# Laboratory Test Ordering by Physicians: The Effect of Reimbursement Policies

M. Susan Marquis

Rand

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# Laboratory Test Ordering by Physicians: The Effect of Reimbursement Policies

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## PREFACE

This is one in a series of reports being prepared under Contract No. 500-78-0048 with the Health Care Financing Administration, U.S. Department of Health and Human Services. The research performed under this contract examines the effects of reimbursement policies on the use of clinical laboratory tests and on prices charged for tests.

The present study uses data from the Health Insurance Experiment to investigate the effects of the patient's insurance coverage and of test-billing arrangements on the frequency of test ordering by office-based physicians.

Other Rand reports prepared under this contract are

Economic Factors in the Use of Laboratory Tests by Office-Based Physicians, by Patricia Munch Danzon, R-2525-1-HCFA, August 1982.

"Profits" in Hospital Laboratories: The Effects of Reimbursement Policies on Hospital Costs and Charges, by Patricia Munch Danzon, R-2582-HCFA, September 1980.

The Use of Pathology Services: A Comparison of Fee-for-Service and a Prepaid Group Practice, by Willard G. Manning, Jr., forthcoming.

This series of reports should be of interest to analysts working in the field of medical economics and to decisionmakers involved in formulating health policy.

## SUMMARY

The use of laboratory tests has more than doubled during the past decade. Some feel that this growth in the use of laboratory tests has been excessive and is a result of the financial incentives inherent in the reimbursement system for tests. A number of authors argue that the profit potential in testing encourages the substitution of laboratory tests for physician time. Further, the patient has little economic incentive to hold down the number of tests ordered because a large share of the bill is financed by insurance.

This study investigates the importance of several reimbursement factors in the frequency of test ordering by office-based physicians. Data for the analysis came from the Rand Health Insurance Experiment (HIE) in which families have been randomly assigned to one of several health insurance plans that vary the share of the medical bill that the family pays. Information about laboratory tests ordered by physicians was obtained from insurance claims forms submitted to the HIE by participating families.

The number of laboratory tests ordered per visit is not related to the level of the patient's insurance coverage. Despite this, more generous insurance coverage for ambulatory care would lead to an increase in total test volumes, because physician visit rates have been shown elsewhere to be strongly influenced by the amount of patient cost sharing for medical care.

Physicians who control test billing are more likely to order tests than physicians who refer their patients to laboratories that bill directly. However, testing in-house and controlling test billing may be the result of a high anticipated volume of tests rather than the cause of a higher test-ordering frequency. The available data do not allow us to disentangle these effects. Although we remain uncertain to what extent, if at all, direct billing regulations would affect test volumes, we do conclude that such regulations are not likely to result in significant reductions in total health care costs. The marginal cost

of the tests is far below their average costs, so that very large reductions in test volumes would be required to achieve significant cost savings.

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## CONTENTS

## TABLES

# I. INTRODUCTION

The spiraling costs of health care have been of major concern for more than a decade. During the 1970s, expenditures for health care rose by more than 200 percent, increasing from 7.6 percent of GNP in 1970 to 9.4 percent in 1980. Despite efforts during the 1970s to control the rising costs of care, medical care price increases have continued to exceed the rise in prices in other segments of the economy.

Although many factors are involved in the growth of health expenditures, medical technologies are often cited as a leading contributor. The adoption and use of high-cost medical technologies are considered by many to be a central cause of accelerating health care costs. Others feel that the increased use of less costly technologies that are readily available to physicians may account for a far greater share of the growth in health care expenses (e.g., Moloney and Rogers, 1979). For example, between 1972 and 1977, out-of-hospital laboratory tests increased by almost 70 percent and expenditures for these tests amounted to $4.2 billion by 1978 (Gibson, 1979).

Reasons cited for the growth in laboratory tests include advances in medical knowledge, automation and increased convenience, the practice of defensive medicine, increased insurance coverage, and financial incentives for physicians (Fineberg, 1979; Danzon, 1982). The focus in this report will be on investigating the importance of the latter two factors in physicians' decisions to perform a laboratory test during an ambulatory care visit.

Insurance coverage for laboratory tests was increased for the aged and poor in 1966 with the introduction of Medicare and Medicaid. The extension of private insurance benefits for laboratory tests has provided coverage for a large fraction of the remaining population; by 1977, almost 75 percent of the nonaged population had private insurance coverage for X-ray and laboratory services (Carroll and Arnett, 1979).[1]

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[1] Benefits for diagnostic X-ray and laboratory tests, however, are often limited. The most common benefit in 1977 was $100 (Carroll and Arnett, 1979).

The growth of private insurance coverage for laboratory tests and the introduction of Medicare and Medicaid have reduced the private cost of obtaining laboratory tests. As financial constraints are reduced, patients and their doctors are free to demand more and more laboratory services.

A number of authors argue that financial incentives inherent in testing have led to excessive test use. Reinhardt (1978) suggested that physicians use laboratory tests to maintain a target level of income, and there is some empirical evidence to support the hypothesis (Moloney and Rogers, 1979; Holahan and Scanlon, 1979). Childs and Hunter (1972) found that physicians providing direct X-ray services used X-rays more intensively than other physicians. Bailey (1968) observed a similar pattern for laboratory use and suggested it was prompted by the profitability of laboratory tests performed in-house. Schroeder and Showstack (1979) also maintain that testing in-house leads to financial rewards. They suggest that fee systems as established by relative value studies have encouraged the acquisition and use of medical technologies because technologies are overpriced on these scales compared with physician time. Using charges for procedures and tests based on the 1974 California Relative Value Studies, they show that the net income of a hypothetical physician increases sharply with the degree to which laboratory tests and other diagnostic procedures are performed in-house.

Bailey (1979) feels that the pricing practices of laboratories also encourage increased testing by physicians who purchase tests and bill their patients for the tests. He suggests that laboratories maintain two price schedules: one for billing patients and a lower schedule of charges to physicians. He argues that physicians who purchase tests and bill their patients can then justify large markups over cost by reference to the laboratory's patient-billing schedule. In fact, Bailey concludes that "moving the physician out of the financial transaction in testing--via direct billing laws--is the only workable means of discouraging unnecessary testing based on economic incentives" (Bailey, 1979, p. 5).

The purpose of this report is to investigate the effects of reimbursement policies and practices on physicians' test-ordering

decisions for ambulatory care. Specifically, we will examine to what degree the number of tests performed per visit is influenced by the level of the patient's insurance coverage and physician-laboratory billing arrangements. The analysis is based on the theoretical model of laboratory test use developed by Danzon (1982), which is reviewed in Sec. II. Data for the empirical investigation came from the Rand Health Insurance Experiment, described in Sec. III. Section IV reports the empirical findings. The empirical analysis shows that the level of the patient's insurance coverage does not influence the number of tests ordered per visit. However, increases in insurance coverage for ambulatory care would be expected to result in a higher total volume of tests because physician visit rates are higher the more generous the insurance coverage (Newhouse et al., 1981). Physicians who control test billing, either by producing tests or billing patients for purchased tests, appear to order more tests per visit than physicians who refer their patients to laboratories that bill patients directly. This finding is consistent with Bailey's argument. However, in-house testing and test-billing control by physicians may be the result of a high anticipated frequency of tests rather than the cause of a high rate of testing. The available data do not allow us to disentangle the causality, and thus we cannot definitively support Bailey's hypothesis that there is an inducement to greater test frequency if the physician controls test billing.

## II. ANALYTIC FRAMEWORK

The framework for the analysis of physicians' test-ordering decisions is based on the theoretical model of physician behavior developed by Danzon (1982). The physician is assumed to face a demand curve for visits that depends on the amount of care provided during a visit and the price consumers pay for a visit. The physician combines his own time and laboratory tests to produce the level of care, or "quality," per visit.[1] The physician is assumed to choose the total price of the visit, the length of the visit, and the number of laboratory tests performed so as to maximize profits. Total visit price includes the charges for the physician's time and charges for the laboratory tests. The consumer's price may be less than the total price charged by the physician, if the consumer has insurance coverage.

In the appendix, the model is formally developed in order to investigate how changes in insurance coverage affect the number of tests ordered per visit. As shown there, the direction of change in the number of tests per visit resulting from an increase in patients' insurance cannot be determined from theory. An heuristic explanation of this ambiguous result lies in the notion that the final product is not laboratory tests per visit but total health care. Total health care is the product of the quantity of medical care visits and the quality or level of care for each visit. Willis (1973) investigates the effects of changes in price (analogous to a change in insurance) on the demand for goods that have both a quality and quantity dimension. He demonstrates that a decrease in the price of the good will increase the demand for the total product, but the effect on either quality or quantity alone is uncertain. Similarly, an increase in insurance coverage would be expected to lead to an increase in demand for total health care, but a priori it cannot be determined how the increased care

[1] Additional physician time and laboratory tests are assumed to result in higher "quality" as perceived by the patient, but not necessarily higher clinical quality. The patient's perceptions of quality and clinical quality may diverge if consumers do not have perfect information.

is divided between changes in the number of visits and changes in quality (hence tests) per visit.

Other determinants of the number of laboratory tests per visit include the supply price of tests and physician time. Again, the direction of change in tests per visit from an increase in supply prices cannot be determined a priori (see the appendix). For example, an increase in the cost of laboratory tests raises the marginal cost schedule for alternative levels of tests per visit. This would tend to lower the optimal number of tests per visit for a specified level of quality per visit. However, an increase in the cost of tests also shifts the marginal cost schedule for quantity of visits, and adjustments in the quantity of visits may have offsetting effects on the optimal level of quality per visit and thus on testing per visit.

Although theory does not tell us how changes in insurance and changes in supply prices affect the number of tests per visit, previous empirical work does suggest that changes in insurance do not affect test-ordering decisions, that an increase in the implicit wage of physicians will raise the number of tests per visit, and that a rise in the supply price of tests will reduce the rate of test ordering.

Danzon (1982) investigated the effect of insurance coverage on the frequency of test ordering and found no consistent relationship between the level of copayment and the frequency of test ordering. The only statistically significant effect of insurance was a lower frequency of tests for Medicaid patients, who usually have no copayment, than for all other patients. However, a true effect of insurance on physicians' test-ordering decisions may be masked in Danzon's data. Her analysis compared the number of tests per visit for patients with Blue Shield coverage, commercial insurance, or insurance through the government Medicare and Medicaid programs. Patients in these plans differ in other characteristics, not just the level of insurance. For example, Medicaid patients include a large number of children; Medicare patients are elderly and disabled. Clinical factors associated with the health problems and needs of these different groups may have dominated any true effect of the level of insurance coverage on physicians' test-ordering behavior.

Specialty training may be a proxy for the implicit wage, and a number of authors have found that primary care specialists order more tests per visit than general practitioners (Eisenberg and Nicklin, 1981; Fishbane and Starfield, 1981; Noren et al., 1980), suggesting that an increase in the opportunity cost of physicians' time may lead to a substitution of laboratory tests for time in providing a visit. Increasing age of the physician or time since graduation may also represent an increase in the implicit wage, capturing both experience and the preference for leisure at older age. However, younger, recent graduates may have had more technological training, and so age may be inversely related to preference or "taste" for laboratory testing. Indeed, most authors have found that test ordering per visit is greater among younger physicians than among older ones (Eisenberg and Nicklin, 1981; Freeborn et al., 1972).

Proximity of the physician to a laboratory may reduce the supply price of tests by lowering collection costs. Danzon (1982) reported that the number of laboratories in the physician's geographic area was positively associated with the rate of test ordering. To the extent that the number of laboratories is a proxy for lower collection costs and a lower total test cost, this result suggests that increases in the supply price of tests will lower test ordering per visit.

In sum, the theoretical model used here does not predict how changes in patients' insurance coverage and the supply price of tests and physician time will affect the number of laboratory tests performed during a physician visit. Although it is frequently argued that health insurance has led to an increase in laboratory use, the one empirical study found no relationship between insurance and the number of laboratory tests per visit. However, data from Rand's Health Insurance Experiment can provide a better assessment of this relationship because families are randomly assigned to insurance plans, ensuring that patients on different plans are alike in their other characteristics. We now turn to a description of those data.

## III. DATA AND METHODS

### DATA SOURCES

The data for this study came from the Health Insurance Experiment (HIE), a social experiment designed to evaluate the effects of varying the generosity of insurance coverage. Details about the HIE and its design are given in Newhouse (1974) and Newhouse et al. (1981). Briefly, the HIE enrolls families in one of several different health insurance plans that vary the share of the bill that the family has to pay for its medical expenditures. Families who are participating in the experiment come from six sites. The majority of the sample participates for three years, the remainder for five years. For the purpose of this report, we analyzed data from two years of the experiment in two of the sites: the second and third year of the experiment in Dayton, Ohio, and the first and second year in Seattle, Washington. The combined sample in the two sites includes approximately 2300 individuals; the period covered by the data included here is roughly calendar years 1976 and 1977.

During their participation in the experiment, the HIE acts as the families' insurance company, and the families file claims with the experiment for all their medical care utilization. For each ambulatory care visit to a physician, the claims data provide information about the physician providing treatment, the diagnosis, and an itemization of each service provided. If the physician orders a laboratory test and bills the patient directly, the claim from the physician will indicate the number and type of tests performed. If the physician refers the patient to a laboratory and does not bill the patient directly, the physician reports the name of the laboratory to which the patient was referred. The laboratory files a separate claim giving the number and type of tests and the name of the referring physician. Referral information is used to link tests billed directly by the laboratory to the physician and visit initiating the test.

We used two other sources of data in this analysis. One is the American Medical Association (AMA) survey of physicians, which

provides information about personal and practice characteristics of physicians in each site. The third data source is a 1978 telephone survey of physicians conducted by the HIE. The telephone survey is taken annually with a sample of primary care providers in each site. The 1978 survey included questions about which laboratory was used for several common tests. We used these data to construct measures of whether the physician or laboratory controls test billing as described below.

## METHODS

The analysis focuses on outpatient laboratory tests ordered by primary care practitioners--general practitioners, internists, and pediatricians--in office-based practice. To control for patient characteristics that may affect prescribing behavior, we analyzed separately the test-ordering decisions of general practitioners and pediatricians in treating children (persons under age 17) from the decisions of general practitioners and internists in treating adults. In each case, the physician's test-ordering behavior was modeled as a two-part decision: the decision to order any tests for a visit and the number of tests ordered during visits with at least one test.[1] For the first decision, we fit a probit equation specifying the probability that at least one test was performed during a visit as a function of the patient's insurance coverage and characteristics of the physician and his or her practice (which are detailed below).

The measure of the number of tests performed per visit was based on the California Relative Value Scales (CRVS) units, which assign relative values to each procedure reflecting differences in complexity among tests; the values are based on cost differences. The CRVS units assigned to each test were summed over all tests performed during a single visit. To model the second decision, the logarithm of the total CRVS units for visits with at least one test performed were regressed on the same set of explanatory variables used to model the first decision. Although we measured the "number" of tests in complexity units rather

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[1] For a more technical discussion of a similar two-part model, see Manning (forthcoming).

than in simple counts of the number of tests, the correlation between the number of intensity units and the number of tests was 0.90; therefore, similar results would be obtained using simple counts of the number of tests as the dependent variable.

A restriction in both univariate probit and ordinary least squares regression is that the individual observations are stochastically independent. However, the vector of observations on our dependent variables contains multiple observations for an individual physician, each observation describing his behavior during a specific visit. The error terms in the equation are therefore likely to be correlated across the visits to a particular physician because of unmeasured factors that influence the physician's decision. In this case, univariate probit and ordinary least squares will yield underestimates of the standard errors and overestimates of the t-statistics. Naihua Duan (1982, Appendix) developed a methodology for calculating an upper-bound adjustment to the precision estimated from the univariate probit models that avoids the computationally expensive multivariate specification when intracluster correlation is a problem. In these analyses, we present both the t-statistic estimated from the univariate probit and the adjusted t-statistic; the true t-statistic will lie between the two estimates.

To take account of intracluster correlation in analyzing the level of tests performed, we used a variance components estimator (see Maddala (1971) or Balestra and Nerlove (1966) for a discussion of this model). The equation includes a variance component for each physician and is estimated by maximum likelihood.

We fit the models in two phases. First, we estimated the models using all ambulatory care visits to primary care practitioners. However, to examine Bailey's hypothesis that physicians who do tests in-house or control test billing perform more tests than physicians who refer their patients to laboratories that bill directly, we needed measures of test location and billing arrangements. These measures are not available for all physicians, but they are available from the sample of physicians who were included in the 1978 telephone survey. In the second phase of the analysis, we estimated the equations using

observations for these physicians and including the measures of test location and billing arrangements among the arguments.

For the full sample, we had observations on 3156 visits by children to 96 pediatricians and 191 general practitioners, and 5891 visits by adults to 92 internists and 274 general practitioners. In this sample, we have excluded from the claims data visits to out-of-area providers and visits to providers for whom AMA information on practice characteristics was unavailable; the exclusions represent about 8 percent of visits by participants to primary care providers. For the analysis on the subsample included in the telephone survey, we had data on 1012 visits by children to 68 physicians and 1750 visits by adults to 120 physicians.

## DEPENDENT VARIABLES

We obtained measures of the frequency of test ordering and of CRVS units for tests performed during a visit from claims submitted to the HIE. We also derived measures of the frequency of ordering two particular test groups--urinalyses and blood cell counts--and fit probit regressions for the probability of ordering the specific tests as well as for any test.

Case mix differs between general practitioners and specialists. Therefore, in addition to estimating the models on all visits, we fit the models for visits for a few of the more common diagnoses.[2] For children, the selected diagnoses were general examination, pharyngitis/tonsillitis (Tonsillitis), and upper respiratory infection (URI). These diagnoses account for 35 percent of all children's visits to pediatricians and general practitioners. For adults, we added to the list hypertension, angina, urinary tract infection (UTI), and headache. The included diagnoses represent 25 percent of visits by adults to internists and general practitioners.

Observed values of the dependent variables for the full sample of visits are given in Table 1. For all diagnoses, laboratory tests were ordered during 25 percent of visits by children and 29 percent of visits by adults.

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[2] For visits with multiple diagnoses, we used the first diagnosis listed by the physician to classify the visit.

Table 1

OBSERVED VALUES OF THE DEPENDENT VARIABLES
(Full Visit Sample)

| Variable | Visits by Children Mean | Visits by Children Number of Visits | Visits by Adults Mean | Visits by Adults Number of Visits |
|---|---|---|---|---|
| All visits | | | | |
| Frequency any test | 0.25 | 3156 | 0.29 | 5891 |
| Frequency urinalysis | 0.11 | 3156 | 0.12 | 5891 |
| Frequency cell counts | 0.09 | 3156 | 0.12 | 5891 |
| Logarithm (CRVS units)[a] | 2.65 | 806 | 3.01 | 1717 |
| Selected diagnoses | | | | |
| Frequency any test | 0.41 | 1098 | 0.29 | 1469 |
| Logarithm (CRVS units)[a] | 2.55 | 449 | 2.92 | 431 |

[a]For visits with at least one test.

## INDEPENDENT VARIABLES

The experimental insurance plans vary on two dimensions: the share of the bill the family pays (coinsurance rate) and an upper limit on out-of-pocket expenses. For our purposes, the insurance coverage was represented as four indicator variables: a coinsurance rate of 25 percent (P25); a coinsurance rate of 50 percent (P50); a coinsurance of 95 percent, which is similar to a family deductible plan (PFD); and a coinsurance rate for outpatient care of 95 percent with free inpatient care and an individual maximum of $150 out-of-pocket expense, or $450 per family, which is similar to an individual deductible plan (IDP). The plan providing free care was the omitted category.

Danzon (1982) analyzed the decision to do tests in-house and found practice size to be a significant determinant. Therefore, we included indicator variables, measured from the AMA data, for the physician's mode of practice as a proxy for in-house testing, lacking a direct measure for the full sample. Group practice was the omitted category. The three indicator variables represent solo practice, partnership, and unknown mode. The latter category also includes physicians who reported employment other than office-based care at the time of the AMA survey.

Other physician characteristics included in the regressions were an indicator for specialist (which takes the value 1 if the physician is a pediatrician or internist; 0 if the physician is a general practitioner) and the decade of graduation (e.g., scored as 5 if the physician graduated between 1950 and 1959).

As noted above, models were fit on all visits and on visits for a few common diagnoses. In the latter case, indicators for the diagnosis were included among the explanatory variables. General examination was the omitted indicator in the regressions.

For the second stage of analysis, direct measures of whether laboratory tests were performed in-house and billing arrangements for purchased tests were obtained from the 1978 telephone survey of physicians. Data were available for 147 physicians who provided care to HIE participants in the study years covered in this analysis. The survey included questions about which laboratory is usually used for a urinalysis and a complete blood count (CBC). Indicator variables for performing tests in-house and for billing arrangements were constructed from the responses. If the physician reported that he or she performed all urinalyses and all CBCs in-house, an indicator, In-house, was set to one. Otherwise, the physician was assumed to purchase tests and In-house was given the value zero.

For physicians who purchased tests, indicator variables for billing arrangements were inferred as follows: If the physician ordered one or more of the tests that he or she reported purchasing, an indicator (Bills Tests) was set to one if he or she billed directly for the test (or the majority of the tests ordered), and zero otherwise. If the physician did not order urinalyses or CBCs for an HIE patient during the two-year period, the indicator for physician billing was set to one if other physicians who reported purchasing urinalyses or CBCs from the same laboratory used by the first physician billed patients directly, and zero if the laboratory billed the patients directly. In some instances, there was insufficient information to determine the billing practice and a missing indicator, DK (Don't Know) Billing, was set to one. The omitted category was direct billing by the laboratory. Among the 147 physicians in the telephone survey subsample, 28 percent performed all

tests in-house, 40 percent purchased tests and billed their patients, and 12 percent referred patients to laboratories that bill directly. Billing arrangements could not be determined for the remaining 20 percent of the physicians.

## IV. EMPIRICAL RESULTS

In reporting the empirical findings, we will focus on the effects of the patient's insurance coverage and of test-billing arrangements on the physician's test-ordering decisions. We first report results using the full sample of data; these results are shown in Tables 2 through 7. We then turn to estimates of the effects of location of testing and billing arrangements, using the subsample of physicians for whom direct measures are available.

### EFFECTS OF INSURANCE

Patients' insurance is not found to be a significant factor in the number of laboratory tests ordered during a physician visit. Plan coefficients for the probability of ordering a test (Tables 2 and 3) are not monotonic with respect to the copayment provisions of the plan, and they are not, in general, statistically significant. Similarly, there is neither a significant nor consistent relationship between the level of patient insurance coverage and the number of tests ordered, during visits with at least one test (Tables 4 and 5).

There are some differences in the frequency of ordering tests among plans in the equations for all visits that appear significant based on univariate probit t-statistics, although the upper-bound adjustment for intracluster correlation renders all plan differences insignificant. For example, the frequency of test ordering for all visits is higher for adults who pay 50 percent of the bill and for adults who pay 95 percent of their charges for ambulatory care (IDP) than for adults with free care (Table 2). However, the tendency for test frequency to be higher for patients with less generous insurance does not hold for the plan that requires 95-percent cost sharing for both inpatient and ambulatory care (PFD); nor is the tendency found after controlling for diagnosis, or in the equations for visits by children. Looking across the results for children and adults, and those for all visits and the selected diagnoses, there is no consistent pattern of plan effects on test frequency.

Table 2

PROBABILITY OF ORDERING A TEST: VISITS BY ADULTS TO INTERNISTS AND GENERAL PRACTITIONERS

| | All Visits | | | Selected Diagnoses | | |
|---|---|---|---|---|---|---|
| | | (t-Statistic) | | | (t-Statistic) | |
| Variable | Coeff. | Unadj. | Adj. | Coeff. | Unadj. | Adj. |
| P25 | 0.027 | ( 0.58 | 0.27) | 0.005 | ( 0.05 | 0.03) |
| P50 | 0.191 | ( 2.42 | 1.12) | -0.245 | (-1.39 | -0.79) |
| PFD | -0.012 | (-0.23 | -0.11) | -0.007 | (-0.07 | -0.04) |
| IDP | 0.179 | ( 3.50 | 1.61) | 0.209 | ( 1.87 | 1.06) |
| Solo | -0.234 | (-5.28 | -2.43) | -0.118 | (-1.19 | -0.68) |
| Partnership | -0.084 | (-1.59 | -0.73) | -0.246 | (-2.16 | -1.23) |
| Unknown mode | -0.376 | (-4.61 | -2.12) | -0.160 | (-0.96 | -0.54) |
| Specialist | 0.374 | ( 8.32 | 3.83) | 0.345 | ( 3.21 | 1.83) |
| Decade | 0.116 | ( 6.18 | 2.84) | 0.173 | ( 4.33 | 2.47) |
| Tonsillitis | -- | | | -0.639 | (-4.43 | 2.53) |
| URI | -- | | | -1.174 | (-8.26 | 4.72) |
| Hypertension | -- | | | -1.218 | (-9.38 | 5.36) |
| Angina | -- | | | -1.168 | (-7.31 | 4.18) |
| UTI | -- | | | 0.370 | ( 2.14 | 1.22) |
| Headache | -- | | | -1.405 | (-8.50 | -4.86) |
| Intercept | -1.117 | (-10.13 | -4.67) | -0.509 | (-2.05 | -1.17) |
| $\chi^2$ | 170.85 | | | 280.64 | | |
| df | 9 | | | 15 | | |
| $\rho$ | 0.20 | | | 0.25 | | |

NOTES: Unadjusted t (Unadj.) is the univariate probit estimate. Adjusted t (Adj.) applies the upper-bound correction factor for intracluster correlation. $\rho$ is the estimated intracluster correlation.

However, it is possible that there are offsetting factors that would mask an effect of insurance on physicians' decisions to order tests. Because patients with higher coinsurance are less likely to visit a physician (see Newhouse et al., 1981), those who do seek physician care may be, on average, more sick than patients with generous coverage who obtain care. Although our analyses do control for diagnoses, they do not control for severity of illness. Greater health needs among patients with higher coinsurance may offset the physician's tendency to order more tests per visit for patients with generous insurance than for other patients with the same health needs.

Table 3

PROBABILITY OF ORDERING A TEST: VISITS BY CHILDREN TO PEDIATRICIANS AND GENERAL PRACTITIONERS

| | All Visits | | | Selected Diagnoses | | |
|---|---|---|---|---|---|---|
| | | (t-Statistic) | | | (t-Statistic) | |
| Variable | Coeff. | Unadj. | Adj. | Coeff. | Unadj. | Adj. |
| P25 | -0.079 | (-1.19 | -0.53) | 0.135 | ( 1.25 | 0.76) |
| P50 | -0.200 | (-2.11 | -0.93) | -0.149 | (-1.04 | -0.63) |
| PFD | 0.062 | ( 0.85 | 0.37) | -0.072 | (-0.58 | -0.35) |
| IDP | 0.004 | ( 0.06 | 0.03) | 0.104 | ( 0.81 | 0.49) |
| Solo | -0.326 | (-5.51 | -2.45) | -0.214 | (-2.18 | -1.32) |
| Partnership | -0.078 | (-1.17 | -0.52) | -0.023 | (-0.21 | -0.13) |
| Unknown mode | -0.270 | (-2.08 | -0.92) | -0.001 | (-0.00 | -0.00) |
| Specialist | 0.255 | ( 4.82 | 2.14) | 0.400 | ( 4.45 | 2.70) |
| Decade | -0.019 | (-0.68 | -0.30) | 0.063 | ( 1.33 | 0.81) |
| Tonsillitis | -- | | | 0.187 | ( 1.78 | 1.08) |
| URI | -- | | | -1.050 | (-9.73 | 5.90) |
| Intercept | -0.537 | (-3.19 | -1.42) | -0.528 | (-1.89 | -1.15) |
| $\chi^2$ | 78.31 | | | 187.38 | | |
| df | 9 | | | 11 | | |
| $\rho$ | 0.20 | | | 0.25 | | |

NOTES: Unadjusted t (Unadj.) is the univariate probit estimate. Adjusted t (Adj.) applies the upper-bound correction factor for intracluster correlation. $\rho$ is the estimated intracluster correlation.

Nonetheless, the findings do show that one would not expect to observe an increase in test ordering per visit if the fraction of ambulatory care paid for by third parties increased.

Although we do not find that insurance coverage is a determinant of the number of tests <u>per visit</u>, still we can expect that changes in insurance coverage would have substantial effects on the <u>total</u> volume of laboratory tests performed. Data from the HIE have demonstrated that the extent of insurance coverage does influence the number of physician visits (Newhouse et al., 1981). Individuals with full coverage for medical care have 46 percent more doctor office visits than individuals who are responsible for 95 percent of their medical expenditures. Because tests per visit appear to be invariant with

Table 4

(LOG) LEVEL OF TESTS: VISITS BY ADULTS TO INTERNISTS AND GENERAL PRACTITIONERS

| | All Visits | | Selected Diagnoses | |
|---|---|---|---|---|
| Variable | Coeff. | (t) | Coeff. | (t) |
| P25 | 0.018 | ( 0.28) | 0.131 | ( 0.95) |
| P50 | -0.203 | (-1.89) | 0.242 | ( 1.22) |
| PFD | -0.109 | (-1.51) | -0.065 | (-0.54) |
| IDP | -0.027 | (-0.37) | 0.025 | ( 0.20) |
| Solo | 0.021 | ( 0.29) | 0.249 | ( 2.11) |
| Partnership | 0.005 | ( 0.05) | 0.357 | ( 2.56) |
| Unknown mode | -0.169 | (-1.39) | 0.153 | ( 0.82) |
| Specialist | 0.472 | ( 6.85) | 0.387 | ( 3.09) |
| Decade | 0.072 | ( 2.29) | 0.053 | ( 1.02) |
| Tonsillitis | -- | | -0.207 | (-1.57) |
| URI | -- | | -0.336 | (-2.22) |
| Hypertension | -- | | -0.042 | ( 0.33) |
| Angina | -- | | -0.067 | (-0.36) |
| UTI | -- | | -0.869 | (-6.86) |
| Headache | -- | | -0.072 | ( 0.36) |
| Intercept | 2.577 | (13.99) | 2.572 | ( 8.45) |
| F | 6.91 | | 6.11 | |
| df | 9,1667 | | 15,415 | |
| ρ | 0.16 | | 0.18 | |

NOTE: ρ is the intracluster correlation.

respect to insurance, this suggests that annual total test rates would vary across insurance plans by about the same percentage as physician visit rates.

## EFFECTS OF PHYSICIAN AND PRACTICE CHARACTERISTICS

Physicians in solo practice are less likely to order a test for all visits than physicians in group practice (Tables 2 and 3). In the selected diagnoses equation for children, the coefficient on solo practice is not significant after adjusting the t-statistic for intracluster correlation; the solo practice coefficient in the selected diagnoses equation for adults is also not significant. Because the sample size is reduced, coefficient estimates in the selected diagnoses

Table 5

(LOG) LEVEL OF TESTS: VISITS BY CHILDREN TO PEDIATRICIANS AND GENERAL PRACTITIONERS

| | All Visits | | Selected Diagnosis | |
|---|---|---|---|---|
| Variable | Coeff. | (t) | Coeff. | (t) |
| P25 | 0.017 | ( 0.26) | 0.031 | ( 0.47) |
| P5C | -0.202 | (-1.99) | -0.042 | (-0.45) |
| PFD | -0.001 | (-0.01) | 0.015 | ( 0.21) |
| IDP | 0.137 | ( 2.01) | 0.041 | ( 0.56) |
| Solo | 0.041 | ( 0.50) | 0.086 | ( 1.06) |
| Partnership | -0.122 | (-1.43) | -0.059 | (-0.72) |
| Unknown mode | 0.248 | ( 1.58) | -0.012 | (-0.08) |
| Specialist | 0.027 | ( 0.39) | 0.129 | ( 1.89) |
| Decade | 0.069 | ( 1.92) | 0.034 | ( 0.95) |
| Tonsillitis | -- | | 0.578 | (10.46) |
| URI | -- | | 0.241 | ( 3.06) |
| Intercept | 2.256 | (10.30) | 2.077 | ( 9.62) |
| F | 2.61 | | 10.98 | |
| df | 9,796 | | 11,437 | |
| ρ | 0.22 | | 0.25 | |

NOTE: ρ is the intracluster correlation.

equations are less precise than coefficients in the equations for all visits, and the solo practice coefficient does remain negative in the selected diagnoses results. However, the point estimate of the effect of solo practice is smaller after controlling for diagnosis. This suggests that there may be case mix differences associated with practice size, and that the solo practice coefficient in the all-visit equation reflects, in part, clinical factors associated with test ordering. The coefficient for physicians in partnership, compared with those in larger groups, is also consistently negative, although it is in general not statistically significant.

As noted earlier, Danzon (1982) found that physicians in solo practice and in small groups are less likely to produce tests in-house than physicians in larger groups. The negative relationship shown here between practice size and the probability of performing a laboratory test may therefore reflect an effect of test location on the frequency

of test ordering. We shall return to this question in more detail later.

The influence of practice size on test frequency may also represent other economic determinants of test ordering. To the extent that larger groups make greater use of ancillary personnel, the implicit cost of time in managing a patient visit may be lower in large groups than in solo practice. As we noted above, the total effect on tests-per-visit of changes in cost functions could not be predicted from theory. Others hypothesize that revenue sharing and cost sharing, which are found more often in larger groups, are disincentives to individual physician effort and may induce a substitution in favor of ancillary services. Whatever the explanation, we do find less frequent test ordering among physicians in solo practice. Evaluated at the mean of the other explanatory variables, the probability of physicians' ordering tests (all visits) for children is 11 percentage points lower among those in solo practice than those in group practice; for adults, the difference in the frequency of testing between solo and group practice is 8 percentage points.[1] Assuming that at least one test is ordered, however, practice mode is not related to the number of tests performed (Tables 4 and 5).

In line with earlier studies, we find that primary care specialists order more tests per visit than do general practitioners. The frequency of ordering tests for adults is 12 percentage points higher among internists than among general practitioners, taken at the mean of the other characteristics. Comparing pediatricians and general

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[1] In nonlinear models, such as the probit, the response of an individual with mean characteristics is not the same as the mean response. For the probit, the marginal probability change, given a change in one of the independent variables, is

$$\frac{\delta(\text{probability})}{\delta X_k} = \phi(X'\beta)\beta_k,$$

where X is a vector of independent variables, $X_k$ is a specific element of X, $\beta$ is the vector of coefficients, $\beta_k$ is the kth element of $\beta$, and $\phi$ is the standard normal density function. The numbers reported in the text evaluate the probability change at one set of values for the X's, namely the mean of the X's.

practitioners, the test-ordering frequency by specialists is 7 percentage points higher for all visits and 13 percentage points higher for visits for the three selected diagnoses.

Specialists also order a greater number of tests, assuming that at least one test is performed, than do general practitioners. Three of the four specialty coefficients in Tables 4 and 5 are significant. The insignificant coefficient on the indicator for pediatricians in the all-visits equation in Table 5 may be due to case mix differences between pediatricians and general practitioners. Controlling for diagnosis, the specialty coefficient in Table 5 is significant at the 10-percent level.

Physicians with a higher implicit wage will tend to substitute tests for their own time to produce a specified level of quality. A higher implicit wage among specialists than among general practitioners may explain the higher rate of test ordering per visit by specialists. However, case mix differences between specialists and general practitioners may remain even after controlling for diagnosis, if specialists tend to treat more severely ill patients with a particular diagnosis. Therefore, differences between specialists and general practitioners may be due to differences in the clinical needs of their patients.

Decade of graduation is significant in explaining the frequency of test ordering by internists and general practitioners in the treatment of adults; more recent graduates order more tests. This variable is not significant in the regressions for visits by children.

The likelihood of ordering particular types of tests shows the same relationships with insurance and physician characteristics as were found for the frequency of ordering any test. Tables 6 and 7 give results for the probability of ordering urinalyses and for the probability of ordering blood cell counts. Insurance is not a significant determinant. Specialists and physicians in larger groups order these specific tests more frequently than other physicians.

## EFFECTS OF TEST LOCATION AND BILLING ARRANGEMENTS

Bailey (1979) has argued that direct billing by laboratories is the only way to discourage excessive testing. In the appendix, we show that

Table 6

PROBABILITY OF ORDERING SPECIFIC TESTS: VISITS BY ADULTS TO INTERNISTS AND GENERAL PRACTITIONERS

| | Urinalysis | | | Blood Cell Count | | |
|---|---|---|---|---|---|---|
| | | (t-Statistic) | | | (t-Statistic) | |
| Variable | Coeff. | Unadj. | Adj. | Coeff. | Unadj. | Adj. |
| P25 | -0.003 | ( -0.05 | -0.02) | 0.144 | ( 2.59 | 1.34) |
| P50 | 0.354 | ( 3.95 | 1.54) | -0.084 | (-0.77 | -0.40) |
| PFD | 0.005 | 0.08 | 0.03) | -0.018 | (-0.27 | -0.14) |
| IDP | 0.017 | ( 0.27 | 0.11) | 0.123 | ( 1.94 | 1.00) |
| Solo | -0.269 | ( -5.05 | -1.96) | -0.290 | (-5.37 | -2.77) |
| Partnership | -0.209 | ( -3.25 | -1.26) | -0.116 | (-1.82 | -0.94) |
| Unknown mode | -0.330 | ( -3.29 | -1.28) | -0.531 | (-5.27 | -2.71) |
| Specialist | 0.205 | ( 3.77 | 1.46) | 0.592 | (11.51 | 5.93) |
| Decade | 0.064 | ( 2.73 | 1.06) | 0.076 | ( 3.21 | 1.65) |
| Intercept | -1.409 | (-10.32 | -4.02) | -1.573 | (11.27 | -5.81) |
| $\chi^2$ | 70.18 | | | 204.69 | | |
| df | 9 | | | 9 | | |
| $\rho$ | 0.30 | | | 0.15 (not significant) | | |

NOTE: Unadjusted t (Unadj.) is the univariate probit estimate. Adjusted t (Adj.) applies the upper-bound correction factor for intracluster correlation. $\rho$ is the estimated intracluster correlation.

physicians who refer their patients to laboratories that bill directly will use fewer tests per visit to provide a specific level of quality than physicians who control test billing, if the prices laboratories charge patients exceed the laboratories' charges to physicians. Differences in test use among physicians who control test billing and those who do not would not be expected, lacking differences in laboratory price schedules. We do not have information on the supply price of tests to physicians to compare with the prices laboratories charge patients. However, we can examine Bailey's hypothesis by looking at test ordering among the subsample of physicians in the telephone survey for whom measures of test location and billing arrangements are available. Probit regressions for the probability of ordering any test are given in Table 8. Indicators for the insurance variables have been omitted because insurance was not found to be a significant determinant in the earlier

Table 7

PROBABILITY OF ORDERING SPECIFIC TESTS: VISITS BY CHILDREN TO PEDIATRICIANS AND GENERAL PRACTITIONERS

| | Urinalysis | | | Blood Cell Count | | |
|---|---|---|---|---|---|---|
| | | (t-Statistic) | | | (t-Statistic) | |
| Variable | Coeff. | Unadj. | Adj. | Coeff. | Unadj. | Adj. |
| P25 | 0.102 | ( 1.26 | 0.45) | -0.099 | (-1.14 | -0.41) |
| P50 | -0.295 | (-2.35 | -0.84) | -0.358 | (-2.58 | -0.92) |
| PFD | 0.141 | ( 1.56 | -0.56) | 0.017 | ( 0.19 | 0.07) |
| IDP | -0.099 | (-1.05 | -0.38) | -0.074 | (-0.77 | -0.28) |
| Solo | -0.389 | (-5.34 | -1.91) | -0.448 | (-5.63 | -2.01) |
| Partnership | -0.296 | (-3.53 | -1.26) | -0.171 | (-2.00 | -0.71) |
| Unknown mode | -0.460 | (-2.48 | -0.89) | -0.216 | (-1.29 | -0.46) |
| Specialist | 0.254 | ( 3.79 | -1.35) | 0.030 | ( 0.43 | -0.15) |
| Decade | -0.090 | (-2.60 | -0.93) | 0.018 | ( 0.48 | -0.17) |
| Intercept | -0.728 | (-3.55 | -1.26) | -1.204 | (-5.49 | -1.96) |
| $\chi^2$ | 73.82 | | | 47.55 | | |
| df | 9 | | | 9 | | |
| $\rho$ | 0.35 | | | 0.35 | | |

NOTES: Unadjusted t (Unadj.) is the univariate probit estimate. Adjusted t (Adj.) applies the upper-bound correction factor for intracluster correlation. $\rho$ is the estimated intracluster correlation.

analysis. In Table 9, we give results for ordering urinalyses and blood cell counts by physicians treating adults. The indicators for in-house testing and physician billing in the regressions for urinalyses and cell counts refer to the arrangements for the specific test. Results for ordering specific tests for children are not presented because these specific tests were ordered in too few of the visits in this subsample.

The results do suggest that tests are ordered more frequently by physicians who perform tests in-house or control test billing than those who do not. Based on the point estimates in Table 8, the probabilities of ordering tests for adults by physicians who test in-house, or purchase tests and bill their patients, are, respectively, 10 percentage points and 7 percentage points higher than the probability for physicians who do not control billing. (These estimates are taken at

Table 8

PROBABILITY OF ORDERING ANY TEST: PHYSICIAN TELEPHONE SURVEY SUBSAMPLE

| | Adults | | | Children | | |
|---|---|---|---|---|---|---|
| | | (t-Statistic) | | | (t-Statistic) | |
| Variable | Coeff. | Unadj. | Adj. | Coeff. | Unadj. | Adj. |
| In-house | 0.359 | ( 3.12 | 1.49) | 0.418 | ( 2.51 | 0.57) |
| Bills tests | 0.226 | ( 2.12 | 1.00) | 0.256 | ( 1.69 | 0.38) |
| DK Billing | 0.015 | ( 0.09 | 0.04) | -0.210 | (-1.46 | -0.33) |
| Solo | -0.167 | (-2.05 | -0.98) | -0.263 | (-2.33 | -0.52) |
| Partnership | 0.086 | ( 0.86 | 0.41) | -0.155 | ( 2.21 | 0.50) |
| Specialist | 0.285 | ( 2.80 | 1.38) | 0.287 | ( 1.00 | 0.22) |
| Decade | 0.013 | ( 0.37 | 0.18) | 0.039 | ( 0.54 | 0.12) |
| Intercept | -0.845 | (-3.63 | -1.73) | -0.989 | (-2.58 | -0.59) |
| $\chi^2$ | 34.19 | | | 43.31 | | |
| df | 8 | | | 8 | | |
| $\rho$ | 0.15 (not significant) | | | 0.55 | | |

NOTE: Unadjusted t (Unadj.) is the univariate probit estimate. Adjusted t (Adj.) applies the upper-bound correction factor for intracluster correlation. $\rho$ is the estimated correlation.

the full sample mean of the other characteristics.) The comparable probability changes in test ordering for children are 12 percentage points and 7 percentage points. However, because of small sample sizes, the coefficient estimates are imprecise, and although the univariate probit t-statistics are significant, adjustment for intracluster correlation would reduce the t-statistics below conventional significance levels. Coefficients for in-house testing and the indicator for direct billing by the physician are also positive in the equation for the probability of ordering urinalyses and blood counts (Table 9), but again the estimates are imprecise.

Sample sizes were too small to estimate precisely any coefficients in the level-of-test equation, and so results are not reported. Coefficients on the indicators for in-house testing and physician billing were positive, but not statistically significantly different from zero. The association of test frequency with location of testing and physician-laboratory billing arrangements does not necessarily mean

Table 9

PROBABILITY OF ORDERING SPECIFIC TESTS FOR ADULTS:
PHYSICIAN TELEPHONE SURVEY SUBSAMPLE

| | Urinalysis | | | Blood Cell Count | | |
|---|---|---|---|---|---|---|
| | | (t-Statistic) | | | (t-Statistic) | |
| Variable | Coeff. | Unadj. | Adj. | Coeff. | Unadj. | Adj. |
| In-house | 0.534 | ( 1.20 | 0.50) | 0.529 | ( 3.45 | 1.92) |
| Bills tests | 0.606 | ( 1.36 | 0.54) | 0.090 | ( 0.60 | 0.33) |
| DK billing | -0.201 | (-1.09 | -0.45) | -0.169 | (-0.73 | -0.41) |
| Solo | -0.244 | (-2.42 | -1.00) | -0.356 | (-3.59 | -2.00) |
| Partnership | -0.276 | (-2.06 | -0.85) | -0.284 | (-2.23 | -1.24) |
| Specialist | -0.078 | ( 0.61 | 0.25) | 0.632 | ( 5.50 | 3.06) |
| Decade | -0.043 | (-0.88 | -0.41) | 0.040 | ( 0.82 | 0.46) |
| Intercept | -1.357 | (-2.40 | -1.00) | -1.502 | (-4.86 | -2.70) |
| $\chi^2$ | 30.44 | | | 89.41 | | |
| df | 8 | | | 8 | | |
| $\rho$ | 0.20 (not significant) | | | 0.10 (not significant) | | |

NOTES: Unadjusted t (Unadj.) is the univariate probit estimate. Adjusted t (Adj.) applies the upper-bound correction factor for intracluster correlation. $\rho$ is the estimated intracluster correlation.

that billing control by physicians leads to a higher test frequency. The causation may be in the reverse direction. For example, as noted by Danzon (1982), if there are scale economies in producing tests, physicians who anticipate a large volume of tests would be more likely to perform tests in-house and realize a higher test frequency. Therefore, the positive coefficient on the indicator in-house does not warrant the conclusion that there is a net effect of in-house testing on test-ordering decisions. Physicians who expect to perform a large number of tests may also have greater incentives to control the billing of purchased tests than other physicians. With what data are available, we are unable to disentangle the direction of causality, and consequently these data do not definitively support Bailey's assertion that direct billing laws would result in decreased laboratory testing.

The coefficients on the other variables in Tables 8 and 9 follow the patterns reported earlier. We find that those in solo practice are

still less likely to order tests than physicians in groups, even controlling for test location and billing arrangements. The comparison, however, is not significant if the full upper-bound correction for intracluster correlation is made. The only finding that is not repeated in the regressions on the subsample is the effect of length-of-time-since-graduation among internists and general practitioners. In this subsample of physicians, there were few recent and few early graduates; hence, the restricted range of observation on the decade variable probably accounts for the lack of decade effect here.

## V. CONCLUSION

Current reimbursement methods are cited as an important factor affecting the growth in the volume of laboratory tests. Schroeder and Showstack (1979) and Moloney and Rogers (1979), among other authors, contend that current pricing systems provide strong financial incentives for physicians to make intensive use of medical technology. Recent Medicare and Medicaid regulations have been adopted in an effort to alter these incentives by limiting the prices that physicians can charge their patients to the actual cost to the physician of purchasing the test ("Blue Sheet," August 26, 1981). Bailey (1979) has argued for direct billing laws to discourage excessive testing. Further, the patient has little economic incentive to hold down the rate at which laboratory tests are ordered because a large share of the bill is financed by third parties. In this report, we have investigated the importance of reimbursement policies and practices on physicians' test-ordering decisions--specifically, the effects of the patient's insurance coverage and direct laboratory billing arrangements.

Patients' insurance coverage was not found to be a significant determinant of the number of laboratory tests per visit. However, there are two reasons why the true effect of insurance on physicians' test-ordering decisions may be underestimated in these data. First, some argue that physicians do not have information about the insurance coverage of each individual patient and therefore make treatment decisions based on the modal or average coverage of their patients.[1] According to this argument, physicians' test-ordering decisions might respond if the average insurance coverage of their patients changed, but one would not observe differences in treatment decisions for individual patients with different levels of insurance coverage. Direct measures of physicians' knowledge about the insurance coverage of individual patients are not available. However, other analyses of HIE data have shown substantial differences between insurance plans in the total amount of medical care

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[1] For a discussion of the "norms" hypothesis and two empirical tests that refute the hypothesis, see Newhouse and Marquis (1978).

provided (Newhouse et al., 1981), suggesting that physicians do take account of individual patients' insurance coverage in ordering total medical care services.

Second, the probability of seeking care increases as the patient's cost sharing decreases, so that patients with generous insurance who obtain care may be less ill than other patients. Any tendency for physicians to order more tests per visit for patients with generous insurance than for other patients with the same illness may be offset by the lower illness levels of patients with extensive coverage. The finding that insurance is not related to the number of tests ordered per visit, therefore, does not necessarily mean that physicians' decisions are not influenced by the level of insurance. The result does show that observed rates of testing per visit would not be expected to change if the level of insurance changed.

Nonetheless, we would anticipate that a reduction in the share of ambulatory care expenditures paid for by patients would lead to an increase in total test volumes because physician visit rates are strongly influenced by the level of cost sharing. Estimates from the HIE, presented elsewhere, show that patients with full insurance coverage have about 50 percent more ambulatory care visits than patients with only catastrophic insurance. Total test volumes would be expected to respond to cost sharing in about the same proportion, other things being equal.

We find that physicians who control test billing perform more tests per visit than other physicians. We estimate that the probability of ordering a test by a physician with average characteristics is about 7 percentage points lower if he refers his patients to a laboratory that bills directly than if he purchases tests and bills his patients directly; this represents a 25-percent reduction in frequency. The finding may indicate that direct billing requirements would lower the number of tests ordered. This conclusion is only tentative, however, for several reasons. First, the estimates of the effect of direct billing are imprecise. Second, if physicians who anticipate high test volumes have an incentive to control test billing, the coefficients overestimate the net effects of billing control on test volume. That is, the causation

may run from test volume to decisions about whether to produce tests and whether to obtain billing control rather than the reverse. With what data are available, we are unable to disentangle the causality and consequently cannot definitively conclude that physicians who control test billing are induced to order more tests than other physicians.

We remain uncertain to what extent, if at all, direct billing regulations would reduce total test volumes; however, such regulations are unlikely to be a promising avenue for achieving significant reductions in total health care costs. Although expenditures for outpatient laboratory tests have grown rapidly, these expenditures represent only 3 to 4 percent of the total health care budget (Scitovsky, 1979). Moreover, because the marginal cost of tests is far below their average costs, reductions in test volumes would not be matched by equivalent cost savings. Large reductions in test use would have to be achieved before realizing significant cost savings.

In sum, a number of authorities believe that financial incentives overreward intensive technological practice modes and have led to an excessive use of laboratory tests. Although theory does not predict how the level of insurance coverage will affect the number of tests per visit, the empirical analysis showed no relationship between tests per visit and the patient's cost sharing. The level of insurance coverage does affect the total volume of tests, but it is due to the relationship between insurance and the number of physician visits. Direct billing regulations are unlikely to affect the number of tests ordered unless laboratories charge individual patients more than they charge physicians for purchased tests. The empirical analysis showed that test frequency is lower when physicians refer patients to laboratories that bill directly, but our data do not allow us to determine whether the lower frequency is a result of the billing arrangements. Other economic factors also affect test-ordering behavior. Physicians in group practice order more tests per visit than those in solo practice, even controlling for test location and billing arrangements. Specialists order more laboratory tests than general practitioners. This may reflect a substitution of tests for time due to

a higher implicit wage for specialists; however, it may be due to differences between specialists and general practitioners in the clinical needs of their patients.

We have not addressed the consequences for patient outcomes of the growth in testing or of differences between practitioners in test use. At least one study has concluded that frequency of laboratory use is not related to outcomes of care (Daniels and Schroeder, 1977). However, before concluding that the growth in laboratory testing has been excessive, more research is needed to assess whether the additional laboratory tests produce patient benefits that are commensurate with the additional costs.

# Appendix

## ECONOMIC MODEL OF PHYSICIANS' ORDERING LABORATORY TESTS

The economic model of physicians' laboratory test-ordering behavior is based on the theoretical development by Danzon (1982). It is assumed that the physician faces a demand for visits, N, which depends on the quality of a visit, S, and price to consumers of a visit, cP:

$$N = N(S,\ cP)\ . \tag{1}$$

The total price charged for a visit, P, includes a charge for the physician's time, $P^v$, and a charge for tests, $P^tT$, where T is the number of tests ordered:

$$P = P^v + P^tT\ . \tag{2}$$

The price to consumers is c percent of the total price charge by the physician, where c is the insurance parameter.

The physician produces visit quality with inputs of physician hours, H, and tests, T:

$$S = S(H,\ T)\ . \tag{3}$$

Physician hours and tests are assumed to be supplied at constant cost w and r, respectively, so the total cost of a visit, R, is given by

$$R = wH + rT\ . \tag{4}$$

The physician is assumed to choose hours per visit, tests per visit, and the visit price to maximize profits:

$$\max_{H,T,P} \Pi = NP - NR\ . \tag{5}$$

Maximization of Eq. (5) yields the first-order conditions

$$\Pi_H = N_S S_H(P - R) - Nw = 0, \tag{6}$$

$$\Pi_T = (N_S S_T + N_{cP} cP^t)(P - R) + N(P^t - r) = 0, \tag{7}$$

$$\Pi_P = (N_{cP})c(P - R) + N = 0. \tag{8}$$

Substitute the relationship in Eq. (8) into Eq. (7):

$$N_S S_T(P - R) - NP^t + NP^t - Nr = N_S S_T(P - R) - Nr = 0. \tag{7'}$$

Rearranging Eqs. (6) and (7') yields the usual conditions for efficient input mix, the equality of the ratio of marginal labor cost to marginal product for each input,

$$\frac{w}{r} = \frac{S_H}{S_T}, \tag{9}$$

and rearranging Eq. (8) yields the equality of marginal cost and marginal revenue,

$$R = P(1 + \varepsilon_{N,cP}^{-1}), \tag{8'}$$

where $\varepsilon_{N,cP}$ is the elasticity of demand with respect to own price.

The above results assume that the physician controls the billing for tests and can set the overall charge for the visit. If the physician refers the patient to a laboratory that bills directly, the charge for tests is set by the laboratory, and the physician chooses hours, tests, and the charge for his own time to maximize profits. His profits are given by

$$\Pi = N(P^v - wH) - Nw = 0. \tag{10}$$

The first-order conditions become

$$\Pi_H = N_S S_H(P^v - wH) - Nw = 0, \tag{11}$$

$$\Pi_T = (N_S S_T + N_{cP} cP^t)(P^v - wH) = 0, \tag{12}$$

$$\Pi_{P^v} = (N_{cP})c(P^v - wH) + N = 0. \tag{13}$$

Substituting Eq. (13) into Eq. (12) yields

$$\Pi_T = N_S S_T(P^v - wH) - NP^t = 0, \tag{12'}$$

and rearranging Eqs. (11) and (12') we have

$$\frac{w}{P^t} = \frac{S_H}{S_T} . \tag{14}$$

Comparing Eqs. (14) and (9), we see that physicians who control test billing will tend to substitute tests for time to produce a specified level of quality if the prices laboratories charge patients are higher than the fees they charge physicians. Bailey (1979) asserts that the use of such multiple price schedules by laboratories is common, and this pricing system is the basis for his argument that financial incentives encourage excessive use of tests by physicians who control billing. Lacking different laboratory price schedules, however, direct billing regulations are analogous to a fee screen on the physician's charge for a test. Controls on the physician's charge for a test will be offset by an adjustment in the charge for the physician's time, but will not affect the length of the visit or the number of tests ordered as long as fees for time are not constrained and patients care only about the composite price of a visit. (See Danzon, 1982, for a discussion of the effects of fee ceilings.)

We are interested in how changes in the exogenous variables affect the physician's test-ordering behavior. However, as we will show, the direction of change in test ordering cannot be determined a priori.

Consider a change in the insurance parameter c. This will change the first-order conditions (Eqs. (6)-(8)) in the following manner:

$$\begin{bmatrix} \Pi_{HH} & \Pi_{HT} & \Pi_{HP} \\ \Pi_{HT} & \Pi_{TT} & \Pi_{TP} \\ \Pi_{HP} & \Pi_{TP} & \Pi_{PP} \end{bmatrix} \begin{bmatrix} dH \\ dT \\ dP \end{bmatrix} = \begin{bmatrix} -\Pi_{Hc} \\ -\Pi_{Tc} \\ -\Pi_{Pc} \end{bmatrix} dc. \tag{15}$$

If we let D denote the determinant of the matrix on the left-hand side of Eq. (15), and $D_{ij}$ represent the i,j minor, then using Cramer's rule, we get

$$\frac{dT}{dc} = \Pi_{Hc}\frac{D_{12}}{D} - \Pi_{Tc}\frac{D_{22}}{D} + \Pi_{Pc}\frac{D_{23}}{D} .$$

If profits are indeed maximized, then $D < 0$, and $D_{22} > 0$. However, second-order conditions do not restrict the signs of $D_{12}$ and $D_{23}$. Consequently, the sign of dT/dc is ambiguous.

Other determinants of the use of tests include the supply price of tests and physician time. The effect of changes in these quantities on physicians' use of laboratory tests also cannot be determined a priori. For example, a decrease in the cost of tests lowers the marginal cost schedule for alternative levels of test per visit, which is in turn an incentive to expand tests per visit. However, a decrease in the cost of tests also lowers the marginal cost of visits, and adjustments in quantity may have offsetting effects on the number of tests per visit.

Formally, changes in the supply price of tests and of time affect tests per visit by

$$\frac{dT}{dr} = \Pi_{Hr}\frac{D_{12}}{D} - \Pi_{Tr}\frac{D_{22}}{D} + \Pi_{Pr}\frac{D_{23}}{D} ,$$

and

$$\frac{dT}{dw} = \Pi_{Hw} \frac{D_{12}}{D} - \Pi_{Tw} \frac{D_{22}}{D} + \Pi_{Pw} \frac{D_{23}}{D} .$$

Further,

$$\Pi_{Tr} = -(N_s S_t + N_{cP} cP^t)\ T - N < 0 \quad \text{if } (P^t - r) > 0 \text{ and } (P^v - sH) > 0$$

by the first-order conditions,

and

$$\Pi_{Tw} = -(N_s S_t + N_{cP} cP^t)H > 0.$$

The direct effect of a change in the supply price of tests on tests per visit $[-\Pi_{Tr}(D_{22}/D)]$ is negative, and the direct effect of a change in the supply price of physicians' time on the number of tests per visit $[-\Pi_{Tw}(D_{22}/D)]$ is positive, because $D_{22}/D$ is negative by the second-order conditions. However, because the signs of $D_{12}$ and $D_{23}$ are not restricted, the indirect and total effects of changes in supply prices on tests per visit are indeterminant.

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