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HEALTH AS AN UNOBSERVABLE
A MIMIC-model of Demand for Health Care*

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This paper develops a model to analyze the demand for health care. It differs from current practice in that (1) it deals explicitly with the complex relation between income, health, health insurance, and the demand for health care, and (2) 'health' is treated as an unobservable variable. We present the Maximum Likelihood estimates of an eleven-equation, simultaneous, multiple-indicator, multiple-causes (MIMIC) model, containing two simultaneously determined unobservables and, in total, nine 'indicators'. Data used stem from a health-care survey among 8000 households in The Netherlands. The results show, among other things, that health and permanent income have mutual, positive impacts. Both age and education have important direct and indirect (via permanent income) effects on health. The estimated impact of the availability of health care on individual demand confirms similar results based on aggregated data.

1. Introduction

This paper analyzes the demand for health care, defined in terms of number of doctor–patient visits, expenditures for drugs and hospital admissions. Our approach is in the spirit of Andersen (1968) [see also Andersen et al. (1975)] and draws on recent developments in the theory of health economics [Grossman (1972), Newhouse (1978a, b, 1981)]. It differs from the current approach, however, in at least two important ways:

First, in our model, we deal explicitly with the complex relationships among health, income, health insurance, and demand for health care. Health and income are determined simultaneously; next health insurance is

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considered, as a function of income, among other things. Finally, the demand for health care is specified as a function of all three – income, health, and health insurance.

Secondly, we treat health as an unobservable variable. Estimation of the structural coefficients enables us to calculate a 'health index' for each individual. This index can be used to compare, for example, the health status of different socio-economic groups and the health status of inhabitants of different areas. By treating health as a latent variable [compare Robinson and Ferrara (1977), Lee (1979), Wolfe and Van der Gaag (1981), Hooijmans and Van de Ven (1982)] we are able to specify and estimate a system of structural equations instead of the partially reduced-form equations usually encountered in research on the economics of health care.

In section 2 we develop the general model. In section 3, we present and discuss the ML-estimates of the model, using data from a health-care survey among 8000 households in The Netherlands. In section 4, we examine in detail the concept of 'permanent' health and illustrate the usefulness of the estimated health index. Section 5 assesses the fit of the model.

2. The general model

2.1. Health

In presenting a general framework to study the demand for health care, Andersen et al. (1975) distinguished among three types of variables: need, enabling variables, and predisposing variables. For the measurement of *need*, ad hoc variables are often used, such as 'presence of an important disease' or 'work days lost because of illness'. *Enabling variables* include income measures, insurance variables, prices and the availability of care. Our measure of health is closely related to the set of *predisposing variables.* Certain demographic and socioeconomic variables are considered to be present at the onset of specific episodes of illness. They are labelled 'predisposing' variables in that they show a clear relationship to health-care utilization, although they are themselves no reason for seeking health care. For instance, health-care utilization rates are known to vary considerably with age and sex, but 'age' and 'sex' themselves are no reason to seek medical assistance. In our model we will define a single predisposing factor, η_1, which is a linear function of such variables as sex, permanent income and education. This predisposing factor (or index of permanent health) enters in the equations explaining permanent income and health-care demand. It is conceptually equal to Andersen's set of predisposing variables, but we will, as noted above, treat it as a single unobservable variable in our model. Levine and Yett (1973) described a three-step method (using factor analysis) for constructing an index of socio-economic and demographic variables that correlates with health. In our approach we *directly* relate the predisposing variables to the health indicators, we explicitly specify the parameters of the health equation and, as a part of our structural model, we specify a simultaneous relation between health and income.

Our data are taken from a health-care survey of 8000 households in The Netherlands.[1] The variables that we shall use in the following equations are tabulated and defined in table 1.

Formally, we can write the permanent health equation of our model as

$$\eta_1 = \beta_1 \eta_2 + \gamma_1' \xi_1 + \varepsilon_1, \tag{1}$$

where

η_1 = the unobservable predisposing factor, permanent health (*PH*),
η_2 = permanent family income (*PINC*), defined in section 2.2,
ξ_1 = a vector of five exogenous variables, *FS*, *UNEMPL*, *AGE*, *SEX*, *EDUC* (to be discussed below; see also table 1),
β_1, γ_1 = parameters to be estimated, where γ_1 is a vector,
ε_1 = disturbance term.

A constant term is added to eq. (1).

Of the exogenous variables, *AGE* and *SEX* are self-explanatory. From the percentage unemployed in a region (*UNEMPL*) we expect a negative (stress-related) effect on an individual's health.

Though it is well known that large families show relatively low figures for per capita medical consumption, that does not imply that we expect family size (*FS*) to exert a positive influence on permanent health since *FS* will also appear in the equation explaining permanent income [i.e., besides the direct effect there is also an indirect (via *PINC*) effect of *FS* on *PH*]. The same complication holds for the number of years of education (*EDUC*). Because some factors (e.g., income, education) influence the demand for health and others (e.g., family size, age) influence the production of health (see section 4), the health eq. (1) is considered to be a mixture of a demand and production function [e.g., Grossman and Benham (1974) and Grossman (1975)].

We should realize that the variable permanent health includes at least two components. We would like to capture someone's 'basic', 'permanent', or 'expected' *health status* — that is, the health status given someone's age, sex, life-style, etc. But since we will use data on the utilization of health care as indicators for this latent variable, our measure of permanent health also captures an individual's *attitude* toward health distortions, as revealed by his use of health-care facilities. In other words, data from two groups of

[1]See appendix for the mean and standard deviation of each variable.

Table 1

Description of the variables.

Predisposing variables	
PH	unobservable predisposing factor, permanent health
PINC	permanent family income (logarithmic)
FS	logarithm of family size
UNEMPL	percentage of unemployment in the region (here, per province in The Netherlands)
AGE	age of the family head (in years)
SEX	dummy variable, 1 if female, 0 if male
EDUC	number of years of education of the family head
Enabling variables	
FINC	logarithm of family-income after taxes
INS1	dummy variable indicating yes/no (1/0) insurance (with a coinsurance rate of 0.20) for GP-visits and prescribed medicine
TIME	total time needed for a visit to the GP
DIST	distance (in km) to the nearest general or university hospital
FULLT	dummy variable, 1 if working in full-time paid job, 0 otherwise
Income-determining variables	
PH	unobservable predisposing factor, permanent health
AGE	age of the family head (in years)
EDUC	number of years of education of family head
EMPL	number of employed family members
INCRS	number of different family income sources (e.g., labor, wealth, pension, Social Security benefits, grant, alimentation)
EARN	dummy variable, 1 if earned income (labor) constitutes the main source of family income, 0 otherwise
Health-services utilization	
SELF	money value of non-prescribed self-medication during six months
GPCON	number of general practitioner consultations during six months
GPMED	money value of medicine prescribed by the GP during six months
SPCON	number of specialist (outpatient) consultations during six months
SPMED	money value of medicine prescribed by a specialist during six months
HOSP	number of days spent in general or university hospital during one year
Supply variables	
SPEC	number of specialists per 1000 population in the region (15 regions)
BED	number of beds in general or university hospitals per 1000 population in the region (123 regions around hospitals)
Other variables	
INS2	dummy variable indicating complete hospital insurance for three categories of 'luxury' treatment in the hospital, 2 if highest class, 1 if medium class, 0 if lowest class
CONST	constant (=1)
Need variable	
ILL	number of days being ill (during a half year) as reported by the respondent

individuals that are equally healthy or unhealthy will give different results if one group uses health-care facilities and services more extensively than the other group. We will suggest some ways to disentangle those two components in section 4.

2.2. Observed income and 'permanent income'

It will be clear that since our main purpose is to estimate an index of permanent health, permanent income (*PINC*), not observed income, is the appropriate variable that should enter eq. (1).

Permanent income is used here as a proxy for someone's 'life-style' or 'quality of life' (quality of food, recreation, housing, etc.). It is by no means clear, however, that the relationship between permanent health and permanent income should be positive. Unhealthy habits such as overeating might increase with income. A nonlinear relationship might be more likely, but in the model presented here *PINC* enters eq. (1) in a linear form.

In order to estimate permanent income, we will estimate a family's earnings function, relating total family income to a number of exogenous variables. Observed income is equal to permanent income plus a disturbance term ('transitory income'). Of special interest here is that permanent health is included as an explanatory variable in the earnings function. Health, as one of the human capital variables, may raise market productivity and increase income [compare Luft (1978) and Lee (1979)].

Thus, the 'income-module' of our model can be written as follows:

$$\eta_2 = \beta_2\eta_1 + \gamma_2'\xi_2 + \varepsilon_2, \tag{2}$$

$$\eta_3 = 1.0\,\eta_2 + \varepsilon_3, \tag{3}$$

where

η_1, η_2 = unobservable variables permanent health and permanent family income,
η_3 = observed family income,
ξ_2 = a vector of six exogenous variables, *FS*, *AGE*, *EDUC*, *EMPL*, *INCRS*, *EARN* (see table 1 for definitions),
β_2, γ_2 = parameters to be estimated, where γ_2 is a vector,
$\varepsilon_2, \varepsilon_3$ = disturbance terms.

A constant term is added to eq. (2).

The earnings equation conforms to conventional human capital theory, though the number of variables we included is restricted by the availability of data.

2.3. Health insurance

In the full model that we have in mind, the demand for health insurance will be endogenous, following the analyses of Phelps (1973, 1976), Keeler et al. (1977), Newhouse (1978a), Van de Ven and Van Praag (1981), and others.

All respondents in our survey are fully insured against the cost of hospital and specialist treatment. About 40% of them are also covered for treatment by a general practitioner and for the cost of prescribed medicine (with a 20% coinsurance rate). Lack of data prevent us from estimating an equation explaining the demand for insurance for general care.[2] This variable (*INS1*) will enter the model as an exogenous variable in the equations for health-care demand.

The demand for one type of health insurance, however, will be included in our model as endogenous. Over and above the insurance against 'normal' hospital costs, there is available coverage for 'luxury' hospital treatment — e.g., single instead of double rooms or wards. We expect that the demand for this type of insurance will be dependent on observed family income[3] and on two 'taste' variables: age and education.

The equation to be estimated is as follows:

$$\eta_4 = \beta_4 \eta_3 + \gamma_4' \xi_4 + \varepsilon_4, \tag{4}$$

where

η_4 = dummy variable for insurance against the cost of 'luxury' treatment (*INS2*),

η_3 = observed family income,

ξ_4 = a vector of two exogenous variables, *AGE* and *EDUC* (see table 1),

β_4, γ_4 = parameters to be estimated, where γ_4 is a vector,

ε_4 = disturbance term.

A constant term is added to eq. (4).

2.4. Health-care demand

Given the distinctions we have just made among the three sets of variables influencing health-care demand, specification of the equations explaining the demand for different types of health care (e.g., inpatient and outpatient care,

[2]We have no indicators for the 'risk aversion' [Pratt (1964)] of a family or individual. We are expanding our data base so as to be able to make the demand for insurance covering general care endogenous.

[3]Since we have only a limited number of variables available for estimating permanent income, we prefer to use observed rather than permanent income in the demand equations. So we use observed income to represent a household's *purchasing power* during the survey period, and permanent income to represent *life-style*.

or drugs) is straightforward. We will use the number of days of illness reported as a proxy for an individual's *need* for medical care. As *enabling variables* we use observed family income, η_3,[4] the two insurance variables, and measures for the availability of outpatient and inpatient care. The set of *predisposing factors* is reduced to one health-status variable, η_1, as defined in section 2.1.

Because permanent health influences the number of days of illness (*ILL*), we specify

$$\eta_5 = \beta_5 \eta_1 + \varepsilon_5, \tag{5}$$

where

η_5 = number of days of illness as reported by the respondent (*ILL*),
η_1 = permanent health,
β_5 = parameter to be estimated,
ε_5 = disturbance term.

In a general form, the health-care demand equation of our model read

$$\beta_6 \eta_6 = \tilde{B}_6 \tilde{\eta}_6 + \Gamma_6 \xi_6 + \varepsilon_6, \tag{6}$$

where

η_6 = a vector of six health-care demand variables, *SELF*, *GPCON*, *GPMED*, *SPCON*, *SPMED*, *HOSP* (see table 1),
$\tilde{\eta}_6$ = $(\eta_1, \eta_3, \eta_4, \eta_5)'$, the vector of permanent health, family income, luxury hospital insurance and need, respectively (all endogenous in the model),
ξ_6 = a vector of exogenous variables,
$\beta_6, \tilde{B}_6, \Gamma_6$ = matrices of parameters to be estimated, and
ε_6 = disturbance vector.

In all equations explaining the above variables, permanent health (*PH*) is entered on the right-hand side except in the equation for self-medication (*SELF*). Because *PH* includes an attitudinal component that we expect to be different for self-medication than for professional medical treatment, we have entered the set of all predisposing variables in the equation for *SELF*, instead of including *PH*.

Family income (*FINC*) enters all equations as an enabling variable except

[4]Observed rather than permanent income is used for the same reason as given in footnote 3. Andersen and Benham (1970) found that within the context of their model, with 'other things being equal', consumption of physician services is not more closely associated with permanent than with observed income. They conclude that the use of measured rather than permanent income to obtain elasticity estimates for physician expenditures may not be as misleading as has often been suggested.

those representing medical care where all costs are fully insured for everyone (*SPCON* and *HOSP*).

'Medical need' is in all equations represented by the number of days of illness, as reported by the respondent (*ILL*).

Since prescribed medicine can only be bought after a visit to a physician, *GPCON* and *SPCON* respectively enter in the equations explaining *GPMED* and *SPMED*.

Before hospital admission, an individual has to see a specialist in an outpatient clinic; *HOSP*, therefore, depends on *SPCON*. For a similar reason *SPCON* depends on *GPCON*.

In the equation explaining the use of prescribed medicine *GPMED* and *SPMED* and in the equation explaining *GPCON*, the insurance variable *INS1*, equal to one if the individual is insured for those types of care and zero otherwise, is included.

We also included a set of variables representing the time needed to 'consume' medical care (e.g., *TIME*, the total time needed to visit a general practitioner, and *DIST*, the distance to the nearest hospital). We will discuss these variables more fully when discussing the estimation results.

To the equation explaining *SPCON*, we have added availability of specialist care (*SPEC*) to represent the notion that the availability of care increases its use: In a situation of under-capacity we may speak of 'need'-induced demand, and in case of over-capacity of physician-induced demand. Furthermore, an increase in the number of specialists per 1000 population (indicated by *SPEC*) may, ceteris paribus, lower the waiting time for the patient which lowers the time-price of medical care.

In the same way, the availability of hospital care (*BED*) is measured by the number of hospital beds per 1000 population, and added to the equation explaining *HOSP*. In our model we deal with *individual demand*, and therefore we specify the supply of health care facilities (*SPCON* and *BED*) to be exogenous [e.g., May (1975) and Phelps (1975)] since it is unlikely that total supply of care in a given region responds to a change in the health status of *one individual* in that region. We also included a dummy variable for insurance against the cost of 'luxury' hospital treatment (*INS2*) as an explanatory variable in the *HOSP*-equation.

Finally, since the general practitioner is the first one to be seen if medical care is needed, we added a dummy variable to the equation for *GPCON*, representing someone's opportunity cost of time. This dummy variable (*FULLT*) equals one if the individual is working full-time and zero elsewhere.

We may include a constant in all but one of the above specified equations, in order to keep the parameters identified. We arbitrarily chose not to include a constant term in the equation explaining *ILL*. In the next subsection, we summarize the complete model and discuss the stochastic specification and the estimation procedure used.

2.5. The general model

The model developed in the subsections 2.1–2.4 can be summarized as follows:[5]

$$PH^* = c_1 + \beta_1 PINC^* + \gamma_{1,1} FS + \gamma_{1,2} UNEMPL + \gamma_{1,3} AGE + \gamma_{1,4} EDUC + \varepsilon_1, \tag{1'}$$

$$PINC^* = c_2 + \beta_2 PH^* + \gamma_{2,1} FS + \gamma_{2,2} AGE + \gamma_{2,3} EDUC + \gamma_{2,4} EMPL + \gamma_{2,5} INCRS + \gamma_{2,6} EARN + \varepsilon_2, \tag{2'}$$

$$FINC = 1.0\, PINC^* + \varepsilon_3, \tag{3'}$$

$$INS2 = c_4 + \beta_4 FINC + \gamma_{4,1} AGE + \gamma_{4,2} EDUC + \varepsilon_4, \tag{4'}$$

$$ILL = \beta_5 PH^* + \varepsilon_5, \tag{5'}$$

$$SELF = c_6 + \beta_{6,1} FINC + \beta_{6,2} ILL + \gamma_{6,1} FS + \gamma_{6,2} UNEMPL + \gamma_{6,3} AGE + \gamma_{6,4} EDUC + \gamma_{6,5} TIME + \varepsilon_5, \tag{6a'}$$

$$GPCON = c_7 - 1.0\, PH^* + \beta_{7,1} FINC + \beta_{7,2} ILL + \gamma_{7,1} INS1 + \gamma_{7,2} TIME + \gamma_{7,3} DIST + \gamma_{7,4} FULLT + \varepsilon_7, \tag{6b'}$$

$$GPMED = c_8 + \beta_{8,1} PH^* + \beta_{8,2} FINC + \beta_{8,3} ILL + \beta_{8,4} GPCON + \gamma_{8,1} INS1 + \gamma_{8,2} TIME + \varepsilon_8, \tag{6c'}$$

$$SPCON = c_9 + \beta_{9,1} PH^* + \beta_{9,2} ILL + \beta_{9,3} GPCON + \gamma_{9,1} DIST + \gamma_{9,2} SPEC + \varepsilon_9, \tag{6d'}$$

$$SPMED = c_{10} + \beta_{10,1} PH^* + \beta_{10,2} FINC + \beta_{10,3} ILL + \beta_{10,4} SPCON + \gamma_{10,1} INS1 + \varepsilon_{10}, \tag{6e'}$$

$$HOSP = c_{11} + \beta_{11,1} PH^* + \beta_{11,2} INS2 + \beta_{11,3} ILL + \beta_{11,4} SPCON + \gamma_{11,1} DIST + \gamma_{11,2} BED + \varepsilon_{11}. \tag{6f'}$$

[5] Because we estimated this model using the data for male family heads only (see section 3), the variable *SEX* is irrelevant.

The c's represent the constant terms. The variables marked with an asterisk (*) are unobservables.

In eq. (6b') we standardized the variable PH^* is such a way that the coefficient of permanent health on the number of general practitioner visits is -1.0, thus making sure that we are dealing with 'good health' and not with 'poor health'. In other words, one unit increase in permanent health will result in one additional visit to a general practitioner.

We assume $\mathrm{E}\varepsilon=0$, ξ is non-random, and $\mathrm{E}\xi\varepsilon'=0$, where ε is the (11×1) vector of disturbances and ξ the (14×1) vector of exogenous variables. Identification of the model is in part obtained by imposing restrictions on the (co-)variance matrix of the disturbances (an appendix proving the identification of all parameters in the model by checking the moment equations and discussing some particular difficulties is available from the authors).[6]

We assume $\mathrm{E}\varepsilon_i\varepsilon_j=0$, if $i\neq j$ (i.e., the latent variables PH^* and $PINC^*$ account for all interdependencies among the observed endogenous variables) with two exceptions. First, two health-care utilization equations represent 'patient-initiated' care: *SELF* and *GPCON*. It is likely that a person's taste and attitude towards seeking medical care plays an important role here. Since we have no measure for 'attitude', we expect that the disturbances in both equations are positively correlated. Secondly, we cannot assume that the disturbances of the two equations related to medicine use, *GPMED* and *SPMED*, are independent, since both general practitioners and specialists will try to coordinate their prescriptions to one patient. We finally assume ε to be normally distributed. This implies that η is normally distributed, given ξ. Since all of our dependent variables are limited and some of them are discrete, the normality assumption is unlikely to hold. Thus, in this sense, our model is misspecified. Given the data and resources available to us, we have not been able to calculate the consequences of this misspecification. Our estimation results should therefore be viewed with caution. The primary goal of this study, however, is to investigate the advances of structural (latent variables) models over the semi-reduced form models usually applied in health economic research. The development of estimators for models where the normality assumption is likely to be violated is a candidate for further research that warrants a high priority.[7] Maximum likelihood estimates of the

[6]As far as we know, there is no generally applicable rule for testing the identifiability of a simultaneous equation system with simultaneously determined latent variables. This 'open territory for econometric theorists' [Goldberger (1972)] has been explored among others by Wiley (1973), Geraci (1976) and Robinson (1974). The latter deals with the identification of a non-simultaneous model with several unobservables. We did rewrite our model in the form used by Robinson (1974). However, it can be shown that our model is a degenerated case of Robinson's general model, so that his criteria are not applicable (detailed information is given in the 'proof of identification', available from the authors).

[7]For a MIMIC model where the observable endogenous variables (the 'indicators') are dichotomous, see Muthén (1979) and Lee (1979).

structural parameters of the Multiple-Indicators and Multiple-Causes (MIMIC) model [Jöreskog and Goldberger (1975)] thus defined can be obtained using the computer program LISREL [Jöreskog (1977) and Jöreskog and Sörbom (1978)].

3. Estimation results

This section presents estimation results based on individual data from a health-care survey (1976) in The Netherlands among 8000 privately insured households, nearly all belonging to the highest income groups.[8] Emphasis will be put on the simultaneous relation between health and income. Therefore we first restrict our analysis to male heads of families ($N=3636$).[9] The estimation results are given in table 2.

3.1. Permanent health

In table 2 we see that an individual's age and the percentage of unemployment in the region have a negative influence on health. Permanent income, reflecting 'life-style', has a positive influence on health.

Looking at the influence of education on health, we see a negative coefficient, but we should realize that besides this direct effect there is also an indirect effect of education (via permanent income) on health; the latter completely offsets the former, resulting on balance in a positive but slight effect. In interpreting these coefficients, we should be very careful, however, and should bear in mind, as noted earlier, that our measure of permanent health covers at least two components, 'health' and 'attitudes towards health distortions' (see section 4).

3.2. Income

All estimated coefficients (table 2) in the income equation are significant (with one exception) and with signs as expected. The positive coefficient of age indicates that the income increases with years of experience. One additional year of schooling completed gives a 3.7% increase in expected income; one additional employed family member raises expected income by 6.0%, while one additional source of income causes a 4.8% increase in permanent income. Where earned income is the main source of family income, that income is on average 20.1% higher than when non-earned income is the main source of income. This finding quite agrees with the level

[8]In the Netherlands every employee with an annual income below Dfl. 30.900 (1976) is compulsorily insured with the Sick Fund Organization, which offers complete insurance for the whole family. Self-employed and aged people with an annual income below Dfl. 30.900 can buy voluntary insurance with the Sick Fund Organization. In this way about 70% of the Dutch population is completely insured against (nearly) all medical expenses. The other 30% consists of higher income groups, and nearly all of them have private health insurance.

[9]Partially answered questionnaires were deleted from the analysis.

Table 2
Full information, maximum likelihood estimates for all male family heads ($N = 3636$, t-values in parentheses).[a]

	PH	*PINC*	*INS2*	*ILL*	*SELF*	*GPCON*	*GPMED*	*SPCON*	*SPMED*	*HOSP*
PH		0.091 (1.04)		−6.074 (4.94)		−1.0 (−)	−24.061 (5.72)	−0.951 (4.86)	−24.019 (4.93)	−1.279 (3.98)
PINC	0.729 (2.33)									
FINC			0.345 (14.8)		−0.633 (1.08)	0.165 (1.06)	7.233 (1.90)		1.667 (0.39)	
INS2										0.030) (0.15)
ILL					0.020 (2.18)	0.036 (14.9)	0.016 (0.27)	(0.043 (14.2)	0.478 (7.11)	0.125 (23.3)
GPCON							10.245 (17.2)	0.184 (6.45)		
SPCON									4.215 (9.55)	0.217 (6.51)
FS	0.036 (0.48)	0.130 (7.50)			−1.247 (2.72)					
UNEMPL(	−0.083 (2.46)				−0.382 (1.40)					
AGE	−0.025 (6.68)	0.0067 (3.41)	0.015 (26.0)		0.061 (3.93)					
EDUC	−0.015 (1.23)	(0.037 (19.4)	0.023 (9.65)		0.270 (4.54)					

INSI						0.410 (4.99)	4.735 (2.29)		4.704 (1.92)	
TIME					0.018 (2.20)	−0.0019 (1.15)	−0.018 (0.44)			
DIST						(0.0086 (0.93)		0.0067 (0.53)		0.027 (1.17)
FULLT						0.144 (0.92)				
SPEC								0.740 (1.66)		
BED										0.208 (1.85)
EMPL		0.060 (7.05)								
INCRS		(0.048 (4.11)								
EARN		0.201 (7.75)								
CONST	−6.808 (2.24)	9.158 (137.5)	−4.258 (18.1)		7.339 (1.19)	−1.548 (0.94)	−85.611 (2.12)	−0.721 (2.16)	−30.349 (0.67)	−2.058 (3.15)

[a]The estimated correlation between the disturbances of the *SELF* and the *GPCON* equations is 0.039 ($t=2.32$), and between those of the *GPMED* and *SPMED* equations it is −0.091 ($t=4.31$).

Table 3

Elasticities of health-care utilization with respect to the number of physician consultations.

	Male family heads	
Variable	*GPCON* elasticity	*SPCON* elasticity
GPMED	0.517	—
SPCON	0.226	—
SPMED	0.056[a]	0.248

[a]Indirect effect through *SPCON*.

of social security benefits for retirement or disability pensions or for unemployment insurance; these generally equal 70–80% of previous income.

The family size elasticity of income (0.13) that has been estimated while controlling for the number of employed family members may be partly explained by child allowances. The relation between permanent income and permanent health will be discussed in detail in section 4.

3.3. Health insurance

In section 2.3 we hypothesized that *INS2* would be influenced by age, income and education of the family head. Indeed, we find three significantly positive coefficients. We also see that income clearly has a dominant influence on the choice of how 'luxurious' the hospital treatment should be.

3.4. Health-care demand

We will first pay attention to the fact that some types of health-care consumption are conditional upon the consumption of other types.

The effect of an additional visit to the general practitioner and specialist on other kinds of health-care utilization is given in table 3, which illustrates the function of the general practitioner as the entry point into the medical system. The effect of *GPCON* on *SPCON*, presented as an elasticity, is 0.23; for *SPCON* we find 0.25 with respect to *SPMED*.

These results illustrate that, though a patient–doctor contact itself adds to the cost of health care, an important amount of additional costs is generated by such a contact.[10]

We shall now take a look at the effect of insurance (*INS1*) on health-care utilization. All persons in the survey are fully insured for *SPCON* and *HOSP*, but only 40% are insured for *GPCON*, *GPMED* and *SPMED*, with a

[10]We did not calculate the elasticities for *HOSP*, since *HOSP* refers to consumption in one year while the other variables in medical care refer to a six-month period.

Table 4

Direct and indirect effects of changing the coinsurance-rate from 0.2 to 1.0 on health-care utilization (*GPCON*, *GPMED*, and *SPMED*).

Variable	Direct effect	Indirect effect (via *GPCON*)	Total effect	Mean value (insured plus non-insured)
GPCON	0.410	—	0.410	1.276
GPMED	4.74	4.20	8.94	25.27
SPCON	—	0.075	0.075	1.038
SPMED	4.70	0.32	5.02	17.65

coinsurance rate of 0.20. In table 2 we see that an individual who is insured for *GPCON* is expected to have 0.41 more consultations with a general practitioner than someone who is not insured.[11] The direct and indirect (via *GPCON*) effects of being insured for *GPCON*, *GPMED* and *SPMED* on different kinds of health-care utilization are presented in table 4.

Another important enabling variable is travel and waiting time, functioning as a time-price [Acton (1973, 1976)]. The variable *TIME* equals total time needed for one visit to the GP. We find a significantly positive cross-*TIME*-elasticity for *SELF* (+0.17) and a negative own-*TIME*-elasticity for *GPCON* (−0.06).

The direct effect of *TIME* on *GPMED* equals the indirect effect (via *GPCON*), resulting in a reduced form elasticity of −0.06. Increasing the mean value of *TIME* by its standard deviation causes, other things being equal, a 3.6% reduction in expected value of both *GPCON* and *GPMED*.

Distance (*DIST*) to the hospital, where the specialist works, functions as a cross-price to *GPCON*, giving a small elasticity of 0.04 [cf. Acton (1975) who found an elasticity of about 0.07]. The effect of *DIST* on *SPCON* is expected to be negative, but we estimated a positive, though not significant, coefficient. This casts some doubt on the reliability of *DIST* as a proxy for the time involved in consuming medical care.

However, *DIST* has a positive effect on the expected number of hospital days (*HOSP*) [elasticity 0.12; cf. Acton (1975) who gives 0.18)]. Possibly laboratory testing and other preoperative research that require the patient to come several times to the hospital are, where long distances are involved, replaced by clinical research.

The negative coefficient of *FULLT* in the *GPCON* equation indicates that people with a full-time, paid job are less willing to contact the general practitioner than people with a part-time or unpaid job, due to higher time-prices.

[11]Our results indicate that a male family head who is insured for *GPCON* with a coinsurance rate of 0.20 is expected to have about 40% more GP contacts than a noninsured person. Because *INS1* is exogenous, the estimated effect of insurance on *GPCON* might be biased due to adverse-selection as well as selection by the insurance company. Our findings differ from those of Phelps (1975, p. 125, table 7-10A), who estimated a 130% difference.

Table 5

Income elasticities of expected value of dependent variables, evaluated at the mean.

	Male family heads	
Variable	Elasticity	t-value
SELF	−0.144	(1.08)
GPCON	0.129	(1.06)
GPMED	0.286	(1.90)
SPMED	0.094	(0.39)

As stated above, we used measured income instead of permanent income as an explanatory variable for health-care utilization.

The income elasticity of *GPCON* (table 5) looks rather small (0.13),[12] while the elasticity of *GPMED* equals a value (0.29) that has also been found by others.[13]

From table 5 we have no clear picture of the effect of income. This may be due to the facts, first, that we are not able to separate earned income from unearned income, and secondly, that we are dealing only with the upper 30% of income classes; this reduced variation in income and the truncated sample may bias our estimations [see Hausman and Wise (1977)].

Many studies have already indicated the large influence of supply variables such as the number of hospital beds and the number of physicians per capita on health care utilization. Most of these studies are based on aggregated data, but May (1975), one of the few studies using data on individuals, also concluded that even after taking into account demographic, social, and illness factors, the availability of resources appeared to influence utilization significantly.

In our model we hypothesized that the number of specialist consultations would be influenced by the number of specialists per capita (*SPEC*), and the number of hospital-days by the bed–population ratio (*BED*). The estimated *SPEC* elasticity of *SPCON* equals 0.38. Comparable results are found in macrostudies: 0.39 by Fuchs and Kramer (1972), 0.36 by Van der Gaag (1978) and 0.22 by Rutten (1978).[14]

[12]Compare, e.g., Phelps (1975) who found an income elasticity for expenses on doctor visits of 0.11; Benham and Benham (1975) estimated an income elasticity for mean number of physician visits of 0.27; Colle and Grossman (1978) found an income elasticity for doctors' visits for children of 0.38, but they stated that their findings contrasted with the lower and insignificant results typically reported in studies of the demand for medical care by adults.

[13]Andersen and Benham (1970) found income elasticities for physician expenditures, other things being equal, of 0.17 to 0.30.

[14]The estimations of Rutten (1978) and Van der Gaag (1978) are based on data for patients in The Netherlands insured by the Sick Fund, while our results refer to privately insured.

The influence of *BED* availability is even more dramatic: after controlling for predisposing variables, need, distance to hospital, and number of specialist outpatient contacts, the estimated *BED* elasticity of hospital days equals 0.86. Compare e.g. Van der Gaag et al. (1975) and Rutten (1978) who gave 0.85; Van der Gaag (1978) with 0.60; and Feldstein (1967, 1970, 1971, 1977) who found elasticities ranging from 0.70 to 0.90.

The estimated coefficients of permanent health are all negative and significant. *ILL*, the number of days ill, has a positive and highly significant influence on all but one of the kinds of health-care utilization.

Looking at the predisposing variables in the *SELF* equation, we note a negative coefficient for family size and a positive coefficient for years of schooling completed by the family head. As already pointed out, attitudinal variables may strongly influence the amount of self-medication.[15] Therefore, we will not draw the conclusion that members of large families and less-educated people are 'healthy', but we will take into account the possibility that members of large families are less inclined to self-medication, and that level of education has a positive influence on the demand for health.

4. Health index

The unobservable variable, permanent health, is fully characterized by its causes and indicators. Causes are the predisposing variables which indicate characteristics existing prior to the onset of a specific illness but which are, per se, no reason for seeking health care [Andersen (1968)]; as indicators, we use different kinds of realized medical consumption.

Interpretation of the predisposing variables may be ambiguous. First, they may stand for some 'expected' level of health. Second, they may indicate attitude or belief. One way to reduce the attitudinal or belief aspects from the unobservable is to exclude all individuals who have a zero value for all five health-care utilization variables. In this way we are left only with patients who had already entered the medical system and who were (or had been) under medical treatment. In analyzing this subsample, we are explaining differences in health-care utilization that are conditional upon an already expressed decision for medical services, while in the previous section we also analyzed the decision of the patient whether or not to go to the doctor. Assuming that the physician's decision about how much care the patient needs is primarily influenced by the patient's health status, the content of our variable 'permanent health' is now indeed closer to 'health' than in the previous section.

In table 6 we see a positive influence of health on income, and vice versa. On a one-tailed test, the effects are significant at the 10 percent but not at

[15]One indication for this is the significantly positive correlation between the disturbances in the *SELF* and the *GPCON* equations; see table 2.

Table 6

Coefficients for the simultaneous structural relation between the unobservables permanent health and permanent income (male family heads with medical consumption) (*t*-values in parentheses).[a]

Equation	*PH*	*PINC*	*FS*	*UNEMPL*	*AGE*
Permanent health		0.5042 (1.31)	0.0976 (0.99)	−0.1202 (2.56)	−0.0256 (4.92)
Permanent income	0.1228 (1.52)		0.1306 (6.05)		0.0084 (4.37)

Equation	*EDUC*	*EMPL*	*INCRS*	*EARN*	*CONST*
Permanent health	0.0156 (1.05)				−5.1156 (1.35)
Permanent income	0.0344 (10.1)	0.0657 (6.54)	0.0498 (3.60)	0.2046 (7.32)	9.1821 (85.1)

[a]The estimation results of the full eleven-equation model are given in table A.2 in the appendix. Because the coefficients of the other equations resemble those analyzed in the previous section, we will not discuss them in detail.

the 5 percent level. Luft (1975) and Bartel and Taubman (1979) estimated a reduction in yearly earnings caused by poor health that ranged from 20% to 40%; they specified health as an exogenous variable. Grossman and Benham (1974) and Grossman (1975) treated health as an endogenous variable and also found that health, as one component of human capital, raised market productivity and the wage rate significantly. Lee (1979), who considered two structural equations with unobservable health capital and wage rate jointly dependent, concluded that wages have strong positive effects on the demand for good health and good health raises market productivity and hence wages.

A positive effect of income on health status was also found by Grossman (1975, p. 196), who analyzed a high-earnings, highly-educated sample like ours. He suspected the major sourse of this finding to be a factor that he termed 'the inconvenience costs of illness':

> 'The complexity of a particular job and the amount of responsibility it entails are certainly positively correlated with the wage. Thus, when an individual with a high wage becomes ill, tasks that only he can perform accumulate. These increase the intensity of his work load and give him an incentive to avoid illness by *demanding more health capital.*'

Phelps (1975) found similar results, concluding 'that higher income may lead to a life-style that helps to avoid hospital stays'.

In the previous section, we estimated a significantly positive coefficient of *EDUC* in the *SELF* equation and a negative effect of *EDUC* in the permanent health equation; we may now conclude, from the positive effect of *EDUC* on health in table 6, that *highly educated people have a high demand*

Table 7
Direct, indirect and total effects of education on health and income (or wage rate).

Effect	Grossman estimates		Our estimates	
	Health effects	Wage effects	Health effects	Income effects
Direct	0.014	0.052	0.0166	0.0367
Indirect	0.016	0.0C3	0.0185	0.0020
Total[a]	0.030	0.055	0.0351	0.0387

[a]Reduced form parameter.

for good health (patient-initiated demand) but also have a high health status (as derived from the analysis of physicians' decisions).

The effect of education on health is quite interesting: besides the positive direct effect we mentioned, more education leads to a higher income, which in turn leads to a better health status. The direct and indirect effect of education on health and income are presented in table 7, together with comparable results found by Grossman (1975, p. 198).

Though Grossman's results are based on *direct* 'health status' measures, there are two striking similarities to our results: first, the indirect effect of education (via income) on health exceeds the direct effect; secondly, in both studies the indirect effect of education on earnings is only a small fraction (5%) of the total effect. A positive effect of education on health, suggesting that health should rise with years of schooling completed, has also been found by Grossman and Benham (1974) and Edwards and Grossman (1978), among others.

Family size has a positive influence on health [cf. Kasper (1975)] and on income. Besides the argument used in section 3 for the influence of family size on income, one could state that increasing family size leads to a more efficient *production of health* and income (e.g., the time-gain of a married individual with respect to an unmarried one, or the health-experience gain of a large family with respect to a small family).

The effect of age on income is as expected: the more years of experience one has, the higher the income. This direct effect, however, has been reduced (with 38%) by the indirect effect of worsening health with increasing age (table 8).

Finally, the negative influence of the percentage of unemployment in the region on health may be explained by the stress that fear of losing one's job generates, or indirectly by the stress experienced by unemployed friends and family members.[16]

[16]For this indirect effect compare, e.g., Van der Gaag and Van de Ven (1978) who estimated that a variable defined as 'problem behavior in the family' (i.e., at least one person with a behavior problem) had a significantly positive effect on the medical care consumed by family members who did not themselves evidence such behavior problems.

Table 8

Direct, indirect and total effects of family size and age of family head on health and income

Effect	Effect of family size on		Effect of age of family head on	
	Health	Income	Health	Income
Direct	0.1040	0.1392	−0.0273	0.0090
Indirect	0.0702	0.0128	0.0045	−0.0034
Total[a]	0.1742	0.1520	−0.0228	0.0056

[a]Reduced form parameter.

We emphasize again, that our estimation results should be viewed with caution, since they are conditional upon the normality assumption of the disturbances. However, in view of the consistency of our results with other work in the literature, it seems — in this case — that this misspecification is quantitatively not important. No doubt, our insight in many of the observed relationships will benefit from further work in this area.

Tables 9 and 10 illustrate the use of the health index $E(\eta_1 | \xi) = \delta'\xi$ with δ a vector of reduced-form parameters.[17] Losing his job (*EARN*:1→0) makes a man about five years older (with respect to his health status); increasing family size from one to two[18] equals about the effect of a 1% reduction of the percentage of unemployment in the region (e.g., from 4% to 3%) or of $3\frac{1}{2}$ additional years of schooling (table 9). The direct effect of a change in permanent health on health care utilization is given in table 10 (first row). Because the number of days of illness (*ILL*) depends on permanent health and on its turn influences health-care utilization, there is also an indirect effect of permanent health (through *ILL*) on health care utilization.

The total effect of increasing permanent health with one 'unit' reduces the number of general practitioner and specialist consultations (during a half year) with about 1.3, the amount spent on prescribed medicines with about 28 Dutch guilders, and the number of days spent in a hospital with 2.3.

Table 9

Total effects of exogenous variables on the health index.[a]

	FS	*UNEMPL*	*AGE*	*EDUC*	*EMPL*	*INCRS*	*EARN*
Effect	0.174	−0.128	−0.023	0.035	0.035	0.027	0.110

[a]Calculated reduced-form parameters.

[17]For a discussion on the MIMIC health status index, see Van de Ven and Hooijmans (1982).
[18]The effect of a change in family size from 1 to 2 equals $(\ln 2 - \ln 1) \times 0.176 = 0.121$.

Table 10

Direct, indirect (through *ILL*) and total effects of the health index on health-care utilization.

Effect	*GPCON*	*GPMED*	*SPCON*	*SPMED*	*HOSP*
Direct	−1.000	−28.470	−1.023	−25.193	−1.487
Indirect	−0.220	−0.073	−0.287	−3.199	−0.855
Total	−1.220	−28.543	−1.310	−28.392	−2.342

Of course, the illustration of the health index that results from our model should only be considered as a tentative result. Improving the specification of our model and extending the data base with so-called 'need' and 'predisposing' variables will yield more reliable results.

Then, by using results as presented in tables 9 and 10 one may compare the costs of improving health in different ways (cost–effectiveness) and, having chosen some way, to compare these costs with the benefits in terms of reduced health-care utilization (cost–benefit).

5. Fit of the model

A χ^2-test[19] of the model indicates that we have to reject the hypothesis that all parameters (a priori) fixed to be zero, indeed are all zero. As stated before, the consistency of our results with the literature suggests that our model restrictions are not quantitatively important. However, for now this statement remains unsupported, until further work on this question sheds more light on the matter.

In order to facilitate the comparison of our structural model with a model consisting of a set of semi-reduced-form equations, we finally present in table 11 the ratio of the estimated residual variance (in the structural equation) to the total variance of the observable endogenous variables. This ratio is compared with the R^2 of the corresponding OLS single-equation regression after we substitute for the two unobservables. As we see, these figures differ only slightly from each other.

6. Discussion and conclusion

In this paper we developed and estimated a structural-equation model for health-care demand. The primary goal of this study is to investigate the advances of structural (latent variable) models over the semi-reduced-form models usually applied in health economic research. We explicitly dealt with the complex relation between health, income, health insurance, and demand

[19]Minus twice the logarithm of the likelihood ratio is, in large samples, distributed χ^2 with, in our case, $171-73=98$ degrees of freedom.

Table 11

Calculated ratio of the estimated residual variance (in the structural equation) to the total variance of the observable endogenous variables (the value of the R^2 in the corresponding OLS regression equation, after substituting for the unobservables, is given in parentheses).

	FINC	*INS2*	*ILL*	*SELF*	*GPCON*
All family heads $N=3636$	0.224 (0.252)	0.212 (0.212)	0.041 (0.015)	0.017 (0.017)	0.200 (0.151)
Family heads with medical consumption $N=2281$	0.264 (0.275)	0.236 (0.236)	0.029 (0.019)	0.012 (0.012)	0.146 (0.124)

	GPMED	*SPCON*	*SPMED*	*HOSP*
All family heads $N=3636$	0.277 (0.238)	0.175 (0.155)	0.156 (0.126)	0.234 (0.226)
Family heads with medical consumption $N=2281$	0.215 (0.189)	0.136 (0.127)	0.122 (0.109)	0.222 (0.220)

for health care, using two unobservable variables. Our results indicate a mutually positive influence of health and income. Education and age appeared to have interesting direct and indirect (via income) effects on health. In explaining the health-care demand, we found that the estimated effect of supply variables quite resembles the results found in macro-studies.

Specifying health as an unobservable, we were able to construct and illustrate a health index that may be used to compare the health status of individuals or, say, differences between regions. Although the model we have developed is already quite comprehensive, the number of variables used to explain health is relatively small. It would be quite realistic to model explicitly the effect of health-care utilization on health.[20] Moreover, variables describing, e.g., environmental hygiene, welfare work, or sporting facilities may also enter the health equation. In that case the health index can, in principle, be used to compare the marginal increase in health that would arise from expenditure of extra dollars on different kinds of health care, on education, income improvement, environmental protection, etc. The benefits of improved health in terms of reduced health-care utilization can then be compared with the costs of improving health. Such comparisons can be useful in the allocation of health-care resources or in assigning budgets to regions, and can help the search for a more effective health-care system.

Though our results look promising, they should be viewed with caution because of the restricted set of measured variables and because of several

[20]For that purpose we need other indicators of health than health-care utilization, e.g., objective norms like urine and blood tests, blood pressure, or presence or absence of some symptoms, or subjective norms like the self-perceived general state of health.

caveats in our approach. First, in order to identify the parameters of interest in the model, various restrictions were imposed on the structure. Second, in order to obtain Maximum Likelihood estimates of the parameters, we assumed normality of the disturbances, in spite of the discrete nature of most of our dependent variables. As of yet, we did not assess systematically the consequences of these two sets of assumptions. Comparison with results in the literature suggest that these consequences are quantitatively small. But a high priority for future research should be given to these problems.

Appendix

Table A.1
Mean values and standard deviations.

	Male family heads $N=3636$		Male family heads with medical consumption $N=2281$	
Variables	Mean	S.D.	Mean	S.D.
Health-services utilization				
SELF	4.612	11.756	5.444	13.198
GPCON	1.276	2.623	2.035	3.070
GPMED	25.273	69.043	40.286	83.635
SPCON	1.038	3.581	1.654	4.408
SPMED	17.649	77.330	28.133	96.118
HOSP	1.203	6.910	1.918	8.646
Predisposing variables				
FS	1.147	0.452	1.121	0.463
UNEMPL	4.028	0.710	4.032	0.725
AGE	44.621	13.452	46.192	13.903
EDUC	12.966	3.634	13.030	3.646
Need variable				
ILL	5.513	21.092	8.427	25.882
Enabling variables				
FINC	10.322	0.350	10.331	0.352
INS1	0.421	0.494	0.445	0.497
TIME	42.757	24.501	46.192	13.903
DIST	5.294	4.371	5.242	4.334
FULLT	0.862	0.345	0.825	0.380
Supply variables				
SPEC	0.528	0.127	0.529	0.128
BED	4.966	0.907	5.004	0.913
Income-determining variables				
AGE	44.621	13.452	46.192	13.903
EDUC	12.966	3.634	13.030	3.646
EMPL	1.338	0.785	1.294	0.794
INCRS	1.188	0.447	1.209	0.470
EARN	0.895	0.307	0.865	0.341
Other variables				
INS2	0.280	0.518	0.322	0.553

Table A.2

Full information, maximum likelihood estimates for all male family heads with medical consumption ($N = 2281$, t-values in parentheses).[a]

	PH	*PINC*	*INS2*	*ILL*	*SELF*	*GPCON*	*GPMED*	*SPCON*	*SPMED*	*HOSP*
PH		0.123 (1.52)		−6.679 (3.82)		−1.0 (−)	−28.470 (4.39)	−1.023 (3.63)	−25.193 (3.75)	−1.487 (3.13)
PINC	0.504 (1.31)									
FINC			0.410 (13.3)		0.202 (0.23)	0.133 (0.56)	13.079 (2.03)		3.313 (0.48)	
INS2										0.114 (0.38)
ILL					0.013 (1.21)	0.033 (11.9)	0.011 (0.15)	0.043 (11.7)	0.479 (5.83)	0.128 (18.9)
GPCON							9.681 (13.2)	0.149 (4.29)		
SPCON									4.242 (8.10)	0.218 (5.30)
FS	0.098 (0.99)	0.131 (6.05)			−1.081 (1.67)					
UNEMPL	−0.120 (2.56)				−0.190 (0.50)					
AGE	−0.026 (4.92)	0.0084 (4.37)	0.016 (21.5)		0.064 (2.98)					
EDUC	0.016 (1.05)	0.034 (10.1)	0.023 (7.61)		0.209 (2.48)					

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INS1					0.450	5.946		5.401	
					(3.67)	(1.84)		(1.40)	
TIME				0.026	−0.0014	−0.014			
				(2.16)	(0.54)	(0.21)			
DIST					(0.013		0.0093		0.042
					(0.95)		(0.46)		(1.13)
FULLT					0.014				
					(0.07)				
SPEC							1.059		
							(1.51)		
BED									0.325
									(1.82)
EMPL		0.066							
		(6.54)							
INCRS		0.050							
		(3.60)							
EARN		0.205							
		(7.32)							
CONST	−5.116	9.182	−4.968	−1.528	−1.103	−152.589	−0.913	−51.329	−3.283
	(1.35)	(85.1)	(16.0)	(0.17)	(0.43)	(2.20)	(1.60)	(0.69)	(3.00)

[a]The estimated correlation between the disturbances of the *SELF* and *GPCON* equations is 0.022 ($t=1.05$), and between those of the *GPMED* and *SPMED* equations it is −0.085 ($t=3.34$).

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