THE RELATIONSHIP BETWEEN MEDICAL RESOURCES AND MEASURES OF HEALTH: SOME ADDITIONAL EVIDENCE

PREPARED UNDER A GRANT FROM THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

JOSEPH P. NEWHOUSE, LINDY J. FRIEDLANDER

R-2066-HEW
MAY 1977

Rand
SANTA MONICA, CA. 90406

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PREFACE

This report was written as part of the Rand Health Insurance Study under grant from the U.S. Department of Health, Education, and Welfare. It examines the question of how alternative levels of medical care resources in an area affect physiological measures of health. Most previous investigations of the subject have studied aggregate mortality and morbidity; none has studied specific physiological measures such as the prevalence of hypertension and periodontal disease. Use of specific physiological measures has several advantages: (1) Many conditions that are self-limiting or irreversible enter into overall morbidity and mortality statistics, making it more difficult to measure the contribution of additional medical resources. (2) The possibility that ill health will draw resources into an area and thus confound estimates is enhanced when aggregate indices are used. (3) The physiological measures are produced routinely by the National Health Survey.

In recent years the public sector has moved increasingly toward control of resource allocation in medical care, through the 1966 legislation that established Comprehensive Health Planning Agencies and the 1974 legislation that established Health System Agencies. These agencies are charged with making decisions concerning the appropriate amount of medical resources in a local area. Little is known at present about alternative choices. This report is intended to assist in developing a methodology that will shed more light on that issue.

SUMMARY

This report examines the relationship between the medical resources of an individual's area of residence and physiological measures of the individual's health status from the Health Examination Survey of the National Health Survey. To assess the effect of the area's medical resources on the individual's health, such variables as age, sex, race, education of the individual, and household income are controlled for.

The physiological variables analyzed include diastolic blood pressure, serum cholesterol concentration, abnormal electrocardiogram, abnormal chest X-ray, varicose veins, and periodontal disease. While additional education and income were found to have an effect in reducing the prevalence of abnormal chest X-rays and periodontal disease, the physiological measures were affected little by additional medical resources. The results thus support the view that what an individual does (or does not) do for himself has a greater impact on his health than the consumption of additional medical care services. This statement must be qualified because the data supporting it come from the early 1960s (the latest available). Because medical technology has progressed in the past fifteen years, these results may no longer hold.

Despite the lack of significant findings, the methods used in this report to assess the relationship between medical care resources and health status appear to be more powerful than the usual regressions of mortality and morbidity on medical resources. The methods used here are probably more sensitive to variation in medical care resources, and because they are to a considerable degree independent, one from another, they are less subject to the simultaneity problem (poor health causing resources to be located in a given area). Therefore, this study should be repeated when more recent data from the National Health Survey become available.

ACKNOWLEDGMENTS

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THE RELATIONSHIP BETWEEN MEDICAL RESOURCES AND MEASURES OF HEALTH: SOME ADDITIONAL EVIDENCE

INTRODUCTION

One of the most vexing questions in health services research is the relationship between resources devoted to personal health services and the outputs of those services. The prevailing view in the United States suggests that additional personal health services do little, if anything, for mortality and/or morbidity. They probably provide relief of anxiety, symptomatic relief, or prognostic information. What the patient does for or to himself (by smoking, drinking, exercise, sleep, and the like) has much more to do with explaining variation in conventional measures of health status outcomes than additional personal health services.

Such a view has probably been most forcefully expressed by Victor Fuchs (Fuchs, 1972, 1974a, 1974b; see also Newhouse, Phelps, and Schwartz, 1974). The evidence supporting this view typically comes from regressions of mortality or morbidity rates on medical care resources across regions (for the most part, regions of the United States) (Letourmy, 1975; Auster, Leveson, and Sarachek, 1969; Newhouse, 1968; Larmore, 1967; Benham and Benham, 1975). Usually, the authors are not able to reject the null hypothesis of no relationship at conventional levels of significance; failing to find a statistically significant relationship, they conclude that there is little effect. Furthermore, the estimated size of the effect (i.e., the size of the regression coefficient) is not only insignificant; it is also frequently close to zero. By contrast, the effect of education often appears significant in these studies. The work of Belloc and Breslow showing that "health habits" such as exercise, smoking, and drinking are predictive of mortality is also consistent with the notion that "lifestyle" is more important to health than variation in personal medical care services (Belloc and Breslow; 1972,1973).

In this report, we illustrate a different approach to the problem of assessing the impact of medical care resources on health status. Rather than look at mortality or morbidity directly, we look at physiological measurements taken in the United States Health Examination Survey. This approach has potentially greater power than existing approaches for isolating the contribution that medical care services or other factors can make to health status, because one can focus on diseases or conditions for which medical care may make a difference. If, as many believe, most diseases that are currently not treated are either self-limiting or irreversible, the set of diseases for which additional medical services can affect mortality may be small. In this case, if mortality from all causes is aggregated and regressed upon medical care resources and environmental factors, as has been done in the literature to date, the observed effect of medical care will be both small and hard to detect. By contrast, there may be some diseases, such as hypertension or periodontal disease, where additional medical care resources can make a difference. If so, it should be much easier to measure the contribution of medical care by focusing on the variation in the prevalence of such problems rather than variation in mortality or morbidity rates from all causes. Effects of health habits may also emerge

more clearly with this approach. We have not attempted to relate changes in the physiological measures that we have examined to changes in mortality or morbidity, although one could clearly do so with longitudinal data such as the Framingham Heart Study data.[1]

METHODOLOGY

We have analyzed data from the United States Health Examination Survey, Cycle I. This survey, which is discussed in detail below, gave screening examinations to a random sample of the U.S. population from 1959 to 1962. In this report, we analyze the results for diastolic blood pressure, serum cholesterol concentration, electrocardiogram evaluation, chest X-ray evaluation, varicose veins, and a periodontal index. Our reasons for choosing this diverse list of indices are discussed below.

The Health Examination Survey was given to the population of 39 areas of the United States selected at random (using a stratified nationwide probability sample clustered by city size). Each area consisted of a county or a small group of contiguous counties. Our procedure is to regress the physiological indices on measures of quantity of medical resources in an area, as well as demographic and socioeconomic characteristics of the person sampled such as age, sex, race, family income, and education. Our interest is in the association, if any, between variation in an area's medical resources and variation in the physiological measures examined, other factors constant.

In the model underlying these relations, it is assumed that variation in medical care resources affects the amount of medical care delivered. In Fig. 1, let the difference between S_1 and S_2 be the quantity of services supplied from additional medical care resources in an area. If the medical care marketplace previously were in equilibrium at point F, a new equilibrium could be expected to be established at point G, and the quantity of services delivered would rise from OB to OD. It may be, however, that price is fixed at some level, say OP, and that more is demanded (OE) than is supplied (OA) at this price. In that event, additional supply moves the quantity of services consumed from OA to OC.

It is also presumed that there is a relationship between the amount of medical care delivered and the physiological indices (Fig. 2). Additional services are assumed to have a steadily diminishing payoff (which may even be negative because of iatrogenic disease), and our task is to discover whether we are presently in the region near A in Fig. 2 or in the region near B. One may ask why we do not seek to measure this relationship directly. The answer is that the amount of medical care resources in an area is increasingly seen as a policy instrument (for example, in health planning legislation), whereas the quantity of services delivered is not a policy instrument in and of itself. Thus, if more resources do not induce more services (if, for example, OB and OD are approximately equal in Fig. 1), it is important to establish that more resources may not alter health status, even if we are in the vicinity of A in Fig. 2.

An objection based on direction of causality may be raised about the above

[1] Weinstein and Stason (1976) have used the Framingham data to estimate the relationship between diastolic blood pressure and the risk of death.

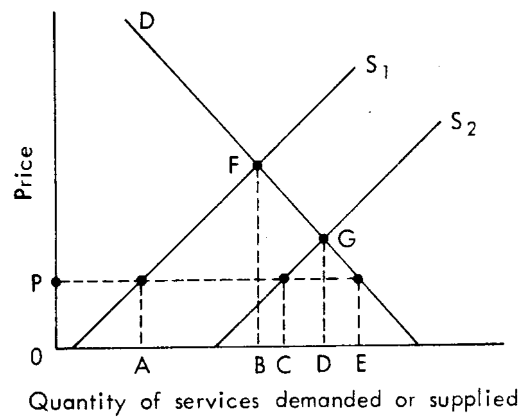

Fig. 1—Illustrative demand and supply curves
for medical services

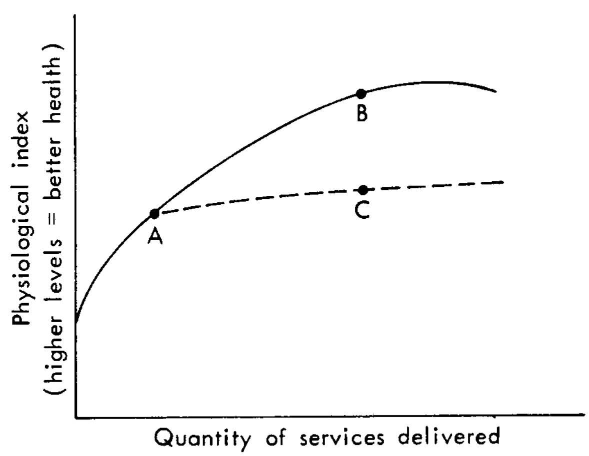

Fig. 2—Hypothesized relationship between
medical services and health status

procedure. Specifically, it may be asserted that our physiological indices do, in fact, measure the health status of an area, but that demand for medical services is higher in "sicker" areas, and therefore more resources are available in those areas (more physicians have chosen to locate there; more hospital beds have been built there; etc.). Hence, the estimated regression coefficients in our procedure are biased toward showing no favorable relationship between resources and health status. In terms of Fig. 2, areas with more resources (and by assumption, services delivered) would have a relationship between resources and health status given by the dashed line, so that the "observed" or estimated relationship would connect points such as A and C. Whereas more resources in the region whose health status lay near A

would actually move that region toward B, the region would be estimated to move toward C (i.e., less improvement).

Two responses may be offered to this objection. First, the problem is much less with specific health indices than with overall mortality and morbidity rates because the specific indices are not very highly correlated across regions. Table 1 shows the simple correlation coefficients between the area means of the six indices (the scaling of the measures is explained below). There are few statistically significant correlations, and the magnitudes are rather small, indicating that there is considerable independent variation. Moreover, the largest simple correlation (between diastolic blood pressure and abnormal electrocardiograms) is negative. Thus, it does not seem likely that all of these indices are associated with a simple sick/healthy characterization of the regions that has in turn determined variation in the distribution of medical care resources. Although there may still be some bias remaining in the estimates if Ordinary Least Squares methods are used, using specific indices rather than an overall mortality rate or morbidity rate to measure health status should reduce the simultaneity problem.

Table 1

CORRELATION COEFFICIENTS AMONG AREA MEANS[a]

Measure	Varicose Veins	Abnormal Electrocardiogram	Abnormal Chest X-Ray	Abnormal Serum Cholesterol	Periodontal Index
Diastolic Blood Pressure	-.070	-.130	-.458	-.234	.341
Varicose Veins		-.060	.142	.017	-.179
Abnormal Electrocardiogram			.002	.224	.393
Abnormal Chest X-Ray				.177	-.133
Serum Cholesterol Concentration					-.116

[a]Number of areas (N) =39.

However, because some possibility of bias remains, we have also estimated the relationships with a simultaneous equation estimator. To implement this approach, we must assume that there are certain variables (instrumental variables) in our data base that affect the quantity of medical care resources in an area, but not the health status levels of the individual observations (more precisely, that are independent of the error term in our equations). We describe these variables in the next section, where we also describe the Health Examination Survey, the list of physiological indices that we have chosen to study, and our list of explanatory variables and instrumental variables.

THE HEALTH EXAMINATION SURVEY

The Health Examination Survey is discussed at length in a publication of the United States National Center for Health Statistics (1965). The survey examined

6,672 individuals (of a sample of 7,710 individuals) from the civilian, noninstitutionalized population in 39 areas from October 1969 to December 1962. The exact areas sampled are shown in the Appendix (Table A-8 and Fig. A-1); both urban and rural areas were included. The design called for individuals between the ages of 18 and 72 to be sampled, but in fact individuals between the ages of 18 and 79 were included.

The data collected included both physiological measurements and responses to an interview concerning demographic and socioeconomic information. The physiological tests performed and data collected included X-rays of the chest, hands and feet; height; weight; air conduction; body measurements such as skinfold; blood tests (including serum cholesterol, microhematocrit, and a modified glucose tolerance test); electrocardiogram; a dental examination; and a vision examination. The data collected through an interview included household composition, age, sex, education, and income.

The Physiological Measures

The six physiological measures we selected were those used by Abrahamse and Kisch (1975) to define their Health Status Age Index. Abrahamse and Kisch selected these six measures because all were significantly related to age, and all appeared related to various aspects of an individual's health status. Abrahamse and Kisch explain their choice of these particular measures as follows:

1. Diastolic blood pressure was chosen because of its demonstrated relationship to the risk of stroke and myocardial infarction.
2. Serum cholesterol concentration was chosen for two reasons: It is related to risk of heart disease, and it may well reflect a body's general metabolic health. Abnormal serum cholesterol levels may, in fact, be as much a total system disorder as are abnormal blood glucose levels in diabetics.
3. Electrocardiogram abnormalities have a strong association with diminished health.
4. Abnormal chest X-rays also have a strong association with diminished health.
5. The presence of varicose veins in the legs (varicosities) was included in the index because these veins may reflect on the general status of the body's connective tissues.
6. A periodontal index was included as one of the few (if not only) physical parameters that reflect, in a graduated manner, preventive-care practices.

While the clinical significance of some of the measures chosen is arguable (e.g., varicose veins), we have treated each component individually, which permits the reader to ignore results for those measures he feels are of little or no significance. Retaining all six of the Abrahamse and Kisch measures, however, has the additional benefit of permitting an assessment of medical care resources using their Health Status Age measure. This measure is the linear combination of the six measures that result when age is regressed upon the measures. Thus, the Health Status Age variable is scaled in terms of years; when compared with an individual's actual age, it yields the statement: "Such an individual is young (old) for his age."

In scaling the physiological data, we followed the procedures employed by Abrahamse and Kisch; these procedures are described in detail in the Appendix.

The Explanatory Variables

The variables used in the equations reported below fall into three categories: biological, medical resources, and socioeconomic.

The biological variables include age in years, age squared, and sex (0 = male, 1 = female). These variables are included because of biological processes that relate them to the physiological measures, and indeed they are practically without exception strongly related to the measures. Because our interest in including these variables is only to control for the variation attributable to them, we report the results for these variables only in the Appendix.

The medical resources variables include primary care physicians per 100,000 population, other practicing physicians per 100,000 population, and short-term general hospital beds per 1,000 population (Theodore and Sutter, 1966). In the case of the periodontal measure, dentists per 100,000 population is used in the place of all three of the above variables (American Dental Association, 1963).

Primary care physicians are defined as physicians engaged in patient care who are in general practice, family practice, internal medicine, or obstetrics and gynecology. (Pediatricians are excluded because we are dealing with an adult population.) The hospital beds variable excludes federal hospitals because of the way the data are collected; however, short-term federal (nonmilitary) hospital beds are included in a separate variable (American Hospital Association, 1964). Dentists are not broken into general practice dentists and periodontists because over 90 percent of all dentists are general practice dentists. These medical resource variables are measured for the years 1962 (dentists), 1964 (hospital beds), and 1966 (physicians), because those were the earliest years found. Such a measure introduces error on two counts. First, the data on health status come from a few years earlier. Because the quantity of medical resources changes little from year to year, this error is probably trivial. A much more significant source of error is that one would like the medical resources in those areas in which the individual resided for his entire life, whereas the data available indicate only the resources in the most recent area of residence. This error acts as a standard errors-in-the-variables problem, biasing the coefficients of the medical resources variables and their t-statistics towards zero.

The socioeconomic variables included in the regressions reported below are education of the individual, family income, race (0 = white, 1 = nonwhite), and the percentage of the sampling area classified as urban. Education is measured as the highest grade completed in school (to a maximum of five or more years of college), and is measured in intervals of none, 1–4 years, 5–8 years, 9–12 years, 1–2 years college, 3–4 years college, and over 4 years college; we have used the mean of the interval (calculated from the 1960 Census of the Population), except at the upper interval where 6 years of college was used.[2] Education of the individual is highly

[2] The distribution of the sample by education interval is: none 1.1 percent, 1–4 years (using 3 years) 4.7 percent, 5–8 years (using 7.2 years) 22.0 percent, 9–12 years (using 1 year) 52.1 percent, 1–2 years college (using 13.5 years) 8.3 percent, 3–4 years college (using 15.7 years) 8.6 percent, and over four years college (using 18 years) 3.2 percent.

correlated with that of family heads (r = .69), so a head of household education measure would give similar results. Income is measured in intervals of less than $500, $500-$999, $1,000-$1,999, $2,000-$2,999, $3,000-$3,999, $4,000-$4,999, $5,000-$6,999, $7,000-$9,999, greater than $9,999; we have again used the mean of the interval; the within-interval mean is race-specific.[3] Persons with missing values for education and income were removed: 602 due to missing income, 145 due to missing education. These along with previous deletions brought the sample size to 4,769. Some persons were deleted from the sample for multiple reasons. The definition of an urban area is complex, but approximates individuals living in cities or towns of 2,500 individuals or more.[4]

A measure of education is included as the best measure available of the "knowledge" available to produce "health." Beneficial effects on health are expected (Grossman, 1972). Income is included as a measure of resources available to the family. In Fuchs' work, the effect of income on mortality has essentially vanished over time, perhaps because greater income engenders a less healthy lifestyle which offsets greater ability to purchase medical care. Therefore, no strong effect of income is expected. Race is included partially for biological reasons, and partially because nonwhites are thought to have poorer access to medical care resources and therefore expected to have poorer health. The percentage of the sample living in urban areas is included partially as a measure of access to medical care resources and partially to control for the supposed "unhealthiness" of the urban environment. Because these two effects tend in opposite directions, no prediction is made concerning the sign of this variable.

A number of other variables were included in computations not reported here. These included ten dummy variables for occupation, ten dummy variables for industry, two marital status variables (ever married and currently married), family size, and whether the individual was self-employed (which, among other things, affects the amount of medical insurance held in the United States; see Phelps, 1973). None of these variables proved to have much explanatory power, nor did the results reported below change with their inclusion. In the interests of simplicity, we have not reported results from the estimated equations which included these variables.

Table 2 presents the means, standard deviations, range, and number of zeroes for the variables that were included.

METHODS OF ESTIMATION

Below we report results using three methods of estimation: ordinary least squares (OLS), two-stage least squares (TSLS), and logit. Logit equations were used for the two dichotomous dependent variables: presence or absence of varicose veins, and presence or absence of an abnormal electrocardiogram (EKG) reading.[5]

[3] The distribution of the sample by income interval is: less than $500 (using $250) 2.5 percent, $500–999 (using $750) 4.8 percent, $1000–1999 (using $1500) 7.9 percent, $2000–2999 (using $2500 8.3 percent, $3000–3999 (using $3500) 11.3 percent, $4000– 4999 (using $4500 11.7 percent, $5000–6999 (using $6000) 22.2 percent, $7000–9999 (using $8317 if white and $8282 if nonwhite) 7.5 percent, greater than $9999 (using $15,679 if white and $14,167 if nonwhite) 13.8 percent.

[4] For the complete definition, see United States Bureau of the Census, *County and City Data Book*, 1967.

[5] Polytomous methods (Nerlove and Press, 1973) would have been appropriate in the case of abnormal chest X-rays and the periodontal index, but the cost of computation precluded their use, so OLS and TSLS were used.

Table 2

SUMMARY STATISTICS

Variable	Mean	Standard Deviation	Maximum	Minimum	Number of Zeroes
Hypertension	.11	.32	1	0	4224
Cholesterol > 300	.048	.21	1	0	4538
Abnormal chest X-Ray	1.67	.99	3	0	557
Abnormal EKG	.22	.41	1	0	3726
Varicose veins	.16	.37	1	0	3999
Periodontal disease scale	1.13	1.64	8	0	1294
Abrahamse-Kisch Health Status Age Index	40.85	9.09	77.37	15.92	0
Age	38.84	13.78	79	18	0
Sex (1 = female)	.53	.50	1	0	2264
Race (1 = nonwhite)	.15	.36	1	0	4057
Income ($)	6235	4408	15,679	250	0
Education	10.50	3.36	18	0	54
Percentage of population, urban	70.97	28.08	98.8	0	198
Primary care physicians/100,000	49.68	16.13	80.36	14.49	0
Other physicians/1000	82.14	55.09	196.41	4.73	0
Beds/1000	3.64	1.03	6.09	0.97	0
Federal beds/1000	.30	.57	3.33	0	2741
Dentists/100,000	51.53	22.05	97.03	8.62	0

The continuous variables—diastolic blood pressure and serum cholesterol concentration—were treated using a two-stage process. Simply using a continuous measure as a dependent variable will not be very informative if the physiological variable has a strongly nonlinear relationship with health status. For example, diastolic blood pressure may relate to health status as shown in Fig. 3. To the left of point P, variation in blood pressure may matter little; above a critical point P, it may matter a great deal. In fact, the medical care process may treat only "abnormal" blood pressures or serum cholesterol values (i.e., only those at elevated risk). If so, we cannot presume that additional medical resources would have any effect on blood pressure to the left of P.

A simple model would be

Diastolic BP = Zb + e, if the individual did not have his blood pressure taken by a physician, or if he had his blood pressure taken but it was less than or equal to some critical value. (1)

Diastolic BP = Zb − Treatment Effect (BP_0) + e, if the individual had his blood pressure taken by a physician and it was greater than some critical value. (2)

where

Diastolic BP = diastolic blood pressure observed in the survey

Z = a vector of demographic characteristics,

e = a random error term with zero mean,

Treatment Effect = the effect on blood pressure of any antihypertensive regimen the physician uses.

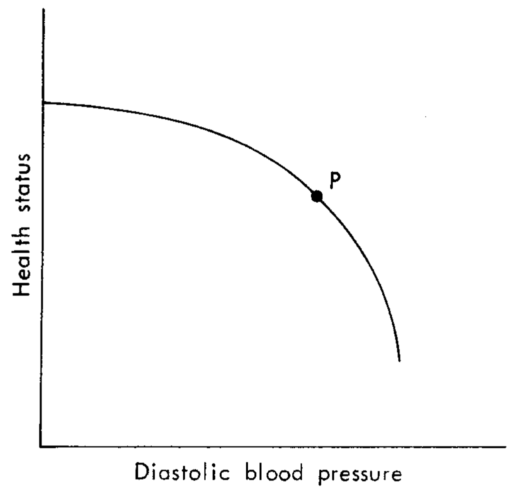

Fig. 3—Hypothesized relationship between blood pressure and health status

The Treatment Effect is written as a function of the blood pressure observed by the physician BP_0, on the assumption that the effect may be greater for those who begin with higher initial diastolic blood pressures.

Because we do not know if an individual has been found to be hypertensive by a physician, we cannot straightforwardly estimate Eqs. 1 and 2, and so we have used the following procedure to estimate the effect of additional resources on the distribution of blood pressure. We have assumed that individuals with diastolic blood pressure greater than 90 if age is less than 40, 95 if age 40 to 60, and 100 if greater than age 60 (and serum cholesterol concentration greater than 300) are at elevated risk. In the first stage of our estimation process, we have estimated how medical resources and other explanatory variables affect the probability of being found by the Health Examination Survey to be at elevated risk. This stage uses logit methods. In the second stage, we estimated the effect of the explanatory variables conditional on being at elevated risk, and have used OLS and TSLS.[6] In this second stage of estimation, we have assumed for simplicity that the effect of additional resources is a simple shift in the location parameter within the subset of the population that is at elevated risk. We further assume that the probability any individual at elevated risk is managed effectively by a physician is independent of diastolic blood pressure (which is plausible, since the individual will not know in general that he is at elevated risk until he sees the physician), but that the probability of seeing a physician is dependent upon the number of medical resources in the area. For simplicity, we have assumed that the relationship between the probability that a physician sees a patient and effectively manages him and the number of resources is linear.

[6] It would be slightly better to use Tobit with a lower limit at the critical value. However, so few observations are exactly equal to the critical value that the gain from Tobit is not worth the computational cost.

Note that the first stage of this process is all that is necessary in the case of the other physiological measures examined, which are dichotomous (or, in the cases of periodontal disease and chest X-ray, already scaled in appropriate units). In the case of the continuous variables, the second stage estimates the effect of medical resources on the mean of the subset of the population that is at elevated risk. This second step allows for the possibility that medical treatment may for some of the population mitigate the problem rather than eliminate it; if medical treatment eliminates the problem, then coefficients on medical resources will be zero in the second stage (because anyone receiving treatment from the additional medical care resources will not be observed to have the problem).[7]

Finally, in the two-stage estimation process, we require instrumental variables that affect the quantity of medical resources in an area but do not affect (or only negligibly) the physiological measures. The three variables used are the median income of the area, the percentage of the adult population that completed high school (recall that both household-specific income and education variables are included as explanatory variables), and a dummy variable indicating the presence or absence of a medical school in an area. All of these variables are arguably endogenous. If the error term in our equations has an "area effect," there is likely to be a correlation between our error term and median income, and perhaps also between our error term and the education variable. Unfortunately, area effects are underidentified because the medical resource variables do not vary within areas; hence, there is no test for area effects. The presence of a medical school could affect the quality of medical care and through that the observed physiological measures. We have assumed that any such effects are small. The reader should keep these caveats in mind when appraising the TSLS results.

THE RESULTS

Table 3 shows results from selected equations for the medical resource variables; a more complete set of equations may be found in Tables A-1 through A-7 in the Appendix. The only substantial beneficial effect of additional medical care resources is that of additional hospital beds on the prevalence of varicose veins; the elasticity is −0.44, and the coefficient is significant in every specification and estimation method used.[8] Another measure of the impact is the coefficient itself; each increment of 0.6 in beds per thousand reduces the probability of varicose veins by about one percentage point. The only other apparent benficial effect of medical care resources is that more nonprimary care physicians in an area are associated with a lower prevalence of abnormal chest X-rays. However, the effect is small; the elasticity is a low −.07. There are two statistically significant coefficients with a

[7] The two-stage procedure is an approximation; one could do better by defining additional intervals and estimating the probability of an individual's being in any particular interval as a function of an area's medical resources (using polytomous methods); if the intervals were sufficiently numerous (i.e., sufficiently small in size), one could omit the second step of estimating a within-interval effect. We have not pursued the problem to this level of detail.

[8] Feldstein's results for the British National Health Service show that the elasticity of patient days (and admissions and length of stay) with respect to beds available is well above average for the diagnosis varicose veins (Feldstein, 1967). Our results are consistent with the view that varicose vein operations are undertaken when hospital beds are sufficiently plentiful.

Table 3

EFFECTS OF MEDICAL CARE RESOURCES—ELASTICITY AT MEAN (e), t-STATISTIC, AND COEFFICIENT (c)[a]

Item		Prevalence of Hypertension, Logit	Diastolic Blood Pressure, Subset of Hypertensives, OLS	Prevalence of Serum Cholesterol >300, Logit	Serum Cholesterol Levels, Subset of >300, OLS	Prevalence of Abnormal EKG, Logit	Prevalence of Abnormal Chest X-Ray OLS	Prevalence of Varicose Veins, Logit	Periodontal Scale, OLS	Abrahamse-Kisch Health Status Age Measure, OLS
		Dependent Variable and Estimation Method								
Primary care physicians/ 100,000	e =	-.06	-.02	.39	.02	.03	-.04	.13		-.004
	t =	.33	1.02	1.34	1.00	.22	1.14	.81		.38
	c =	-.00013	-.040	.00037	.15	.00011	-.0014	.00036		-.0036
Other physicians/ 100,000	e =	.20	-.003	-.03	-.02	-.06	-.07	.002		.0006
	t =	2.07	.30	.22	1.52	.93	3.44	.026		.10
	c =	.00026	-.0034	-.000019	-.076	-.00015	-.0014	.0000036		.00030
Beds/1000	e =	.32	.009	-.13	.03	.06	.07	-.44		.01
	t =	1.90	.53	.47	1.12	.50	2.06	2.99		1.04
	c =	.0096	.24	-.0016	2.40	.0032	.033	-.017		.12
Federal beds/1000	e =	.02	-.0008	-.04	-.001	-.05	-.005	-.003		-.006
	t =	.67	.34	1.12	.36	3.36	1.15	.15		4.08
	c =	.0055	-.26	-.0063	-1.80	-.035	-.030	-.0013		-.78
Dentists/ 100,000	e =								.005	
	t =								.08	
	c =								.00012	

[a]Coefficients are from OLS equation for ease of interpretation; t-statistics are absolute value.

positive (i.e., "wrong") sign: nonprimary care physicians in the case of the prevalence of hypertension and hospital beds in the case of abnormal chest X-rays. However, neither coefficient is significant in the TSLS results, suggesting that simultaneity (or Type I error) may be present in the OLS results.

Table 4 shows results from selected equations for the education and income variables. Education has substantial and statistically significant beneficial effects upon the prevalence of abnormal chest X-rays and of periodontal disease, and possibly hypertension. In the case of hypertension, the elasticity with respect to education is −.25, and in the case of the periodontal scale, it is −.77. The periodontal scale has no natural units, so the elasticity is the best measure of the size of the effect; in the case of hypertension, each additional four years of education reduces the probability of hypertension by about one percentage point. There is also a statistically significant effect of education on the prevalence of abnormal chest X-rays, but the elasticity is relatively small, −.09. The summary measure of all six indices, Abrahamse and Kisch's Health Status Age Index, is significantly reduced by additional education, although the effect is not large; an additional five years of education makes an individual roughly one year "healthier" than is average for his age group.

Some sensitivity tests were performed on the specification of the education variable. The first test was whether a linear specification was appropriate, or whether a nonlinear specification would have been preferred. The education variable was respecified as a linear spline with two knots (Poirier 1976) at eight and twelve years of education. The estimated change in slope at eight and twelve years of education was never significantly different from zero, so the appealing hypothesis that education has diminishing marginal productivity is not supported by the data.

The second test of specification was whether the medical resource variables affected the poorly-educated differently from the better-educated. There was no a priori hypothesis because two different forces might be at work. It may be the case that the better-educated are better at exploiting additional resources; alternatively, if resources are few, the poorly-educated may be "squeezed out," and additional resources may differentially help them. To test these notions, a dummy variable was added which took the value one for individuals with less than eight years of education, and this variable was interacted with the medical resource variables. The results from estimating this specification showed no overall pattern; occasionally, a medical resource variable would be significant for one educational group and not the other, but the conclusions drawn above about the resource variables are unchanged. In particular, increasing the dentist/population ratio had no significant effect on either group. It is noteworthy that primary care physicians had a significant negative effect on the prevalence of abnormal X-ray in the poorly-educated group ($e = -.04$ at the mean; $t = 2.49$), but no effect on the better-educated group. By contrast, other physicians had a significant and negative effect on the prevalence of abnormal X-ray for the better-educated group ($e = -.08$ at the mean, $t = 3.78$), while primary care physicians had no effect on this group.

Income has significant effects on the periodontal disease scale, where the elasticity is −0.21, as well as on the Health Status Age measure and the prevalence of abnormal chest X-ray; however the effect of income on these latter measures is small. The elasticities are, respectively, −0.01 and −0.03. An additional $12,500 of

Table 4

EFFECTS OF EDUCATION AND INCOME, ELASTICITY AT MEAN (e), t-STATISTIC, AND COEFFICIENT (c)[a]

Item		Dependent Variable and Estimation Method								
		Prevalence of Hypertension, Logit	Diastolic Blood Pressure, Subset of Hypertensives, OLS	Prevalence of Serum Cholesterol >300, Logit	Serum Cholesterol Levels, Subset >300, OLS	Prevalence of Abnormal EKG, Logit	Prevalence of Abnormal Chest X-Ray OLS	Prevalence of Varicose Veins, Logit	Periodontal Scale, OLS	Abrahamse-Kisch Health Status Age Measure, OLS
Education	e =	-.25	.01	-.08	.02	-.02	-.09	-.19	-.77	-.05
	t =	1.71	1.17	.35	1.35	.16	3.12	1.52	11.11	5.51
	c =	-.0026	.15	-.00037	.79	-.00030	-.015	-.0026	-.082	-.20
Income ($)	e =	-.006	-.003	.05	-.003	-.04	-.03	-.04	-.21	-.01
	t =	.09	.40	.43	.34	.86	2.00	.74	6.63	2.83
	c =	-.00000010	-.000045	.00000035	-.00016	-.0000013	-.0000074	-.00000098	-.000038	-.000078

[a]Coefficient is always from OLS equation for ease of interpretation; t-statistic always is absolute value.

income (1960 dollars) would make an individual roughly one year healthier than his age group, while an additional $1,300 of income reduces the probability of abnormal chest X-ray by about one percentage point.

Table 5 shows the effects of the percentage of the population living in an urban area and the effect of race. In both cases, the effects are mixed. There is a beneficial effect from urbanization in the case of hypertension, and a negative effect in the case of chest X-rays. Nonwhites have a much higher probability of having hypertension, abnormal electrocardiogram readings, and periodontal disease than whites, .12 in the case of hypertension, .15 in the case of the electrocardiogram, and .19 in the case of periodontal disease. Further, according to the health status age measure, a nonwhite individual is less healthy than average for his age group (.72 years). However, nonwhites do better than whites in the case of abnormal serum cholesterol levels and varicose veins; their likelihood of having high serum cholesterol levels is two percentage points smaller, and their likelihood of having varicose veins is five percentage points smaller. These latter findings were unexpected, but appear robust against changes in specification and estimation method.

Discussion

The results reported are consistent with the view that in the United States what an individual does for himself is probably more important to his health than the quantity of medical care resources in his area of residence. There are very few effects of additional medical care resources, while the beneficial effect of additional education is quite noticeable in the case of chest X-rays and periodontal disease.

The lack of effect of medical care resources on physiological measures of health must be qualified for two reasons at least: (1) Because of the mobility of the population, the medical resource variables are measured with random error, biasing coefficients and t-statistics towards zero; the authors, however, conjecture that this bias does not account for the results.[9] (2) Because the data are from 1960, and medical technology has progressed in the intervening 15 years, especially in the area of antihypertensive drugs, results based on current technology could well differ. However, particularly noteworthy from the point of view of the lack of efficacy of additional medical care resources is the lack of association between the prevalence of periodontal disease and the number of dentists in an area. Because periodontal disease can be prevented by periodic cleaning of the teeth, it is surprising that there is no association between the number of dentists and periodontal disease. It might be argued that the number of dentists in an area reflects demand for services, and the household income and education variables are measuring this variation in demand. However, there will be variation in supply that is independent of demand (due to variation in location preferences, for example); education and income will also not completely explain demand. Thus, this argument cannot explain the lack of association. It might also be thought that where there are few

[9] 76 percent of the population lived in the same house or same SMSA in 1975 as in 1970; another 11 percent lived in a different house but were outside SMSAs in both 1970 and 1975. Undoubtedly, some portion of this latter group remained within the same medical service area. (Statistical Abstract, 1976, Table 32.) These figures include members of the Armed Forces living off post or with their families on post, and so are biased toward zero for our purposes.

Table 5

EFFECTS OF RACE AND URBANIZATION ESTIMATED USING COEFFICIENT (c) AND t-STATISTICS[a]

Item		Prevalence of Hypertension, Logit	Diastolic Blood Pressure, Subset of Hypertensives, OLS	Prevalence of Serum Cholesterol >300, Logit	Serum Cholesterol Levels, Subset >300, OLS	Prevalence of Abnormal EKG, Logit	Prevalence of Abnormal Chest X-Ray OLS	Prevalence of Varicose Veins, Logit	Periodontal Scale, OLS	Abrahamse-Kisch Health Status Age Measure, OLS
		Dependent Variable and Estimation Method								
Percentage of population in urban area	c =	-.00069	-.0068	-.000014	.031	.000016	.0024	.00029	-.0015	.0023
	t =	2.90	.33	.09	.33	.05	3.31	1.11	1.32	.42
Race (1=nonwhite)	c =	.12	2.48	-.019	-1.01	.15	-.082	-.052	.19	.72
	t =	8.89	2.49	2.08	.15	8.89	1.91	3.42	2.97	2.25

[a]t-Statistic always is absolute value.

dentists there are many dental hygienists, so that there is less variation in total dental manpower than in dentists. However, a negative correlation was not found ($r = +.41$) when using counts for dental hygienists employed in 1970 for 20 of the 39 areas (1960 figures are not available).[10] It is more likely that simply increasing the supply of dentists does relatively little to the fraction of the population that utilizes preventive dentistry.

In contrast to the effect of dentists on periodontal disease, the effects of education and income on periodontal disease are marked. It is hypothesized that those with higher education do utilize preventive dental care; it is also well known that in the United States visit rates to dentists are strongly correlated with income. Seeing the dentist more frequently would thus appear to reduce periodontal disease.

The contrasting lack of association between income and the other five physiological measures is also suggestive. In 1960 visit rates to a physician rose steadily with income (this is no longer true). Yet there is no noticeable effect on the five physiological measures from those additional visits. It is quite possible, of course, that additional income induced changes in lifestyle inimical to health (e.g., more smoking) that was offset with additional medical care, but the results are consistent with the view that preventive medical care in 1960 was not very efficacious for adults.

Conclusion

Several studies of mortality and a few studies of morbidity have concluded that the effect of additional medical care resources on mortality and morbidity was small, if it existed at all. However, this conclusion was suspect because mortality appears to be a relatively insensitive measure of outcome; in other words, the power of statistical tests when mortality is used as a dependent variable might not be great. As a result, this study utilized physiological measures of health status, at least some of which (e.g., hypertension) are known to be predictive of mortality. It was thought that effects of medical care resources that might be concealed in the variation of an aggregate mortality rate would appear if one looked at particular physiological measures; additionally, the simultaneity problem (i.e., more resources locating where "health status" is poorer) should be less severe when looking at individual measures.

Our results using data from 1960 support the conclusions of the studies of mortality and morbidity; the effect of additional medical care resources appears to be minimal. It is possible that this conclusion would need to be modified if data from more recent years were used; data from a similar survey conducted roughly a decade later than the survey used in this report will be available in the future and will permit testing for the effects of technological change in medicine (e.g., antihypertensive drugs). It is also possible, although it does not seem likely, that our conclusion would have to be modified if additional indices were examined, but we leave that to others.

[10] Data on hygienists were available for only 20 of the 39 areas.

Appendix

SCALING THE PHYSIOLOGICAL DATA

The following is taken from Abrahamse and Kisch (1975):

Diastolic Blood Pressure

Documentation provided with the Health Examination Survey data contains the following description of the manner in which diastolic blood pressure readings were made:

> The average systolic and diastolic blood pressure readings were computed from the three blood pressure measurements that were taken. The first measurement was taken just after the physician met the examinee. The second was taken midway in the examination, after completing the auscultation of the heart in the sitting position. The third measurement was taken at the end of the physical examination.
>
> Blood pressures were taken while the examinee was sitting on the examining table. The nurse placed the middle of the cuff over the bulge in the upper left arm. The cuff was left on the arm between the first and second measurements, was removed after the second, and returned for the third. The physician held the arm at the level of the atrium, with the nurse raising the Baumanometer to the physician's eye level. Using the bell of his stethoscope, the physician noted the pressure when the sound first was heard, when it first became muffled, and when it disappeared. All three measurements were recorded. The point at which the Korotkov sounds disappeared was taken as the diastolic pressure. If the sounds did not disappear, the point of muffling, if distinctly heard, was used. Since the Baumanometer is scaled in intervals of 2 mm, measurements were so recorded.
>
> The average of three readings only was used.

Serum Cholesterol Concentration

Documentation provided with the Health Examination Survey data contains the following description of how serum cholesterol concentrations were obtained:

> A blood specimen was collected from each examinee in a 15-cc Sheppard-Keidel tube. The tube was kept at room temperature for a minimum of one hour following venipuncture, then refrigerated for a minimum of six hours to assure a good clot. The blood clot was freed gently from the tube, and the tube was centrifuged for twenty minutes.
>
> Determination of total serum cholesterol concentration was made by a modified ferric chloride procedure. The values were then converted to comparable Abell-Kendall values.

For an unknown reason, the mg percent values were recoded to integers (1, 2, . . .) in the Health Examination Survey data. We reconverted these codes back into mg percent values, but the code-recode procedure, by its nature, left each value

rounded off to an odd 10 (e.g., values taken in our data are 90, 110, 130, ... mg percent). Out of the 6,672 records, 170 contained unknown serum cholesterol levels, and one was coded above 520 mg percent. These 171 cases were eliminated.

Electrocardiogram Readings

According to documentation provided with the Health Examination Survey data,

> The electrocardiogram was read independently by three cardiologists according to certain criteria they developed. . . .The three electrocardiographic readings were compared. Where they all agreed the unanimous decision was used for subsequent diagnosis. In the event that there was any disagreement, the three readers met with a coordinator and came to a final decision.

For our purposes, a single dummy variable was created in the following way: If the final summary reading agreed to by the three cardiologists indicated a normal electrocardiogram, a variable EKG (the dependent variable) was set equal to zero. If any abnormality was noted, EKG was set equal to one.

Chest X-Ray Reading

X-ray films taken by the Health Examination Survey were interpreted by "three radiologists with a special interest in pulmonary disease." Unlike the EKG readings, no attempt to reconcile different readings was recorded in the data base. We defined a variable called X-RAY equal to the number of radiologists who indicated anything abnormal in a specific X-ray interpretation. X-RAY thus takes on the range of values 0,1,2,3.

Varicosities

Varicosities were checked for in both legs. We coded a variable VARICOSE equal to one if either leg was other than normal. Otherwise, VARICOSE was set equal to zero.

Periodontal Index

The following definition of the periodontal index is provided with the Health Examination Survey data:

A periodontal score is recorded for each tooth in the mouth, and the arithmetic average of all scores is the individual's Periodontal Index. The scoring was as follows:

0— Negative. There is neither overt inflammation in the investing tissues nor loss of function due to destruction of supporting tissues.

1— Mild gingivitis. There is an overt area of inflammation in the free gingival, but this area does not circumscribe the tooth.

2— Gingivitis. Inflammation completely circumscribes the tooth, but there is no apparent break in the epithelial attachment.

6— Gingivitis with pocket formations. The epithelial attachment has been broken, and there is a pocket (not merely a deepened gingival crevice due to swelling in the free gingival). There is no interference with normal masticatory function, the tooth is firm in its socket, and has not drifted.

8— Advanced destruction with loss of masticatory function. The tooth may be loose; may have drifted; may sound dull on percussion with a metallic instrument; may be depressible in its socket.

Scores on the index for patients examined ranged from 0 to 8. Nineteen cases were not examined; 1,201 cases were assigned the score 9.8. While this score was not explained, we believe it to represent people who were examined but had no teeth. We eliminated from our study the 1,220 cases who either were not examined or were examined and given a score of 9.8.

Table A-1

COMPLETE EQUATIONS
HYPERTENSION, COEFFICIENTS AND ABSOLUTE VALUES OF t-STATISTICS

	Dependent Variable and Estimation Method							
	Prevalence of Hypertension, Logit		Prevalence of Hypertension, OLS		Prevalence of Hypertension, TSLS[a]		Diastolic Blood Pressure, Subset of Hypertensives, OLS	
Primary Care Physicians/100,000	-.0014 (.33)	.0045 (1.26)	.00043 (1.26)	-.00013 (.33)	.027 (1.09)	.0016 (1.83)	-.040 (1.02)	-.032 (1.04)
Other Physicians/ 100,000	.0027 (2.07)	—	—	.00026 (2.07)	-.0063 (1.15)	—	-.0034 (.30)	—
Beds/1000	.10 (1.90)	—	—	.0096 (1.90)	.0050 (.10)	—	.24 (.53)	—
Federal Beds/ 1000	.057 (.67)	—	—	.0055 (.67)	.098 (1.33)	—	-.26 (.34)	—
Education of Individual, Years	-.027 (1.71)	-.026 (1.63)	-.0025 (1.63)	-.0026 (1.71)	-.0024 (1.06)	-.0027 (1.75)	.15 (1.17)	.15 (1.17)
Income ($)	-.0000011 (.09)	-.0000013 (.10)	-.00000012 (.10)	-.00000010 (.09)	.00000015 (.08)	-.00000024 (.20)	-.000045 (.40)	-.000059 (.54)
Race (1=Nonwhite)	1.27 (8.89)	1.27 (9.01)	.12 (9.01)	.12 (8.89)	.14 (6.27)	.12 (9.04)	2.48 (2.49)	2.40 (2.43)
Percentage of Population Urban	-.0072 (2.90)	-.0043 (2.06)	-.00041 (2.06)	-.00069 (2.90)	-.00083 (1.18)	-.00079 (2.41)	-.0068 (.33)	-.011 (.63)
Age	.15 (7.77)	.14 (7.68)	.014 (7.68)	.014 (7.77)	.011 (2.72)	.014 (7.62)	.62 (3.19)	.63 (3.26)
$(Age)^2$	-.0013 (6.22)	-.0013 (6.12)	-.00013 (6.12)	-.00013 (6.22)	-.00010 (2.41)	-.00013 (6.10)	-.0030 (1.43)	-.0031 (1.50)
Sex (1=Female)	-.25 (2.67)	-.25 (2.63)	-.024 (2.63)	-.024 (2.67)	-.039 (2.28)	-.024 (2.69)	.037 (.046)	-.0081 (.01)
Constant	-5.42 (11.90)	-5.27 (12.27)	-.18 (4.28)	-.19 (4.33)	-.95 (1.67)	-.20 (4.50)	80.94 (17.06)	81.31 (17.61)
R^2	.052	.050	.050	.052	.002	.048	.192	.191
F	23.49	31.19	31.19	23.49	—	—	11.51	15.82
d.f.	11,4757	8,4760	8,4760	11,4757	—	—	11,533	8,536

[a]In case of TSLS, values given beneath coefficients are asymptotically normal variates. R^2 is between actual and estimated dependent variable.

Table A-2

COMPLETE EQUATIONS, SERUM CHOLESTEROL, COEFFICIENTS AND ABSOLUTE VALUE OF t-STATISTICS

	Dependent Variable and Estimation Method				
	Prevalence of Cholesterol >300, Logit		Prevalence of Cholesterol >300, OLS		Subset with Cholesterol >300, OLS
Primary Physicians/100,000	.0082 (1.34)	.0074 (1.41)	.00037 (1.34)	.00033 (1.41)	.15 (1.00)
Other Physicians/100,000	-.00043 (.22)	—	-.000019 (.22)	—	-.076 (1.52)
Beds/1000	-.036 (.47)	—	-.0016 (.47)	—	2.40 (1.12)
Federal Beds/1000	-.14 (1.12)	—	-.0063 (1.12)	—	-1.80 (.36)
Education of Individual (Years)	-.0082 (.35)	-.0078 (.34)	-.00037 (.35)	-.00035 (.34)	.79 (1.35)
Income ($)	.0000078 (.43)	.0000077 (.42)	.00000035 (.43)	.00000034 (.42)	-.00016 (.34)
Race (1=Nonwhite)	-.44 (2.08)	-.46 (2.24)	-.019 (2.08)	-.021 (2.24)	-1.01 (.15)
Percentage of Population Urban	.00032 (.09)	-.00060 (.20)	.000014 (.09)	-.000027 (.20)	.031 (.33)
Age	.041 (1.50)	.042 (1.54)	.0018 (1.50)	.0019 (1.54)	-.76 (.85)
$(Age)^2$	.00018 (.56)	.00016 (.52)	.0000078 (.56)	.0000073 (.52)	.0074 (.79)
Sex (1=Female)	.28 (2.04)	.28 (2.03)	.013 (2.04)	.012 (2.03)	3.78 (.94)
Constant	-5.44 (8.16)	-5.56 (8.82)	-.048 (1.62)	-.054 (1.90)	327.34 (13.92)
R^2	.030	.029	.030	.029	.034
F	13.24	18.02	13.24	18.02	.71
d.f.	11,4757	8,4760	11,4757	8,4760	11,219

Table A-3

COMPLETE EQUATIONS,
PREVALENCE OF ABNORMAL EKG
COEFFICIENTS AND ABSOLUTE VALUES OF t-STATISTICS

	Estimation Method			
	Logit	Logit	OLS	TSLS[a]
Primary Care Physicians/ 100,000	.00073 (.22)	.0015 (.53)	.00011 (.22)	-.016 (.67)
Other Physicians/100,000	-.00096 (.93)	—	-.00015 (.93)	.0039 (.74)
Beds/1000	.021 (.50)	—	.0032 (.50)	-.0093 (.19)
Federal Beds/ 1000	-.23 (3.36)	—	-.035 (3.36)	-.095 (1.34)
Education of Individual (Years)	-.0019 (.16)	-.0012 (.09)	-.00030 (.16)	-.00041 (.18)
Income ($)	-.0000084 (.86)	-.0000099 (1.02)	-.0000013 (.86)	-.0000017 (.93)
Race (1=Nonwhite)	1.00 (8.89)	.93 (8.43)	.15 (8.89)	.14 (6.63)
Percentage of Population Urban	.00010 (.05)	-.0017 (1.02)	.000016 (.05)	.000039 (.06)
Age	-.083 (5.66)	-.082 (5.59)	-.013 (5.66)	-.011 (2.90)
$(Age)^2$	.0014 (8.46)	.0014 (8.39)	.00022 (8.46)	.00021 (5.15)
Sex (1=Female)	-.63 (8.58)	-.63 (8.55)	-.098 (8.58)	-.088 (5.39)
Constant	-.35 (.99)	-.35 (1.02)	.39 (6.96)	.89 (1.63)
R^2	.091	.089	.091	.021
F	43.42	57.87	43.42	—
d.f.	11,4757	8,4760	11,4757	—

[a]In case of TSLS, values given beneath coefficients are asymptotically normal variates. R^2 is between actual and estimated dependent variable.

Table A-4

COMPLETE EQUATIONS,
PREVALENCE OF ABNORMAL CHEST X-RAY
COEFFICIENTS AND ABSOLUTE VALUES OF t-STATISTICS

	Estimation Method			
	OLS	TSLS[a]	OLS	OLS
Primary Care Physicians/ 100,000	-.0014 (1.14)	-.10 (1.15)	-.0018 (1.70)	—
Other Physicians/ 100,000	-.0014 (3.44)	.025 (1.30)	—	-.0014 (3.89)
Beds/1000	.033 (2.06)	-.059 (.32)	—	—
Federal Beds/ 1000	-.030 (1.15)	-.41 (1.56)	—	—
Education of Individual (Years)	-.015 (3.12)	-.017 (2.00)	-.015 (3.19)	-.015 (3.08)
Income ($)	-.0000074 (2.00)	-.000011 (1.60)	-.0000086 (2.32)	-.0000080 (2.17)
Race (1=Nonwhite)	-.082 (1.91)	-.18 (2.22)	-.10 (2.44)	-.097 (2.29)
Percentage of Population Urban	.0024 (3.31)	.00066 (.26)	.0010 (1.59)	.0023 (3.22)
Age	-.037 (6.68)	-.026 (1.84)	-.037 (6.63)	-.038 (6.71)
$(Age)^2$	.00053 (8.25)	.00043 (2.88)	.00053 (8.18)	.00053 (8.28)
Sex (1=Female)	.15 (5.40)	.22 (3.54)	.16 (5.51)	.15 (5.47)
Constant	2.25 (16.51)	5.46 (2.70)	2.38 (18.44)	2.31 (18.18)
R^2	.045	.0003	.042	.044
F	20.52	—	25.81	27.40
d.f.	11,4757	—	8,4760	8,4760

[a]In case of TSLS, values given beneath coefficients are asymptotically normal variates. R^2 is between actual and estimated dependent variable.

Table A-5

COMPLETE EQUATIONS,
PREVALENCE OF VARICOSE VEINS
COEFFICIENTS AND ABSOLUTE VALUES OF t-STATISTICS

	Estimation Method				
	Logit	Logit	OLS	OLS	TSLS[a]
Primary Care Physicians/ 100,000	.0031 (.81)	—	—	.00036 (.81)	.035 (1.24)
Other Physicians/ 100,000	.000030 (.026)	—	—	.0000036 (.026)	-.0063 (1.01)
Beds/1000	-.14 (2.99)	-.13 (2.89)	-.015 (2.89)	-.017 (2.99)	-.16 (2.81)
Federal Beds/ 1000	-.011 (.15)	-.016 (.20)	-.0018 (.20)	-.0013 (.15)	.072 (.86)
Education of Individual (Years)	-.022 (1.52)	-.022 (1.49)	-.0025 (1.49)	-.0026 (1.52)	-.0028 (1.05)
Income ($)	-.0000083 (.74)	-.0000078 (.70)	-.00000091 (.70)	-.00000098 (.74)	-.0000033 (1.51)
Race (1=Nonwhite)	-.44 (3.42)	-.44 (3.39)	-.051 (3.39)	-.052 (3.42)	-.067 (2.65)
Percentage of Population Urban	.0025 (1.11)	.0034 (2.03)	.00039 (2.03)	.00029 (1.11)	-.0012 (1.52)
Age	-.0089 (.52)	-.0086 (.51)	-.0010 (.51)	-.0010 (.52)	-.0055 (1.20)
$(Age)^2$	.00098 (5.01)	.00097 (5.01)	.00011 (5.01)	.00011 (5.01)	.00016 (3.31)
Sex (1=Female)	.82 (9.67)	.82 (9.68)	.096 (9.68)	.096 (9.67)	.089 (4.60)
Constant	-3.24 (7.86)	-3.22 (7.92)	.022 (.46)	.020 (.41)	-.46 (.71)
R^2	.133	.133	.133	.133	.015
F	66.43	81.13	81.13	66.43	—
d.f.	11,4757	9,4759	9,4759	11,4757	—

[a]In case of TSLS, values given beneath coefficients are asymptotically normal variates. R^2 is between actual and estimated dependent variable.

Table A-6

COMPLETE EQUATIONS, PERIODONTAL DISEASE, COEFFICIENTS, AND ABSOLUTE VALUE OF t-STATISTICS

	Estimation Method	
	OLS	TSLS[a]
Dentists/ 100,000	.00012 (.084)	.0042 (1.87)
Education of Individual (Years)	-.082 (11.11)	-.083 (11.16)
Income ($)	-.000038 (6.63)	-.000039 (6.80)
Race (1=Nonwhite)	.19 (2.97)	.20 (3.10)
Percentage of Population Urban	-.0015 (1.32)	-.0036 (2.50)
Age	.032 (3.73)	.032 (3.71)
$(Age)^2$	-.000019 (.19)	-.000020 (.20)
Sex (1=Female)	-.41 (9.42)	-.41 (9.44)
Constant	1.29 (6.53)	1.25 (6.30)
R^2	.166	.164
F	118.22	—
d.f.	8,4760	—

[a]In case of TSLS, values given beneath coefficients are asymptotically normal variates. R^2 is between actual and estimated dependent variable.

Table A-7

COMPLETE EQUATIONS
ABRAHAMSE-KISCH HEALTH STATUS AGE INDEX,
COEFFICIENTS AND ABSOLUTE VALUES OF t-STATISTICS

	Estimation Method	
	OLS	TSLS[a]
Primary Care Physicians/ 100,000	-.0036 (.38)	-.022 (.05)
Other Physicians/100,000	.00030 (.10)	.041 (.46)
Beds/1000	.12 (1.04)	-2.15 (2.53)
Federal Beds/1000	-.78 (4.08)	-1.56 (1.29)
Education of Individual (Years)	-.20 (5.51)	-.21 (5.42)
Income ($)	-.000078 (2.83)	-.00012 (3.90)
Race (1=Nonwhite)	.72 (2.25)	.11 (.31)
Percentage of Population Urban	.0023 (.42)	-.024 (2.04)
Age	.49 (11.68)	.48 (7.35)
$(Age)^2$	-.0013 (2.59)	-.0012 (1.74)
Sex (1=Female)	.014 (.069)	.21 (.74)
Constant	26.20 (25.71)	34.58 (3.72)
R^2	.367	.304
F	251.22	—
d.f.	11,4757	—

[a]In case of TSLS, values given beneath coefficients are asymptotically normal variates. R^2 is between actual and estimated dependent variable.

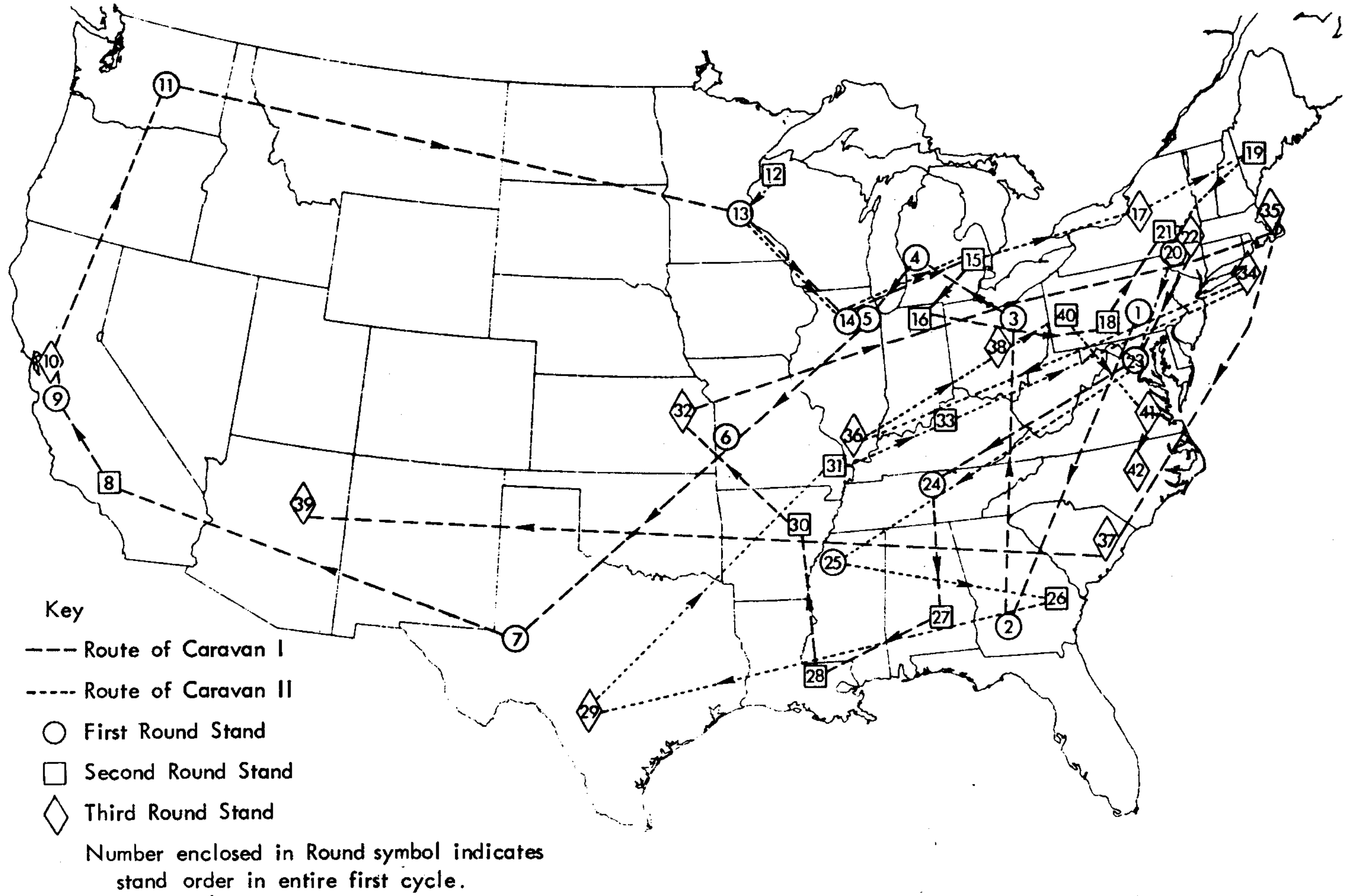

Fig. A-1—Routes followed by mobile health examination centers in moving from one location to another

Table A-8

AREAS IN THE HEALTH EXAMINATION SURVEY'S SAMPLE

Caravan I

1. Philadelphia, Pennsylvania
2. Valdosta, Georgia
3. Akron, Ohio
4. Muskegon, Michigan
5. Chicago, Illinois
6. Butler, Missouri
7. Midland, Texas
8. Los Angeles, California
9. San Jose, California
10. San Francisco, California
11. Grand Coulee, Washington
13. Minneapolis, Minnesota
14. Chicago, Illinois
15. Detroit, Michigan
16. Fort Wayne, Indiana
18. York, Pennsylvania
21. New York, New York
22. New York, New York
23. Baltimore, Maryland
24. Nashville, Tennessee
27. Eufaula, Alabama
28. Clinton, Louisiana
30. Newport, Arkansas
32, Topeka, Kansas
35. Boston, Massachusetts
37. Conway, South Carolina
39. Winslow, Arizona

Caravan II

(During the early part of the Health Examination Survey only one Mobile Examination Center was used.)

12. Washburn, Wisconsin
13. Minneapolis, Minnesota
14. Chicago, Illinois
15. Detroit, Michigan
17. Auburn, New York
19. Biddeford, Maine
20. New York, New York
23. Baltimore, Maryland
25. Oxford, Mississippi
26. Savannah, Georgia
29. San Antonio, Texas
31. Kennett, Missouri
33. Louisville, Kentucky
34. Providence, Rhode Island
36. Carbondale, Illinois
38. Columbus, Ohio
40. Pittsburgh, Pennsylvania
41. Newport News, Virginia
42. Rocky Mount, North Carolina

NOTE: Taken from National Center for Health Statistics (1965). Note that three separate samples were drawn in New York City, and two separate samples were drawn in Chicago; thus the actual number of distinct areas involved in the survey was 39 as reported in the text.

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