAGE = \beta_5 S + u_5$

The terms ’s and u’s can be interpreted as residuals due to uncorrelated measurement errors. $\omega \sim N(0,)$. S in equation 3.5 is a measure of the aggregate severity of the person’s illnesses combined. Each coefficient in equation 3.5 accounts for the influences of the corresponding variable on severity S, while coefficients in equations 3.6 to 3.10 each accounts for the reverse influences of severity S on the corresponding variable.

DATA SET AND DEFINITION OF VARIABLES

The data is cross-sectional and taken from the PERSON file of the public use tape of the United States National Medical Care Utilization and Expenditures Survey (NMCUES). NMCUES is a national household probability sample (augmented with samples drawn from Medicaid) of 17231 observations collected between early 1980 to mid 1981, and is published by the National Center for Health Statistics and Health Care Financing Administration. This paper uses the version published by ICPSR. The data set has information on each person's medical care utilization, diagnostic conditions, activity limitations, work loss, as well as socioeconomic and demographic variables.

The present study focuses on 4581 adult males aged twenty-two (22) years and older. In households with multiple males, only the highest-ranking male is included in the data. Members of a household are ranked as follows: 1 = head, 2 = spouse, 3 = parent, 4 = child, 5 = grandchild. Wedig (1988) uses the same data set to study adults 17 years and older, while Haveman, Stone and Wolfe (1989) uses the same data set to study adult males aged 22 to 71 years. Sixteen limitations and fifty-seven illnesses are listed in the PERSON file. Family sizes range from 1 to 13; 1.3% died; 4.5% were disabled veterans; 0.22% were institutionalized; 8% had no health insurance of any kind; and 10% were nonwhite; 88% had zero hospital admissions; and 24% had zero outpatient and nonhospital visits. In terms of hospital inpatient care, the highest 1% had more aggregate hospital nights than the lowest 97%. For the remaining descriptive statistics see Table 1.

DEFINITION OF VARIABLES

C1 – C5 are the first five principal components of the indicators of the following chronic health conditions: Malignant neopl lip, oral cavi & pharynx; malign neopl digestive organs & peritone; malig neopl respirat & intrathorac organ; malig neop bone, connec tiss skin& brea; malign neoplasm genitourinary organs; malign neoplasm oth & unspecif sites; malign neopl lymphat & haemopoietic tiss; endoc & metabolic diseases, immune disord; mental disorders; rheumatic fever & rheumatic heart diseas; hypertensive disease; ischaemic heart disease; disease pulmon circ & oth form heart dis; cerebrovascular disease; disease musculoskel system &connect tis; congenital anomalies.

A1 – A6 are the first six principal components of the indicators of the following acute (non-chronic) health conditions: intestinal infectious diseases; tuberculosis; other bacterial diseases; viral diseases; rickettsiosis & oth arthropodborne dis; oth infect & paras dis& lt eff infpara; nutritional deficiencies, diseases of the nervous system; disorders of the eye& adnexa; diseases of the ear & mastoid process; other diseases of the circulatory system; diseases of the upper respiratory tract; other diseases of the respiratory system; disease oral cavity, sally glands & jaws; diseases of oth parts of digestive system; diseases of the urinary system; diseases of male genital organs; diseases of skin & subcutaneous tissue; signs, symptoms& ill-defined conditions; fractures; dislocations, sprains, and strains, intracranial &intern injur, include nerv; open wounds & injury to blood vessels; poisonings& toxic effects; complication of medical & surgical care; other injur, early complication of trauma; late effect/injurpoi-tox effect-ext caus; part impair sens-ot spec impaiacc-injur.

L1 and L2 are the first two principal components of the indicators of the following limiting factors of illness: # of bed-days; # of days restricted activities; # of cond (ICD codes) reported during 1980; # of months limited; functional limitation scale score; # of perceived illnesses medically unattended; limitations of activity; limits vigorous activities person can do; limits person in any way; does health keep person from driving car?; limits travel around community unless assisted; does person have to stay indoors most of day?; is person in bed/chair for most of day?; does person have problem bending, lifting, or stooping?; has trouble walking one block, climbing few flights; limits walking unless assisted; limits kind or amount of work, homework or schoolwork; limited from working, housework or schoolwork; needs help eating, dressing, bathing, using toilet; limited in any (other) way in doing anything wants to.

FINC is the natural log of family income. Family income is adjusted by poverty level of participant's main family, as recorded by dividing the annualized income of participant's main family by the appropriate poverty level or imputed. Poverty level is determined by the gender, and age of the head of the family and by the average number of persons in the family.

HED is the level of education (schooling) of head of family or household in six ordinal categories: 1 = none, 2 = elementary, 3 = some high or secondary school, 4 = high school graduate, 5 = some university or post-secondary, 6 = university graduate. MCARE is a n indicator of whether a person is on Medicare for any interview. MCARE= 1 if the person is on Medicare, 0 otherwise. Qualification for Medicare is either through old age or through severe disability. An example is the need for renal dialysis. Hence, being on Medicare is a health indicator for persons under the age of sixtyfive years; thus, the product of indicators of Medicare and age-less-than-65, MCARAGE.

MCAID is an indicator of whether a person is on Medicaid for any interview. MCAID = 1 if the person is on Medicaid, 0 otherwise. Qualification for Medicaid (MCAID) is means-tested, but a person may be poor and, therefore, qualify for Medicaid, through the influence of illness on income. As such, being on Medicaid may be a health indicator.

PH is a person's perception of his health condition, in four ordinal categories: excellent, good, fair, poor.

DEAD is an indicator of whether a person died in 1980. DEAD is included because more-severely ill persons tend to die, relatively death during a time period may be an indicator of how severely ill the person was.

PE is percentage of family income earned in 1980. A low percentage of earned income may indicate an inability to work due to illness or old age. Therefore, the product of percentage-of-income-earned and age-lessthan-65 (PEAGE) is included.

DVET = 1 if person is a disabled veteran, 0 otherwise.

MS = 1 if person has a spouse, 0 otherwise.

RACE = 1 if person is white, 0 otherwise.

CITY = 1 if person resides in the inner city, 0 otherwise.

AGE = natural log of person's age.

FS = natural log of person's family size.

TABLE 1: DESCRIPTIVE STATISTICS

Variable	Mean	Std. dev.	Minimum	Maximum
FINC	18704.8	18511.1	0	600,000
FS	3	1.5	1	13
AGE	46.3	16.5	22	96
CITY	0.29	0.45	0	1
PRIV	0.84	0.37	0	1
MCAID	0.05	0.22	0	1
MCARE	0.19	0.39	0	1
RACE	0.9	0.3	0	1
HED	4	1.34	1	6
MS	0.81	0.4	0	1
COIN1	0.39	0.41	0	0.999
COIN2	0.015	0.088	0	0.999
DVET	0.045	0.21	0	1
PH	1.8	0.87	1	4
PE	0.72	0.4	0	0.999
DEAD	0.013	0.11	0	1

DISCUSSION OF ESTIMATED RESULTS The model in Equation 3.5 to Equation 3.10 is estimated by Maximum Likelihood methods using the statistical package LISREL 7. The estimates are presented below 'Potential' SOI estimates would use the full sample (rather than males, etc. as in the present essay) to obtain the coefficient estimates (Duan et al. 1984, Hensher and Milthorpe 1987):

4.1.

$$S \; \underset{(3.7)}{0.036 \times C1} + \underset{(18.1)}{0.208 \times C2} + \underset{(4.4)}{0.044 \times C3} + \underset{(3.8)}{0.038 \times C4} + \underset{(7.9)}{0.080 \times C5}$$

$$+ \underset{(8.8)}{0.088 \times A1} - \underset{(-0.9)}{0.009 \times A2} + \underset{(11.1)}{0.114 \times A3} + \underset{(10.7)}{0.109 \times A4} + \underset{(4.7)}{0.046 \times A5} + \underset{(2.5)}{0.025 \times A6} + ($$

$$DEA \; \underset{(5.0)}{0.078 \times S} + \eta_2$$

$$L1 \; \underset{(31.6)}{0.662 \times S} + \eta_3$$

$$L2 \; \underset{(11.9)}{0.191 \times S} + \eta_4$$

PH = S 1

$$PE \; \underset{(-36.5)}{-0.844 \times S} + \eta_5$$

4.2.

4.3.

4.4.

4.5.

4.6.

Each variable in equations 4.1 to 4.6 is measured as a deviation from the its respective mean, with the mean normalized to zero. The solutions are standardized. That is, the latent variable SOI is scaled to unit variance (see Joreskog and Sorbom, 1989, p.38). t-values of the individual coefficients are shown in parenthesis. The goodness-of-fit of the model is assessed with respect to the following. The total coefficient of determination is $R^2 = 0.785$, which is a measure of the strength of several linear relationships jointly. It measures how well the observed variables serve jointly as measurement instruments for the latent variable. $R^2 = 0.845$ for the structural equation model. Note that these R^2 values are only illustrative. Appropriate test statistic requires R^2's derived from models with intercepts. Estimated coefficients of determinants of SOI in equation 4.1 can be used to predict SOI for any individual in the data set. That task is left to the future.

CONCLUSION

The present study illustrates how the severity of a person's illness (SOI) can be estimated directly from the types of data sets available to economists. Given the symptoms, diagnostic conditions, and other indicators of a person's illness, it is possible to ascertain empirically the severity of a person's illness. The predicted SOI can then be used to as regressor variables in medical care utilization models. In such utilization models, persons with higher SOI would utilize greater medical care, all else equal. Also, SOI would be relatively higher for inpatient care users. A person demands zero medical care if he is not ill and does not expect to be ill. Stated differently, in a static non-stochastic model, medical care is demanded by persons with positive severity S rather than those with low H or low H^* as is the case with Grossman's model (Eze, 1991). That is a major conceptual difference between the present model and previous models. In a medical care utilization model, it is illness that enters the person's utility function.

Future research will apply the methodology of this model to obtain the aggregate severity of illness (ASOI) of a group of patients (such as a hospital) by calculating the aggregate or average SOI values across the group's (hospital's) patients. For example, a hospital has a higher ASOI if its patients are sicker on average. Such ASOI is important in determining differences in costs, quality or efficiency across hospitals. Depending on the intended purpose, a hospital's ASOI can even be estimated using the hospital's potential patient population (that is, the hospital's likely patient population) instead of the hospital's actual patient population. Lastly, if it is possible to measure a person's health status empirically, then it is possible to measure many other latent variables such as quality, utility, etc. According to Jöreskog and Sörbom (1989) (see also Aigner et al. 1984, p.1323):

"Most theories and models in the social and behavioural sciences are formulated in terms of theoretical and hypothetical concepts or constructs, or latent variables, which are not directly measurable or observable. However, often a number of indicators or symptoms of these variables can be used to measure the unobserved variables, more or less" (p. 76).

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