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EFFECTS OF FOOD AND HEALTH SPENDING PATTERNS ON THE HEALTH OF THE ELDERLY

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Abstract: Examines linkages between food and health spending patterns, income, and health status of the elderly. Links these relationships to food insecurity and expenditures on nutraceuticals. Methodology includes simultaneous estimation of expenditure systems and health production functions. Preliminary results indicate simultaneity between health production function and spending patterns throughout the life cycle.

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1. Introduction

The increasing proportions of elderly in the population, the rising life expectancy, as well as the aging of the population, are among the most interesting demographic changes in developed societies in the twenty first century. In the United States, the Census Bureau predicts that by year 2030 there will be nearly 70 million persons 65 years of age and older, representing a 100 percent increase relative to 1995. Moreover, the number of persons of age 85 and older will increase by 150 percent during this 35-year period. As the proportion of elderly increases, policy decisions affecting the well being of this vulnerable population group will affect all of society and the entire economy.

This study examines the simultaneous relationships among spending patterns, with particular emphasis on necessities (medical, food and housing), and health status of the elderly in the United States. It presents a theoretical framework consistent with utility maximization to examine the interdependence of demand for necessities and a health production function throughout the life cycle. In turn, an empirical model is constructed to investigate research questions such as the following: (1) As medical expenses increase as a proportion of the elderly household's budget, do those expenses crowd out (lower) expenditures on food? (2) Do higher medical expenditures also affect household food security as well as Food Stamp and other food program participation? (3) Does the increasing use of nontraditional medicine in the form of nutraceuticals (vitamins, minerals and herbs) substitute for medical and/or food expenditures?

Addressing these questions allows us to understand whether these choices worsen or enhance health outcomes and related medical expenditures.

The data are a sub-sample from the year 2000 Health and Retirement Study (HRS). This survey includes ample information on demographics, health care utilization, health status, employment, family structure, income, expenditures, participation in government programs, and event history. The sub-sample employed in this study consists of 1,160 individuals from the year 2000 HRS wave who responded the special module on utilization of nontraditional medicine. The empirical model is a simultaneous estimation of an expenditure system and a health production function to capture the linkages between expenditure choices and health outcomes, controlling for demographic and personal characteristics.

The study is organized as follows: Section 2 provides a review of relevant literature on the links between health and consumption patterns of the elderly. Section 3 derives the theoretical model. Section 4 describes the data and discusses the empirical model. Empirical results are discussed in Section 5 and Section 6 concludes with a discussion of policy implications, study limitations and extensions for future research.

2. Relevant Literature

2.1) Income, health and the elderly

Although linkages between income and health have been extensively studied in the health economics literature, relatively less research on this area has focused on the elderly. Deaton and Paxson (1998a, 1998b) have conducted research on life cycle patterns showing that health status is positively correlated with income but varies with age. This

correlation is weak among the youngest; increases up to age 60 and then starts to decrease. Their findings agree with Smith and Kington (1997), who apply the concept of a socioeconomic status-health gradient to show that health produces contemporaneous and long run feedbacks on economic status, implying simultaneity between these variables.

Other income-health status studies have focused on the elderly that are more vulnerable given their economic and health conditions. Zhang (1999) addresses the effect of income in determining health status in U.S. elderly Medicare beneficiaries. Stum et al. (1998) use the National Long-Term Care Survey to examine whether medical expenses are financially burdensome for disabled elders and to determine what factors are likely to put disabled elderly at risk of financial burden. Smith and Kington (1996) investigate the health outcomes resulting from alternative sources of income including the implications for gender, racial, and ethnic differences. In short, the health economics literature indicates that: (1) There is strong evidence that income is positively correlated with health status. (2) This relationship is simultaneous and changes during the life-cycle. Finally, (3), the most vulnerable groups (i.e. low income and/or deficient health) are likely to be at risk and therefore policy intervention might be required.

The literature on expenditure patterns of aging populations is another research area relevant to this study. Rubin and Nieswiadomy (1997) conducted a comprehensive examination of the expenditure patterns of the elderly in the United States showing significant differences over time between (1) elderly and non-elderly households, (2) retired and non-retired elderly households, and (3) elderly poor versus elderly non-poor. They conclude that, even though food is a necessity, food spending declines 1 percent for each year of age of the elderly, while increasing by 1 percent for each year of age of the

non-elderly, indicating that food expenditures might be crowded-out by other expenditures as income decreases with age.

The studies discussed above point out to the need of a theoretical framework consistent with utility maximization that reflects the interdependence between health and expenditure patterns of the elderly. Seminal work by Grossman (1972a, 1972b) provides an enticing framework to address this need. Grossman's model, inspired by earlier work optimal quantity of investment in human capital (Becker, 1993; Ben-Porath, 1967), rests upon the principle that consumers do not demand medical services but better health. Consumers therefore use various health-related inputs in a health production function in which the level of health is an object of choice. Moreover, Grossman was first constructing a model treating health as a stock arguing that health capital differs from other forms of capital. In particular, a person's stock of knowledge affects her productivity in market and non-market activities while the stock of health affect the amount of time available to produce monetary earnings and commodities.

Grossman's pioneering research was followed by a series of studies that conducted empirical tests his model, which is often referred to in the literature as the human capital model of the demand for health. Wagstaff (1986, 1993) and Erbsland et al. (1995) utilize principal component techniques to account for the several dimensions associated to health status and conduct empirical investigation employing European data. These studies find inconsistencies of the model when health is treated as a "pure consumption" good. These findings called the attention of Zweifel and Breyer (1997) to critique the model, which Grossman defended arguing that the aforementioned studies treated health stock as an exogenous variable. More recently, empirical work by Stratmann (1999), contributes to

Grossman's argument. The author examines the effect of medical care inputs in the production of health demonstrating endogeneity of medical services. That is, the utilization of medical services tends to *increase* work loss days when they are examined in a simple regression framework; conversely, allowing for endogeneity implies that medical services indeed tend to *decrease* work loss days.

There have also been important theoretical extensions to Grossman's 1972 model. Muurinen (1982) addresses earlier criticisms of the model by incorporating both the investment and consumption nature of the demand for health. Most recent contributions, on their part, introduce uncertainty in the original model, based on the principle that risk-averse persons make larger investments in health relative to risk-neutral individuals (Dardanoni and Wagstaff, 1987; Selden, 1993; Chang, 1996). These theoretical extensions, however, have not been incorporated into empirical specifications of the model (Grossman, 1999).

Our study argues that it is possible to employ the human capital model of the demand for health to examine the interdependence of health and expenditure patterns of the elderly. Moreover, this literature review clearly indicates the need for further research on the economics of aging. Extensive research has been conducted on the relationship between income and health and several articles have estimated expenditure functions of the elderly. Nevertheless, the question still remains regarding how changes in expenditure patterns affect health outcomes of the elderly. This study argues that it is possible to employ the human capital model of the demand for health to examine the interdependence of health and expenditure patterns of the elderly. This research addresses this gap in the literature by simultaneously estimating an expenditure system -- in which the

substitutability between food and health expenditures is a key issue -- and a health production function to capture the linkages between expenditure choices and health outcomes. Additionally, our empirical model contributes to the discussion on three relevant policy issues presented in turn.

2.2) Three relevant policy issues

From a policy perspective, at least three related issues relevant to the study of the elderly can be investigated employing Grossman's framework. One is whether increasing medical expenses expose the elderly to food insecurity, and therefore increase the need for subsidized food programs. The second is whether the increasing out-of-pocket expenditures on prescription drugs, now approximately 50 percent of total out-of-pocket medical spending, are generating additional stresses on elderly budgets. The third is to link spending patterns and health outcomes to the use of non-traditional medicines in the form of nutraceuticals. We address each, in turn, below.

According to Dwyer, Mayer and Cook (2001), after the seminal work by Burt and Cohen (1993), little research has been done on the causes and consequences of food insecurity of the elderly. The Food Security Measurement Study of the U.S Department of Agriculture conducted by Hamilton et al. (1997) is the most recent measure of food insecurity among the elderly with somewhat surprising results. Household structure greatly affects the incidence of food insecurity. The study shows that households with elderly people and no children had the lowest incidence of food insecurity among all households in 1995 (5.9 percent). In contrast, the incidence of hunger of elderly living alone was the highest among all households (8.2 percent were food insecure and 2.8 experienced hunger). Food insecurity was even higher among old women living alone.

These incidence rates, Hamilton et al. emphasize, are nearly 40 percent higher than those corresponding households with elderly but no children. Moreover, as the proportion of elderly in the population increases, those elderly households will challenge policy makers to devise efficient ways to avoid increasing income inequalities among age cohorts. It is important to point out that these food insecurity measures have not been linked to health outcomes in the past, as is proposed in this study. Dwyer, Mayer and Cook (2001) point out the need to refine measures of food security incidence among the elderly and encourage researchers to identify who among them are in need of some type of assistance to better target public programs. This literature also suggests that aggregate measures of food insecurity might be misleading and it is necessary to take into account particular family, health and economic characteristics when designing policies aimed at improving the welfare of the elderly.

The increase in both absolute dollars and in the proportion of out-of-pocket medical expenditures spent on prescription drugs by the elderly has led to vigorous policy debate regarding whether Medicare should be expanded to include a prescription drug component. While these rising costs are clearly of concern, a related concern is the extent to which rising prescription drug expenditures effectively crowd out expenditures on food. We can contribute further information to this policy debate by delineating the extent to which this crowding out may occur and it's concomitant affect on health status.

The third related issue is the increasing use of nutraceuticals. Nutraceuticals are foods or food ingredients that purport to provide health benefits by either preventing or curing disease. These novel products are relevant to the investigation because they are blurring the line between food and drugs. Nutraceutical products represent the fastest

growing segment of the food industry, due to the combination of increased consumer demand for healthy foods with nutritional and nutraceutical advances in medical science (Childs, 1999). According to Adelaja and Schilling (1999), the drivers of nutraceutical industry growth are the improved knowledge of diet-related disease among the public; the changing demographics, in particular as "baby-boomers" approach an age wherein health care is a priority issue; and the increasing trend towards personal responsibility for health, which emphasizes disease prevention over illness treatment. With the continuing fast growth of the nutraceutical industry and given that these products may be substitutes for traditional medicines and compete for consumer expenditures on food, the policy relevance of including this category in our research is warranted.

3. Theory

Our model builds upon the stock approach to the demand for health (Grossman 1972a, 1999; Muurinen, 1982) together with a system of demands for necessities. The motivation is that consumers do not demand medical services *per se* but to improve their health. This implies that examining variables related to medical care markets only is insufficient to understand the economics of the demand for health. The model, therefore, treats health as a stock variable in which individuals inherit an initial stock of health that depreciates over time and that they can modify by choosing a level of investment on medical care inputs. Although health is a component of the broad definition of human capital stock, essential differences with respect to the stock of knowledge make it necessary to model health in a different manner.

Each consumer maximizes an inter-temporal utility function of the form:

$$U = U(h_0, h_1, ...h_T, Z_0, Z_1, ...Z_T), \quad (1)$$

where $\boldsymbol{Z_t}$ is a vector of commodities (food, housing, and other goods) and h_t is the services of the stock of health (e.g. number of healthy days in a given year or an index of health status). Here, h_t is produced as a function of the health stock H_t according to the function $h_t = \boldsymbol{F}_t(H_t)$, with $\boldsymbol{F}_t^{'} > 0$. Changes in the stock of health are defined by the motion function

$$H_{t+1} - H_t = I_t - \boldsymbol{d}_t H_t, \quad (2)$$

where I_t is gross investment in health and $\boldsymbol{d}_t$ is the depreciation rate of health at time t with $0 < \delta_t < 1$. The model assumes that the depreciation rates are exogenous but depend on age. Consumers produce gross investments in health according to the household production function

$$I_t = I_t(M_t, TH_t; D_t), \quad (3)$$

where M_t is a vector of inputs purchased in the market that contribute to the person investments in health at time *t* (e.g., doctor visits, pharmaceuticals, nontraditional medicine, etc.), TH_t is time input, and *D* is a vector of demographic characteristics that are assumed exogenous.

Both market goods and time are scarce resources. The budget corresponding to market goods equates the present value of expenditure on market goods equal to the present value of life-time earnings income plus initial assets:

$$\sum_{t=0}^{T} \frac{PM_t^{'} M_t + PZ_t^{'} Z_t}{(1+r)^t} = \sum_{t=0}^{T} \frac{W_t TW_t + R_t TR_t}{(1+r)^t} + A_0 \ , \quad (4)$$

where PM'_t and PZ'_t are transposed vector of prices for health inputs and other market goods respectively; W_t and R_t represent the income of working and retired individuals

respectively; TW_t and TR_t are the amount of time spent working or retired and A_0 is amount of initial assets. Note that the budget constraint (4) takes into account both income from work and retirement earnings, thus extends Grossman model incorporating the value of healthy time of retired individuals to enjoy their retirement. The time constraint implies that total time available is allocated across working time (TW), retired time (TR), illness time (TL) and time investment in the production of health (TH):

$$\Omega = TW_t + TR_t + TL_t + TH_t . \tag{5}$$

If we assume that $\partial TL_t / \partial H_t < 0$ (i.e., sick time and stock of health H are inversely related), that the unit of observation is days per year (i.e., $\Omega = 365$), and if φ_t is the flow of healthy time per unit of health stock H_t, then h_t is the number of healthy days in a given year, and $TL_t = \Omega - h_t$. In order to obtain an expression of a full wealth constraint of an individual who could be economically active, retired, or both (i.e. partially retired), assume that the cost of the illness time as well as the time devoted to the production of health is distributed proportionally across retired and working time

$$\pi_t = \frac{TW_t}{TW_t + TR_t}(TL_t + TH_t), \tag{6}$$

where π_t is the proportion at rate W_t and $(1-\pi_t)$ is the proportion at rate R_t. Using this assumption and substitution TW_t from (5) into (4) yields the full wealth constraint:

$$\sum_{t=0}^{T} \frac{PM_t' M_t + PZ_t' Z_t + \pi_t W_t (TL_t + TH_t) + (1-\pi)_t R_t (TL_t + TH_t)}{(1+r)^t} = \sum_{t=0}^{T} \frac{\pi_t W_t \Omega + \pi_t R_t \Omega}{(1+r)^t} + A_0 . \tag{7}$$

The consumer therefore chooses the stock of health H_t and the demand for market goods Z_t that maximizes the utility function (1), subject to the health stock motion

equation (2), the health production function (3) and the full wealth constraint (7). The first order conditions to the maximization problem in period t-1 are:

$$\frac{\pi_{t-1}}{(1+r)^{t-1}} = \frac{\gamma_t \phi_t}{(1+r)^t} + \frac{\gamma_{t+1}\phi_{t+1}(1-\delta_t)}{(1+r)^{t-1}} + ... + \frac{\gamma_T \phi_T (1-\delta_{T-1})}{(1+r)^T} + \frac{\phi_t}{\lambda} Uh_t + \frac{\phi_{t+1}}{\lambda} Uh_{t+1}(1-\delta_t) + ... + \frac{\phi_T}{\lambda} Uh_T (1-\delta_t)(1-\delta_{t+1})...(1-\delta_{T-1}) \quad (8)$$

$$\pi_{t-1} = \frac{PM_{1,t-1}}{\partial I_{t-1} / \partial M_{1,t-1}} = \frac{PM_{2,t-1}}{\partial I_{t-1} / \partial M_{2,t-1}} = ... = \frac{PM_{M,t-1}}{\partial I_{t-1} / \partial M_{M,t-1}} = \frac{\gamma_{t-1}}{\partial I_{t-1} / \partial TH_{t-1}} \quad (9)$$

$$\frac{PZ_{1,t-1}}{\partial U_{t-1} / \partial Z_{1,t-1}} = \frac{PM_{2,t-1}}{\partial U_{t-1} / \partial Z_{2,t-1}} = ... = \frac{PM_{N,t-1}}{\partial U_{t-1} / \partial Z_{N,t-1}} \ , \quad (10)$$

where $\varphi_t = \partial h_t / \partial H_t = -(\partial TL_t / \partial H_t)$ represents the marginal product of the stock of health in the production of healthy time; π_{t-1} is the marginal cost of gross investment in health in period t-1, $Y_t = \theta_t W_t + (1-\theta_t) R_t$ is weighted earnings rate distributed among wage and pension earnings; λ is the marginal utility of wealth; ($PM_{i,t-1}$, $M_{i,t-1}$) with i=1,…M, represents the price and quantity of the input i in the health production function; and ($PZ_{j,t-1}$, $Z_{j,t-1}$) with j=1,…N, represents the price and quantity of the market commodity j.

Equation (8) states that present value of marginal costs of investments must equal present value of marginal benefits. Equation (9) is simply the conditions to minimize the cost of a given amount of gross investment, while equation (10) is the maximization condition for other consumption goods in the utility function. To facilitate interpretation of equation (8), note that the discounted marginal benefits at age t are $\phi_t \left(\frac{\gamma_t}{(1+r)^t} + \frac{Uh_t}{\lambda} \right)$. The expression in brackets consists of two terms because consumers desire health for two reasons: the first represents the monetary value of a one-unit increase in time available (for

both market and non-market activities) and the second is the monetary value of increased utility due to an additional unit of healthy time. Finally, it can be shown that from the first order conditions (8)-(9) can be expressed as

$$\gamma_t + \zeta_t = r - \tilde{\pi}_t + \delta_t, \tag{11}$$

where $\gamma_t \equiv \phi_t \psi_t / \pi_{t-1}$ is the marginal return to investments in health in monetary terms and

$\zeta_t = [(Uh_t / \lambda)(1+r)^t \phi_t)] / \pi_{t-1}$ defines a "psychic" rate of return; $\tilde{\pi}_t$ is the percent rate of change of marginal cost between *t-1* and *t* and δ_t is the depreciation rate of health.[1] Expression (11) states that in equilibrium, marginal benefits (monetary and non-monetary) equal the marginal cost of capital in terms of the gross investment. Because it includes the individual interest rate (r) and the rate of health's depreciation (δ_t), the right-hand-side represents the opportunity cost of health capital.

4. Empirical Model

4.1) Specification

The stock of health of a particular agent produces a flow of healthy days in a given year, namely h_t. Assume that the function governing the relationship between the stock and the flow of healthy days (Φ) is of the form $h_t = 356 - aH_t^{-b}$, where a and b are constants and $0<b<1$. The marginal product of the health stock is therefore $\phi_t = abH_t^{(-b-1)}$, which expressed in logarithmic form yields

$$\ln(\phi_t) = \ln(ab) - (b+1)\ln(H_t), \tag{12}$$

[1] See Grossman (1972a, p.7) for a detailed discussion on the derivation of equation (11).

and assume that the health gross investment function is of a Cobb-Douglas type implying homogeneity of degree one:

$$I_t = AM_{1,t}^{a_1} M_{2,t}^{a_{21}} ... M_{M,t}^{a_M} TH_t^{1-\sum_{i=1}^{M} a_i}. \quad (13)$$

It is therefore possible to employ the following structural equations:

$$\ln H_t = \varepsilon \ln \varphi_t - \varepsilon \ln \pi_t - \varepsilon \ln \delta, \quad (14a)$$

$$\ln \delta_t = \ln \delta_0 + \tilde{\delta} t, \text{ and} \quad (14b)$$

$$\ln I_t = \ln A + \alpha_1 \ln M_{1,t} + \alpha_2 \ln M_{2,t} + ... + \alpha_M \ln M_{M,t} + (1 - \sum_{i=1}^{M} \alpha_i) \ln TH_t. \quad (14c)$$

Equation (14a) is obtained by employing equations (11) and (12) and solving for lnH_t, and by assuming that the interest rate as well as the percent change in the marginal cost of gross investment are zero (i.e., $r = \tilde{\pi}_{t-1} = 0$). It represents the demand for the stock of health in a given year. Equation (14b) is the depreciation rate function so age is endogenized. Equation (14c), which is the gross investment in logarithmic form, includes the qualitative properties such as personal, family and demographic characteristics of the individual.

Given the structural equations (14a)-(14c) and the system of demand for market goods included in vector Z_t of the utility function, the empirical model corresponding to a sample of individuals in a particular year (eliminating the subscript t since data are cross section observations) yields:

$$\ln H = a_{1,H} + a_{2,H} \ln y + \sum_{m=1}^{M} b_{m,H} PM_m + c_H t + \sum_{j=1}^{J} d_{j,H} D_j + u_1, \quad (15a)$$

$$\ln M_m = a_{1,M} + a_{2,M} \ln y + \sum_{m=1}^{M} b_{m,M} PM_m + c_M t + \sum_{j=1}^{J} d_{j,M} D_j + e_M \ln H + u_{2,m} \; for \; m = 1,...M \,,$$

(15b)

$$\ln Z_n = a_{1,Z} + \sum_{n=1}^{N} f_{n,Z} PZ_n + c_Z t + \sum_{j=1}^{J} d_{j,Z} D_j + u_{3,n} \qquad for \; n = 1,...N \,,$$

(15c)

where *M*, *N*, and *J* are the number of health related inputs, market goods and personal characteristics, respectively. Equation (15a) is the demand for health; equations (15b) are the household's supply of health inputs and equations (15a) is the demand system for market goods.

4.2) Data and Variables

The data are from the year 2000 Health and Retirement Study (HRS). The Institute for Social Research (IRS), University of Michigan, collects these longitudinal data for the National Institute of Aging. This is a national panel study with an initial sample of about 22,000 residents of the United States over the age of 55. The survey includes ample information on demographics, health care utilization, health status, employment, family structure, income, expenditures, participation in government programs, and event history. Thus, it is possible to construct variables to examine the dynamic relationship between expenditure patterns and health status as people age, controlling for other factors such as employment, family conditions, and event histories.

Table 1 summarizes results from our preliminary analysis of the data. The sample is divided into four groups according to age: (1) people born before 1924 that today are 78 years of age or older, (2) people born between 1924 and 1931, called "Children of the Depression Age" (CODA), who today are between 71 and 77 years of age; (3) people born

between 1932 and 1941 or between 60 and 70 years of age, and (4) “war babies”, 55-59 years of age, representing people born between 1941 and 1947. The health index is a self-reported health status in a scale ranging from 1 (excellent) to 5 (poor).

Table 1a shows that health, food insecurity incidence, as well as income tend to decrease with age. Examination of the categories of expenditure shares of household income indicate that medical and food expenditures are positively correlated with age while housing and other expenditures have an inverse correlation with age. Two-tailed t tests were conducted for all variables to identify significant differences between their means across age cohorts. Results indicate that means are significantly different in all cases, except for housing expenditures between cohorts 54-59 and 60-70 years of age.

Tables 1b – 1d show the same information as 1a but divide the sample into three income groups, low-income (annual income lower than $10,000), middle-income (annual income between $10,000 and $21,000) and high-income groups (annual income of more than $21,000). Controlling for income shows several substantial differences compared to Table 1a. For instance, for the low income group, self-reported health status as well as the food expenditure shares are not statistically different for persons less than 78 years of age (i.e., the three youngest age cohorts). For the middle-income group, in turn, mean health status and mean food expenditures shares are not statistically different for groups 60-70 and 71-77 years of age. Furthermore, with the exception of members of the high-income group, food insecurity decreases with age and while the food expenditure shares tend to increase with age for the entire sample (Table 1a), this relationship is reversed for low-income persons.

The HRS data show, in particular, that shares of expenditure categories (health, food, housing) tend to change with age and income indicating that substitution between these expenditures does occur and can affect health outcomes and vise versa. It is important to note, however, that these changes are far from homogeneous across individuals; Tables 1b to 1d, for instance, indicate significant differences in health outcomes, income patterns and incidence of food insecurity between low, middle, and high-income groups. Furthermore, other variables such as family characteristics and demographic variables are likely to be correlated with income and health, thus adding more complexity to the analysis. In short, given that linkages between health status and expenditure patterns involve simultaneous relationships among a considerably large number of variables, the use of an econometric model to understand these interactions is warranted.

Employing HRS data one can address policy questions regarding publicly-sponsored subsidized food programs as well as the utilization of nontraditional medicines. Table 2, for instance shows estimates of food insecurity for elderly females living alone, males living alone, and couples living alone. The incidence of food insecurity among elderly females living alone is the highest (6.77 versus 4.78 for the entire sample). Moreover, incidence of food insecurity is much higher in low-income households and elderly females living alone experience incidence rates that are nearly as twice as high than the average for all household types. The heterogeneity of food insecurity incidence warrants the addition of family characteristics into the model as well as examination of the linkages between targeted government food assistance programs and food insecurity.

Table 3 indicates the importance of addressing potential impacts of non-traditional medicines in the form of nutraceuticals. The table shows that nearly two-thirds of the respondents use nutraceuticals with no significant differences across age cohorts. The last column shows the annual average expenditure on nutraceuticals as a percent of food and medical expenses. Such a ratio is relevant because these products are blurring the line between food and pharmaceuticals. The ratio is higher among the youngest and the oldest (4.4 and 6.0 percent respectively) than for the two other age groups. A relevant hypothesis is that "war-babies" are approaching an age in which health care is a priority issue; moreover they belong to a generation that increasingly believes in their own responsibility for maintaining good health, emphasizing disease prevention over disease treatment. Lower expenditures on nutraceuticals of persons between 60 to 77 years of age (3.0 and 3.7 percent for people 60-70 and 70-77 years of age, respectively) might be the result of inter-generational differences. If this is true, future potential increased use of nutraceuticals may affect expenditures on traditional medicine as well as health outcomes of the elderly. Although attractive, this hypothesis requires rigorous quantitative analysis, because one might argue, for example, that "war-babies" spend more on nutraceuticals simply because they have higher incomes and the income elasticity for nutraceutical products is higher than that for food or medical services.

The following variables were constructed to examine the economic relationship between consumption patterns and health of the elderly and to assess the incidence of food insecurity and demand for nutraceuticals:

Health Stock:

H1 Self reported health status, ranges from 1 (poor) to excellent (5)
H2 Number of healthy days in year 2000

Expenditures:

FOODEXP Food expenditures in year 2000
HOUSEXP Housing expenditures in year 2000
NUTEXP Nutraceutical expenditures in year 2000
HAIDEXP Total co-pays from participation in health aid programs in year 2000 (social security, medicare and medicaid)
HINSEXP Total health insurance premiums in year 2000
HDRGEXP Total out-of-pocket expenditure on prescription drugs in year 2000
HHOSEXP Total out-of-pocket expenditure on hospital services in year 2000
HDENEXP Total out-of-pocket expenditure on dental services in year 2000
HHOCEXP Total expenditure on homecare services in year 2000
HEALEXP Total health expenditure in year 2000 (HAIDEXP + HINSEXP + HDRGEXP + HHOSEXP + HDENEXP + HHOCEXP)

Income:

INC Household earnings in year 2000
NETWTH Net household worth in year 2000 (Total Household Assets plus home equity)

Food Insecurity – Food Assistance Program Participation:

FOODINS equals one if individual is food insecure, zero other wise
FIN_FS equal one if person is food insecure and participates in Food Stamp program; zero otherwise
FIN_FSN equal one if person is food insecure and does not participate in Food Stamp program; zero otherwise

Individual Characteristics:

AGE respondent's age
EDUCATN number of years through formal education
GENDER one if male; zero otherwise
RETIRED one if retired; zero otherwise
HOMEMKR one if homemaker; zero otherwise
DISABLED one if disabled, zero otherwise
ECONACT one if in the workforce, zero otherwise
MARRIED one if married; zero otherwise
DIVORCED one if divorced; zero otherwise
WIDOWED one if widowed; zero otherwise
NEVERM one if never married; zero otherwise
RACE_A one if African-American; zero otherwise
RACE_H one if Hispanic; zero otherwise
RACE_W one if white, zero otherwise
M_ONLY type of household, equals one if male only; zero otherwise
F_ONLY type of household, equals one if female only; zero otherwise
COUPLE type of household, equals one if couple; zero otherwise

Assuming that all individuals face the same prices of medical care inputs and market goods (i.e., no spatial price variability), the above variables can be utilized to

estimate Engel curves for necessities simultaneously with the demand for health stock as follows:

$$SFOODEXP = \alpha_{1,f} + \alpha_{2,f} \ln INC + \alpha_{3,f} \ln H + \alpha_{4,f} AGE + \alpha_{5,f} \ln NETWTH + \hat{\boldsymbol{\alpha}}'\mathbf{D} + u_f, \tag{16a}$$

$$SHOUSEXP = \alpha_{1,ho} + \alpha_{2,ho} \ln INC + \alpha_{3,ho} AGE + \alpha_{4,ho} \ln NETWTH + \hat{\boldsymbol{\alpha}}'\mathbf{D} + u_{ho}, \tag{16b}$$

$$SHEALEXP = \alpha_{1,he} + \alpha_{2,he} \ln INC + \alpha_{3,ho} \ln H + \alpha_{4,he} AGE + \alpha_{5,he} \ln NETWTH + \hat{\boldsymbol{\alpha}}'\mathbf{D} + u_{he}, \tag{16c}$$

$$\begin{aligned} \ln H \quad &= \alpha_{1,H} + \alpha_{2,H} \ln INC + \alpha_{3,H} AGE + \alpha_{4,H} \ln HEALEXP + \alpha_{5,H} \ln FOODEXP \\ &+ \alpha_{65,H} \ln NUTEXP + \alpha_{4,ho} \ln NETWTH + \hat{\boldsymbol{\alpha}}'\mathbf{D} + u_H \end{aligned} \tag{16d}$$

The new terms here are *SFOODEXP*, *SHOUSEXP* and *SHEALEXP*, the income shares of food, housing and health expenditures, respectively; and $\mathbf{D}$ is a vector of demographic characteristics. Note that all dollar figures are transformed into logarithms.

5. Findings

Tables 4 and 5 present Seemingly Unrelated Regression (SUR) and Three Stage Least Square (3SLS) estimates corresponding to the system of equations (16a)-(16d). SUR is a generalization of ordinary least squares for multiple equation systems. While it assumes that all the regressors are independent variables, it uses the correlations among the errors in different equations to improve the regression estimates. On its part, 3SLS generalizes the Two-stage Least-squares method account for the correlations between. It requires three steps: first-stage regressions to get predicted values for the endogenous

regressors; a two-stage least-squares step to get residuals to estimate the cross-equation correlation matrix; and the final 3SLS estimation step. Both SUR and 3SLS must be considered as partial estimates because of the lack of variability in prices of both inputs in the health production function and market goods.

Table 4 utilizes aggregate health expenditures in the demand for health stock equation. The SUR and 3SLS procedures explain 24 and 21 percent of the variability of endogenous variables respectively and, overall produce similar parameter estimates. Single-equation analyses of variance (OLS in the case of SUR and 2SLS in the case of 3SLS), indicate that the demand for health as well as the food Engle equations show the best fits ($\overline{R}^2$ of SUR and 3SLS are both 0.23 for the demand of health; and 0.36 and 0.34 for the food Engle curve). Consider the demand for health stock first. Results indicate that larger personal income, stock of knowledge and household net worth all have a positive and significant effect on the demand for health. In contrast, higher expenditures on health care inputs reduce the demand for health stock. These results agree with the theoretical predictions of Grossman's model, providing additional evidence in favor of health as a stock variable in the case of the economics of aging. Parameter estimates also suggest that age does not appear to influence the demand for health stock.

Table 4 confirms the relevance of the various policy issues linked to health outcomes such food consumption, utilization of nontraditional medicines in the form of nutraceuticals, participation in subsidized food programs as well as employment status. Both larger spending in food and in nutraceuticals have a positive effect on the demand for health. The fact that nutraceutical expenditures increase demand for health suggest that preventive approaches to health are an alternative to produce the commodity "good

health." Overall, food insecure individuals demand less health stock than the rest of the population.[2] Moreover, considering only persons that are food insecure, significant differences exist between individuals that participate in the Food Stamp Program (FSP) and those that *do not* participate in the FSP. Among the food insecure, individuals that participate in the FSP have lower demand for health than their non participant counterparts. Finally, individuals that are in the work force appear to have a different demand schedule for health relative to retired individuals.

Engle curves estimates indicate that, while all three commodities are normal goods, health is a luxury whereas housing and food are necessities. Consequently with the descriptive analysis, results demonstrate that aging has significant effects on spending patterns. This is because the share of health expenditures in total income rises with age; and conversely, the share of food and housing expenditures in income decrease with age. Estimates also show that health stock affects spending patterns via the share of health expenditures. Nevertheless, no direct significant effects of health stock on food expenditures were identified. Employment status has a significant impact on expenditure patterns: retired individuals are likely to have higher health and food expenditure shares relative to economically active persons. Finally, household wealth is positive and significant in the housing and health equations but not in the food equation. This means that elderly people are likely to deplete their assets in order to increase their spending on medical inputs.

[2] Even though food insecurity and Food Stamp Program participation are endogenous, our model treats as exogenous variables. Therefore one can only make partial inferences based on coefficients of these variables.

Table 5 presents the same models but health expenditures are disaggregated into different expenditure categories, namely, co-pays on health aid programs, co-pays on health care plan, insurance premiums, out of pocket prescription drug spending, co-pays on the utilization of hospital services, dental health expenditures and homecare expenses. Parameter estimates of the Engle equations are similar to those presented in Table 4. Disaggregating health expenditures provides valuable additional information regarding the demand for stock health. In particular, SUR estimates provide an appealing theoretical interpretation. Health insurance premiums do not affect the stock demand for health because they constitute a fixed amount that consumer pays aiming at reducing the risk of high health care costs. Outlays on prescription drugs, on the other hand, have the largest negative effect among all health spending categories, implying that increased out of pocket prescription drug expenditure tend to decrease the demand for health more than any other input in the health production function. Results indicate that, similar to findings in Table 4, the utilization of nutraceuticals has a positive and significant effect on the demand for health. Also, food insecurity has a negative impact on the demand for health especially for those individuals participating in subsidized food programs.

6. Conclusion

Our study investigated the simultaneous relationships between spending patterns and health status of the elderly. The model affirmed the need to recognize simultaneity between health outcomes and spending patterns of the elderly and shows that the stock approach to the demand for health can provide these simultaneous links. Furthermore, the findings contribute to a variety of policy debates. Unsurprisingly, the share of income

allocated to health expenditures was found to increase as health stock decreased. Another relevant finding is that the utilization of nontraditional medicine in the form of nutraceuticals is a significant input to the gross investment function for health. The model also suggests that food insecurity and the decision whether or not to participate in the Food Stamp Program (FSP) affect the health demand of the elderly. In particular, it is intriguing that those food-insecure that do participate in FSP appear to have lower demand for health than food insecure individuals that *do not* participate in FSP. Interpreting this finding, however, requires treating food insecurity and participation in subsidized food programs as endogenous variables.

Beyond the research questions discussed above, there are additional findings of the study relevant to the economics of aging. In particular, among the elderly, aging seems to affect consumption patterns but not the demand for health stock. If one believes that health stock depreciates at increasing rates along the aging process, the marginal productivity of health investments decrease with age. Consequently, an older elderly person is required to make gross health investments that are larger than the investments of a younger elderly person in order to achieve the same level of health stock. But, by investing more heavily in health, the older elderly might sacrifice consumption of other goods that are also determinants of the demand for health (e.g., food), thus reducing the level of health stock simultaneously.

Because food expenditures are a significant factor, through nutrition, in the demand for health, the possibility of medical expenses crowding out food expenses might decrease consumer's demand for the commodity "good health", thus further decreasing his/her health status. One expects, therefore, the existence of substitution effects between

food expenditures and traditional medical care inputs in the production of health. These effects will be tested more rigorously after price variability is introduced into the empirical specification. To conclude, our findings are valuable but future research must and will include price variability in order to estimate a complete demand system endogenize food insecurity and FSP participation.

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Table 1. Selected Economic and Health Variables by Age Cohort and by Income

Table 1a. Complete sample

Age Cohort	N	Average Health Status	Food Insecure (%)	Average Income ($/year)	Expenditure Shares of Household Income (%)			
					Medical	Food	Housing	Other
Before 1924	4,350	3.15	4.52	18,679	22.22	15.63	8.35	44.23
1925-1931	1,927	2.85	5.43	20,790	17.67	16.31	9.60	48.65
1932-1941	9,064	2.75	6.27	26,944	12.49	14.39	11.44	56.49
1942-1947	2,150	2.47	7.26	36,166	7.97	10.49	11.49	66.59
Total	17,491	2.83	5.77	25,344	14.93	14.43	10.48	53.82

Table 1b. Selected economic and health variables by age cohort: Low-income persons

Age Cohort	N	Health Status	Food Insecure (%)	Average Income ($/year)	Expenditure Shares of Household Income (%)			
					Medical	Food	Housing	Other
Before 1924	1,748	3.35	8.51	6,301	16.76	23.05	9.08	45.69
1925-1931	715	3.12	9.88	6,556	14.90	24.91	13.01	41.52
1932-1941	2,732	3.22	13.19	5,971	14.16	26.47	17.59	33.64
1942-1947	397	3.10	22.73	5,754	9.58	26.16	19.94	35.43
Total	5,592	3.24	11.75	6,134	14.74	25.18	14.51	38.54

Table 1c. Selected economic and health variables by age cohort: Middle-income persons

Age Cohort	N	Health Status	Food insecure (%)	Average Income ($/year)	Expenditure Shares of Household Income (%)			
					Medical	Food	Housing	Other
Before 1924	1,722	3.09	1.99	14,275	18.16	13.31	8.49	55.75
1925-1931	728	2.78	3.64	14,584	13.20	14.19	9.73	60.81
1932-1941	2,787	2.79	4.35	15,122	10.38	13.07	10.76	64.00
1942-1947	500	2.54	7.07	15,420	6.92	10.92	12.64	67.22
Total	5,737	2.86	3.66	14,825	12.77	13.09	10.11	61.40

Table 1d. Selected economic and health variables by age cohort: High-income persons

Age Cohort	N	Health Status	Food Insecure (%)	Average Income ($/year)	Expenditure Shares of Household Income (%)			
					Medical	Food	Housing	Other
Before 1924	880	2.87	1.19	51,882	41.04	5.44	6.65	18.77
1925-1931	484	2.54	2.74	51,154	28.48	6.78	4.35	40.90
1932-1941	3,545	2.37	1.98	52,401	12.86	6.11	7.24	68.20
1942-1947	1,253	2.24	1.36	54,080	7.88	5.36	8.36	76.21
Total	6,162	2.43	1.79	52,571	17.10	5.91	7.16	60.62

Table 2. Incidence of Food Insecurity

Household Type		All Households		Low-income Households	
		No	Yes	No	Yes
Female alone	Number	2,921	212	754	130
	(%)	93.23	6.77	85.29	14.71
Male alone	Number	1,070	64	195	27
	(%)	94.36	5.64	87.84	12.16
Elderly couple	Number	4,552	153	876	75
	(%)	96.75	3.25	92.11	7.89
Total	Number	8,543	429	1,825	232
	(%)	95.22	4.78	88.72	11.28

Table 3. Use and Expenditure on Nutraceuticals

Age Cohort		Yes	No	Avg. Expenditure as a Percent of Food and Medical Expenses
Before 1924	Number	191	100	6.0
	(%)	65.64	34.36	
1925-1931	Number	98	40	3.7
	(%)	71.01	28.99	
1932-1941	Number	381	184	3.0
	(%)	67.43	32.57	
1942-1947	Number	105	61	4.4
	(%)	63.25	36.75	
Total	Number	775	385	4.0
	(%)	66.81	33.19	

Table 4: Simultaneous Estimation of Engle Curves and Demand for Health Stock Aggregate Health Expenditures. Weighted R^2 equal 0.24 (SUR) and 0.21 (3SLS)

	Demand for Health Stock		*Engle Curve Health*		*Engle Curve Food*		*Engle Curve Housing*	
Dependent Variable:	Self-reported Health Status		Health Spending Share of Income		Food Spending Share of Income		Housing Spending Share of Income	
Method:	SUR	3SLS	SUR	3SLS	SUR	3SLS	SUR	3SLS
OLS or 2SLS R^2(adjusted)	0.23	0.23	0.10	0.07	0.36	0.34	0.15	0.14
H	--	--	-13.40***	3.76	1.13	8.26	--	--
			(1.86)	(13.38)	(0.94)	(6.76)		
LINC	0.061***	0.039**	3.14***	2.48**	-10.77***	-11.05***	-2.26***	-2.26***
	(0.020)	(0.020)	(1.15)	(1.30)	(0.57)	(0.65)	(0.78)	(0.78)
LHEALEXP	-0.040***	-0.015***	--	--	--	--	--	--
	(0.006)	(0.006)						
LFOODEXP	0.014**	0.041***	--	--	--	--	--	--
	(0.007)	(0.006)						
LNUTEXP	0.009**	0.010**	--	--	--	--	--	--
	(0.005)	(0.005)						
AGE	0.001	0.001	0.49***	0.49***	-0.26***	-0.26***	-0.17**	-0.17**
	(0.001)	(0.001)	(0.09)	(0.09)	(0.04)	(0.05)	(0.06)	(0.06)
FIN_FS	-0.649***	-0.560***	--	--	--	--	--	--
	(0.140)	(0.139)						
FIN_FSN	-0.201***	-0.205***	--	--	--	--	--	--
	(0.076)	(0.074)						
EDUCATN	0.019***	0.018***	0.31	-0.03	-0.18**	-0.32**	0.17	0.17
	(0.004)	(0.004)	(0.22)	(0.35)	(0.11)	(0.17)	(0.14)	(0.14)
GENDER	--	--	-3.67**	-3.77**	0.87	0.85	1.12	1.19
			(1.71)	(1.75)	(0.85)	(0.85)	(1.16)	(1.16)
ECONACT	0.123***	0.143***	-3.95**	-6.52**	-1.67**	-2.75**	-0.39	-0.39
	(0.032)	(0.032)	(1.92)	(2.81)	(0.95)	(1.41)	(1.28)	(1.28)
MARRIED	0.017	0.002	-2.46	-4.36	14.20**	13.69**	-16.00*	-16.00*
	(0.272)	(0.040)	(16.03)	(16.52)	(8.01)	(7.99)	(10.90)	(10.89)
F_ONLY	-0.008	0.010	-2.46	-2.49	0.05	0.05	-0.51	-0.51
	(0.047)	(0.043)	(2.78)	(2.87)	(1.38)	(1.43)	(1.87)	(1.88)
COUPLE	--	--	3.73	5.46	-12.53*	-12.12*	13.22	13.22
			(16.25)	(16.66)	(8.09)	(8.06)	(11.00)	(11.00)
LNETWTH	0.032***	0.028***	1.17***	0.64*	0.19	-0.03	-1.71***	-1.71***
	(0.005)	(0.005)	(0.28)	(0.50)	(0.14)	(0.25)	(0.18)	(0.18)
CONSTANT	-0.076	-0.201	-49.55***	-50.68***	140.35***	139.90***	64.46***	64.46
	(0.234)	(0.233)	(13.20)	(13.68)	(6.57)	(6.85)	(8.93)	(8.93)

[a] Standard errors in parenthesis; *** p-value<0.01; ** p-value<0.05; * p-value<0.10

Table 5: Simultaneous Estimation of Engle Curves and Demand for Health Stock: Disaggregate Health Expenditures. Weighted R^2 equal 0.25 (SUR) and 0.22 (3SLS)

	Demand for Health Stock		*Engle Curve Health*		*Engle Curve Food*		*Engle Curve Housing*	
Dependent Variable:	Self-reported Health Status		Health Spending Share of Income		Food Spending Share of Income		Housing Spending Share of Income	
Method:	SUR	3SLS	SUR	3SLS	SUR	3SLS	SUR	3SLS
OLS or 2SLS R^2	0.25	0.25	0.10	0.07	0.36	0.34	0.15	0.15
H	--	--	-11.10***	3.78	1.00	8.26	--	--
			(1.87)	(13.38)	(0.94)	(6.76)		
LINC	0.041**	0.023	3.05**	2.47**	-10.77***	-11.05***	-2.26***	-2.26***
	(0.020)	(0.019)	(1.15)	(1.29)	(0.57)	(0.65)	(0.78)	(0.78)
LFOODEXP	0.010*	0.036***	--	--	--	--	--	--
	(0.007)	(0.006)						
LNUTEXP	0.008*	0.009**	--	--	--	--	--	--
	(0.005)	(0.005)						
Medical Exp.:								
Health Aid	-0.012**	-0.005	--	--	--	--	--	--
	(0.006)	(0.005)						
Insurance	-0.004	0.008**	--	--	--	--	--	--
	(0.004)	(0.003)						
Prscp. Drugs	-0.026***	-0.022***	--	--	--	--	--	--
	(0.005)	(0.004)						
Hospital	-0.016**	-0.014**	--	--	--	--	--	--
	(0.008)	(0.008)						
Dental	0.017**	0.016**	--	--	--	--	--	--
	(0.008)	(0.007)						
Homecare	-0.037**	-0.033**	--	--	--	--	--	--
	(0.016)	(0.015)						
AGE	0.001	0.001	0.49***	0.49***	-0.26***	-0.26***	-0.17***	-0.17**
	(0.001)	(0.001)	(0.09)	(0.09)	(0.04)	(0.04)	(0.06)	(0.06)
FIN_FS	-0.626***	-0.583***	--	--	--	--	--	--
	(0.138)	(0.136)						
FIN_FSN	-0.209***	-0.198***	--	--	--	--	--	--
	(0.076)	(0.073)						
EDUCATN	0.018***	0.016***	0.27	-0.03	-0.18**	-0.32**	0.17	0.17
	(0.004)	(0.004)	(0.22)	(0.34)	(0.11)	(0.17)	(0.14)	(0.14)
GENDER	--	--	-3.71**	-3.70**	0.87	0.90	1.19	1.12
			(1.71)	(1.74)	(0.85)	(0.85)	(1.15)	(1.16)
ECONACT	0.125***	0.145***	-4.29**	-6.53***	-1.65**	-2.75**	-0.39	-0.39
	(0.032)	(0.032)	(1.92)	(2.81)	(0.95)	(1.41)	(1.28)	(1.28)
MARRIED	-0.027	-0.018	-2.68	-5.08	14.16**	13.06*	-16.00*	-16.00*
	(0.268)	(0.040)	(16.10)	(16.42)	(8.01)	(8.02)	(10.89)	(10.89)
F_ONLY	0.007	0.013	-2.48	-2.44	0.05	0.09	-0.51	-0.51
	(0.046)	(0.043)	(2.78)	(2.87)	(1.38)	(1.43)	(1.88)	(1.88)
COUPLE	--	--	3.93	6.19	-12.50*	-11.48*	13.22	13.22
			(16.25)	(16.55)	(8.09)	(8.08)	(11.00)	(11.00)
LNETWTH	0.028***	0.025***	1.10***	0.64*	0.19*	-0.03	-1.71***	-1.71***
	0.005)	(0.005)	(0.28)	(0.50)	(0.14)	(0.25)	(0.18)	(0.18)
CONSTANT	0.115	0.012	-49.73***	-50.57***	140.36***	139.96	64.46***	64.46***
	(0.234)	(0.231)	(13.20)	(13.68)	(6.57)	(6.85)	(8.93)	(8.93)

[a] Standard errors in parenthesis; *** p-value<0.01; ** p-value<0.05; * p-value<0.10

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