The Demand for Dental Care

Evidence from a Randomized Trial in Health Insurance

Willard G. Manning, Howard L. Bailit,
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PREFACE

This report examines people's utilization of dental health services under varying levels of cost sharing, the fraction of the bill paid directly by the patient. The work was undertaken as a part of the Rand Health Insurance Experiment, a large-scale social experiment designed to study the effects of health insurance on the use of health services and health status. An abridged version of this report was published in the *Journal of the American Dental Association* in June 1985. The effects of insurance coverage on oral health status are discussed in H. L. Bailit, J. P. Newhouse, R. H. Brook et al., "Does More Generous Dental Health Insurance Coverage Improve Oral Health?" *Journal of the American Dental Association*, May 1985.

SUMMARY

Using data from a randomized trial in health insurance, this report examines the effect of cost sharing on use of dental services other than orthodontia. The data come from a sample of the nonaged, noninstitutionalized civilian population of four urban and two rural sites. We find that: Reducing the level of cost sharing increases demand for dental services; dental expenses rise 46 percent when the coinsurance rate falls from 95 percent to 0 percent, subject to a catastrophic limit on out-of-pocket expenses. Of this increase, two-thirds is attributable to an increase in the likelihood of visiting a dentist during the year. Moreover, over and above the 46-percent increase, there is a substantial surge in demand during the first year of more generous coverage. The first-year response to cost sharing is nearly twice the second-year response.

We also find that increased income affects dental visits differently than dental expenditures. Depending on the insurance plan, the high-income group has 20 percent to 40 percent more visits than the low-income group. Expenditures of the high-income group are less than 10 percent higher than the low-income group's. The visit differences by income group are significant at the 1 percent level, but the expenditure differences are statistically insignificant. Thus, lower-income individuals tend to have more expensive visits.

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I. INTRODUCTION

For the last several decades, health insurance has been a major area of policy debate. Proponents of more generous coverage (lower out-of-pocket cost) have argued that better coverage would reduce the family's financial risk and reduce the role of price as a barrier to a more equitable distribution of health services. Others have opposed more generous coverage, suggesting that the purchase of services below cost leads to overuse of resources and reduces the ability of price competition to force efficient production. For example, more generously covered health services have higher rates of inflation (Newhouse, 1979).

In the argument over health insurance, dentistry has received much less attention than medical and mental health services; but paradoxically, dental insurance has changed more than medical insurance during the last two decades. In 1967, only 2 percent of the population had any private dental coverage; by 1981 the figure had risen to 38 percent (Health Insurance Association, 1983).[1] This change has occurred largely through the addition of dental coverage to employee fringe benefit packages. Government has limited its role to the tax subsidy given to all health-related fringe benefits and to the provision of coverage to the poor by Medicaid in some states.

Little is known about the effect of dental insurance on utilization. The few nonexperimental studies that exist have produced widely varying estimates, perhaps because of problems with self-selected or unrepresentative populations, or other methodological flaws.[2] If, for example, individuals with poorer oral health status purchase better dental insurance coverage, comparing them with people who have poorer dental insurance will likely overstate the effect of insurance on use. Moreover, the insured population will not have a representative mix of people with good and bad dental health.

The lack of information on the effect of dental insurance led the federal government to include dental benefits in a randomized trial of health insurance, the Rand Health Insurance Experiment (HIE). In this report we provide evidence from that trial on how dental insurance affects the use of dental services. Bailit et al. (1983) examine the effect of dental insurance on oral health status and health habits.

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[1] In 1967, 74 percent of the population had private insurance for hospitalization, while 60 percent, had physician coverage. In 1981 the numbers were 82 and 71 percent, respectively.

[2] Feldstein, 1973; Phelps and Newhouse, 1974; Maurizi, 1975; Conrad, 1983; Manning and Phelps, 1978a,b; Grembowski and Conrad, 1984; Manning et al., 1985.

II. METHODS

THE DESIGN OF THE TRIAL

The Health Insurance Experiment (HIE) is a randomized trial designed to study the effects of different health insurance policies on the demand for health services and the health status of individuals. The HIE was designed to overcome many of the shortcomings of nonexperimental studies (e.g., self-selected insurance) so that it could provide estimates of the effects of cost sharing for a general or representative population (Newhouse, 1974; Brook et al., 1979; Newhouse et al., 1983).

The HIE enrolled families in six sites between 1974 and 1982, selected to represent all Census regions: Dayton, Ohio; Seattle, Washington; Fitchburg, Massachusetts; Franklin County, Massachusetts; Charleston, South Carolina; and Georgetown County, South Carolina. Dayton began fluoridation in 1977, Seattle in 1970, and Fitchburg in 1975; Franklin County and Charleston have no fluoridation; Georgetown County is naturally fluoridated. The sites were not selected with respect to fluoridation status, however, but to show variation in city size and waiting times to appointment. In each site, families enrolled for either three or five years.

Participating families were assigned to several fee-for-service health insurance plans with different levels of cost sharing. The coinsurance rates (percentage paid out-of-pocket) were 0 (free), 25, 50, or 95 percent for all health services.[1] Each plan had an upper limit (the maximum dollar expenditure or MDE) on out-of-pocket expenses of 5 percent, 10 percent, or 15 percent of family income, up to a maximum of \$1000. Beyond the MDE, the insurance plan reimbursed all expenses in full.

Some families faced a 95-percent coinsurance rate for all outpatient dental, medical, and mental health services, subject to a \$150 annual limit on out-of-pocket expenses per person (\$450 per family). In this

[1]One plan had a 25-percent coinsurance rate for inpatient and outpatient medical services and a 50-percent rate for dental and outpatient mental health services. In this analysis, we combined this plan with the plan with 50 percent coinsurance rate for all services because both plans had dental coinsurance rates of 50 percent.

Finally, some Seattle families were randomly assigned to a plan that had a zero coinsurance rate for dental care from fee-for-service dental providers but received their medical and mental health care in a prepaid group practice, Group Health Cooperative of Puget Sound. We have combined this plan with the free fee-for-service plan because we found no evidence that the source of medical care affected dental use.

plan, all inpatient services were free. In effect, this plan had an individual deductible for all outpatient care, and is referred to as the individual deductible plan.

All plans covered the same wide variety of services. The only significant exclusion for this analysis was nonpreventive orthodontia services (e.g., orthodontia services with fixed appliances); preventive orthodontia services were covered. There were no limits on the numbers of dental examinations, prophylaxes, or other services that a person could receive. Prior authorization was required for any treatment plan exceeding $500. If a dental consultant questioned the plan, a local dentist would take the matter up with the treating dentist. In general, dentists were paid their billed charges, except in the few cases that were considered grossly unreasonable.

A simple example will illustrate how an HIE insurance plan works. Consider a family with a coinsurance rate of 25 percent for all services and an MDE of $1000. For the first $4000 ($1000/0.25) spent on health care (dental, medical, and mental health care), the participating family pays 25 percent and the insurance plan pays 75 percent. After the first $4000 of total expenditures, the family pays nothing out of pocket and the plan pays everything because out-of-pocket expenses have reached the MDE of $1000. At the beginning of the next accounting year, the family would again pay 25 percent of all health costs until they reached the $1000 annual limit on out-of-pocket expenses.

As this example illustrates, the participant's response to an HIE insurance plan is an amalgam of responses to coinsurance rates and free care beyond the MDE. In this report we will not analyze separately the effects of coinsurance rates and upper limits.[2]

Families were enrolled in the insurance plans as a unit, with only eligible members participating. No choice of plan was offered; the family could either accept the experimental plan or choose not to participate. To minimize refusals, families were given a lump-sum payment equal to their worst-case financial risk associated with the plan; the amount of the lump-sum payment was independent of the use of the health care services. Thus, no family was worse off financially for being in the study. The family's nonexperimental coverage was maintained for the family by the HIE during the experimental period, with the benefits of the policy assigned to the HIE. If the family had no coverage, the HIE purchased a policy on their behalf. Thus, no family could become uninsurable as a result of their participation in the study.

[2]See Keeler et al., 1977, for a theoretical discussion of the effects of plans with deductibles. See Keeler et al., 1982, for an early effort at estimating the separate effects of coinsurance rates and deductibles.

Within each site, families were assigned to plans using a variant of stratified random assignment (Morris, 1979). Although there was a lower refusal rate for the more generous dental health insurance plans, we have found no significant or appreciable differences among the plans in terms of the sociodemographic and oral health status characteristics of the individuals enrolled in the study (Bailit et al., 1983; Brook et al., 1983, 1984). Except for a slight overrepresentation of children in the enrolled population, we have found no significant or appreciable difference between the enrolled and nonenrolled populations that met the eligibility criteria for the study (Morris, 1985). Hence, we expect no appreciable bias due to differential refusal of plan.

Individuals and families dropped out of the study at a higher rate on the less generous plans. However, there was no difference in oral health status between those who stayed in the study and those who left early (Bailit et al., 1983). Thus, differential sample loss by insurance plan should not bias our estimates of plan effects.

THE SAMPLE

The sample is a random sample of each site's population, but the following groups were not eligible: (1) those in families in which the head was 62 years of age or older; (2) those with family incomes exceeding $57,000 in 1984 dollars; (3) those eligible for the Medicare program because of disability; (4) those in jails and those institutionalized in long-term hospitals; (5) the military and their dependents; and (6) those with service-related disabilities. Table 1 shows the number of individuals initially enrolled by site and insurance plan.[3] Table 2 shows the characteristics of this sample.

For this analysis, we have excluded individuals with partial years of participation: newborns, adoptees, suspended participants (e.g., those who joined the military), and participants who withdrew or were terminated from the study during the year. A person who, for example, left the study during the second year was included in the first year if he participated for all of that year. These exclusions account for about 7 percent of the number of person-years for the total sample. During the first year in Dayton, the HIE covered dental services for children (aged less than 18) on all plans, and adults only on the free plan; adults on the nonfree plans were not covered until the second year. As a result, we have excluded observations for all adults on cost-sharing plans in Dayton during the first year of the study.

[3]Because of the larger numbers of enrollees in the free dental plan, the standard errors for that plan are smaller than for other plans in subsequent tables.

Table 1

SAMPLE IN HEALTH INSURANCE EXPERIMENT AT INITIAL ENROLLMENT

	Dental Insurance Plan					
Site	Free	25	50[a]	95	Deductible	Total
Dayton, Ohio	301	260	193	280	105	1139
Seattle, Wash.[b]	1580	132	121	253	285	2371
Fitchburg, Mass.	241	37	144	113	188	723
Franklin Co., Mass.	297	61	149	162	220	889
Charleston, S.C.	264	68	104	146	196	778
Georgetown Co., S.C.	359	89	164	168	282	1062
Total	3042	647	875	1122	1276	6962

NOTE: This table excludes babies born into or adopted into enrolled families after initial family enrollment; insurance plan refers to dental coinsurance rate, or the Individual Deductible Plan.

[a]490 of these individuals faced a 25-percent medical and 50-percent dental/mental coinsurance rate; 385 faced a 50-percent coinsurance rate for all services.

[b]Includes the experimental group of 1149 persons who received medical care at Group Health Cooperative of Puget Sound, a health maintenance organization (HMO), but received dental care through the fee-for-service system. Excludes the control group of 742 persons who self-selected the HMO and remained on whatever dental benefit plan they had previously.

MEASURES OF DENTAL UTILIZATION

Our analysis focuses on the number of dental visits and expenditures for dental services. Claims filed by participants, including those for covered and unreimbursed expenses, provide data on the amount and type of utilization. The expenses do not include any prescriptions filled, supplies purchased, or inpatient use. The number of visits is a count of the visits with a nonzero charge. That is, our visit measure is a count of billed visits. Because the data are derived from claims, the HIE did not necessarily receive a claim if the dentist did not bill for the visit; most zero-charge visits are part of a course of treatment that is billed on a lump-sum or flat-fee rather than per-visit basis.[4]

[4]To estimate the difference between total visits and billed visits, we compared visit rates based on a biweekly health diary with claims visits for Seattle year 1 and Dayton year 2. To avoid missing-data problems, we used only those individuals who filled out at least 25 of the 26 biweekly health reports. Total visits were 15 percent higher than billed visits. More important, we observed no systematic difference by insurance plan. The difference was 16 percent for the free plan, 20 percent for the 25-percent plan, 7 percent for the 50-percent plan, 11 percent for the 95-percent plan, and 11 percent for the Individual Deductible. Hence, we do not feel that our comparisons of visit rates by insurance plan are biased by using a billed-visit definition.

Table 2

CHARACTERISTICS OF THE ENROLLMENT SAMPLE

Variable	Mean	Standard Deviation[a]
Age (years)	24.9	16.3
Age group (%)		
1–4	10.4	30.5
5–11	16.8	37.4
12–17	13.6	34.3
18+	59.2	49.1
Female (%)	51.8	50.0
Income ($1000, 1984)	24.4	12.1
Education years[b]	12.0	2.8
Education group (%)[b]		
Less than 12 years	28.7	45.3
12 years	40.3	49.1
13–15 years	17.4	37.9
16+ years	13.6	34.3
Family size	3.9	1.8
Black (%)	16.1	36.5
Dental visits (preexperimental)[c]	1.56	2.56

NOTE: Based on 6962 individuals enrolled in experimental plans with dental coverage.

[a]Not corrected for intrafamily correlation.

[b]Own education for those aged 18 or older. For children, the education of the mother, if present; otherwise, the education of the father.

[c]Visits during the year prior to the study. Based on individual self report.

Because we rely on claims data, we have been concerned about possible underreporting, especially on plans with high coinsurance rates. Using data from billing records, we have found that the differences among insurance plans in the underreporting for medical utilization are much smaller than the observed differences in medical use (Rogers and Newhouse, 1985). Therefore, we believe that the differences we observed in use among the insurance plans reflect true differences, and are not merely an accounting artifact.

ANALYTICAL METHODS

Rather than rely on the more common analysis of variance (ANOVA), we have improved the precision of our estimates by using multiple regression methods. We used the following explanatory variables: age, sex, geographic site, family composition and income, education, and race, in addition to experimental insurance plans that were specified as dummy variables. The standard errors and test statistics are corrected for intrafamily and intertemporal correlation, i.e., for the tendency for the level of use (e.g., visits) to be positively correlated over time and among members of the same family. Appendix B describes our statistical models. Appendix C provides the parameter estimates for the visit and expenditure equations separately for the first, middle, and last year of the study.

One of the major goals of this report is to examine the magnitude of any transitory surges in the demand for dental services as individuals changed to more or less generous insurance coverage. By transitory surge, we mean simply a change in behavior at the beginning (or end) of the study that was not sustained throughout the experiment (e.g., in the first, but not in the second year).

Such a surge may have occurred because few members of the HIE sample had preexperimental dental insurance for routine dental care. What coverage they did have was largely limited to accident provisions of medical plans. As a result, most families on the free, 25-percent, 50-percent, and individual deductible plans had much better experimental than preexperimental dental coverage. Most families in the 95-percent plan faced little change unless they exceeded the catastrophic cap on their insurance plan; beyond that point, all dental services were free to the family for the remainder of the accounting year.

We test for transitory surge at the outset by comparing use in the first year of experimental dental coverage with use in the second year; formally, we test whether the average difference in expenditures is zero. To test for a transitory surge at the conclusion of the study, we compare the use in the last and second to last years of the study.

In most analyses we will make comparisons in terms of predictions to a standard population—a population with the same set of sociodemographic (nonplan) characteristics as the enrollment sample. This adjusted comparison is similar to the usual age/sex adjustment, except that it is carried out on a more extensive scale, adjusting for age, sex, site, and income, and other population characteristics. This corrects for the differing proportions of participants on the free plan by site and the imbalance by age, plan, and year in Dayton in insurance coverage noted above.

III. RESULTS

THE EFFECT OF COST SHARING

Table 3 presents the sample means and standard errors for each of the dental insurance plans during the first two years of dental coverage on the study. Expenditures are stated in constant January 1984 dollars.

Table 3

USE OF DENTAL SERVICES BY DENTAL PLAN: SAMPLE MEANS
(Standard errors)

Dental Insurance Plan	Year 1 of Dental Coverage: Probability of Use (%)	Year 1: Visits	Year 1: Expenses per Enrollee ($)	Year 2 of Dental Coverage: Probability of Use (%)	Year 2: Visits	Year 2: Expenses per Enrollee ($)
Free	68.7	2.50	380	66.8	1.93	261
	(1.19)	(.065)	(18.0)	(1.18)	(.049)	(12.5)
25%	53.6	1.73	224	52.6	1.51	190
	(3.39)	(.138)	(32.8)	(3.34)	(.111)	(28.0)
50%	54.1	1.80	219	53.0	1.50	177
	(2.41)	(.118)	(31.3)	(2.55)	(.103)	(32.3)
95%	47.1	1.39	147	48.3	1.44	179
	(2.59)	(.098)	(18.7)	(2.62)	(.099)	(24.9)
Individual deductible	48.9	1.70	242	48.1	1.33	158
	(2.12)	(.104)	(24.1)	(2.12)	(.080)	(20.4)

NOTE: Expenses were converted to January 1984 dollars using the dental fee component of the Consumer Price Index. There has been no adjustment for regional differences in prices, or differences in population characteristics across plans and years. Standard errors are corrected for intrafamily and intertemporal correlation.

Transitory Demand

The results in Table 3 indicate a substantially greater response to dental insurance in the first year of dental coverage than during the second year on plans other than the 95 percent coinsurance percent plan, subject to an upper limit on out-of-pocket expenses. These year-to-year differences in the response to the free, 25, 50, and individual deductible plans (compared with the 95-percent plan) are statistically significant ($p = 0.001$) whether use is measured in dollars or visits. Because there is little change over the two years in the likelihood of having any use of dental services, all of the surge is in the intensity of use for people who use dental services.[1] There is no evidence of a surge in demand during the first year for the 95-percent plan; in fact, there is higher use during the second year of dental coverage.

We conducted a similar analysis using data from the last two years of the study. There is a statistically significant ($p = 0.05$) but smaller surge in use on the free and 25-percent plans in the last year of the study. In contrast, we found no appreciable differences in the use of dental services among the middle years (the second year for the group enrolled for three years and the second through fourth years for the group enrolled for five years).

In light of these results, we use only the middle years of the study to estimate the steady-state response to dental insurance. Because there is no middle year of dental coverage for Dayton adults on family coinsurance plans with a three-year period of enrollment, these people are excluded altogether from the steady-state sample.

Steady-State Demand

Table 4 presents the steady-state (i.e., middle years') response to dental insurance plans in terms of the probability of any use, number of dental visits, and annual expenditures. The table results are for a standardized population with the same mix of characteristics as those initially enrolled on experimental dental plans.

Utilization increases significantly as the generosity of coverage increases from the 95-percent to the free plan. Participants on the free plan had 34 percent more visits and 46 percent higher dental expenses than enrollees on the 95-percent coinsurance plan subject to an upper limit on out-of-pocket expenses. Most of the observed response to insurance plans occurs between the free and the 25-percent plan. The other plans differ by a much smaller, and usually insignificant, amount.

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[1] We obtain the same inferences when we limit the sample to those present in both years.

Table 4

PREDICTED STEADY-STATE ANNUAL USE OF DENTAL SERVICES FOR A STANDARD POPULATION, BY INSURANCE PLAN

	Probability of Any Use (%)		Visits per Enrollee		Expenses per Enrollee ($)	
Plan	Mean	t vs 95% Plan	Mean	t vs 95% Plan	Mean	t vs 95% Plan
Free	66.1 (1.07)	6.77	1.87 (.045)	5.23	243 (13.0)	3.54
25%	52.3 (2.44)	0.57	1.47 (.093)	−0.63	185 (23.1)	0.69
50%	49.8 (2.07)	−0.25	1.41 (.084)	−0.16	165 (23.7)	0.04
95%	50.5 (2.07)	—	1.40 (.077)	—	166 (18.6)	—
Individual deductible	48.9 (1.72)	−0.60	1.33 (.069)	−0.65	156 (20.4)	−0.37

NOTE: Standardized population consists of all participants present at enrollment. t statistics are adjusted for intrafamily correlation. Expenses are converted into January 1984 dollars using the dental fee component of the Consumer Price Index.

Nearly two-thirds of the response to cost-sharing occurs in the probability of any use, and about three-quarters of the response to cost sharing is in the number of visits per enrollee rather than in dollars per user. Only the free plan has significantly higher expenditure rates per user than the 95-percent coinsurance plan subject to an upper limit on out-of-pocket expenses.

A small individual deductible ($150 per person or $450 per family per year), followed by free care, is not significantly different from the 95-percent plan with a catastrophic cap.

We also examined the data to see if there was a differential response to insurance plan by children and adults. For expenditures and the likelihood of any visit, we found that the differences were less significant than one would expect at random, and that the estimates of the plan/adult interactions exhibited no meaningful pattern. For visits, we observed a one-third higher response, significant at the five-percent

level, for adults on the family coinsurance plans, but an insignificantly lower response for adults on the individual deductible plan. Because of the insignificant results for probability and expenditures, and the contradictory signs for visits, we dropped the plan/adult interactions.

Mix of Dental Services

To examine plan differences in the mix of services, we disaggregated utilization into the following categories: diagnostic and preventive care, restoration, prosthodontia, endodontia and periodontia, and other dental work. Although prosthodontic, periodontic, and endodontic services are received by a relatively small fraction of the population, they accounted for two-fifths of dental expenditures (see Table 5).

We also examined the probability of any use of each type of service by plan (see Table 6); the results are predictions to the standardized population. The probabilities of any diagnostic/preventive work or of any restorative work show the same response to plan as the overall probability of any use; the probability of any use is about one-third higher on the free than on the 95-percent plan. Prosthodontia is more responsive to plan than is overall use; the probability of any use is 62 percent larger on the free plan than the 95-percent plan. Endodontia and periodontia exhibit an intermediate response; the probability of any use is one-half larger on the free than on the 95-percent plan.

Table 5

DISAGGREGATED ANNUAL USE OF DENTAL SERVICES: SECOND YEAR OF DENTAL COVERAGE

Service	Probability of Any Use (%)	Share of Total Dental Expense (%)	Expenses of Enrollee ($)
Diagnosis/preventive	54	17	34
Restoration	31	35	73
Prosthodontics	6	30	62
Endodontic/periodontic	9	11	22
Other	12	7	14

NOTE: Based on full-year participants. Expenses are converted into January 1984 dollars using the dental fee component of the Consumer Price Index.

Table 6

PREDICTED STEADY-STATE PROBABILITY OF ANY USE OF DENTAL SERVICES FOR A STANDARD POPULATION BY INSURANCE PLAN, YEAR 2

	Any Dental Services		Diagnosis/ Preventive		Restora- tion		Prostho- dontia		Endodontia/ Periodontia	
Plan	Mean %	t vs 95%	Mean %	t vs 95%	Mean %	t vs 95%	Mean %	t vs 95%	Mean %	t vs 95%
Free	66.1	6.77	61.3	6.20	35.8	4.57	7.8	3.49	9.7	2.27
25%	52.3	0.57	48.3	0.53	28.4	0.34	6.6	1.45	9.6	2.27
50%	49.8	−0.25	44.5	−0.70	26.1	−0.69	7.2	2.03	6.3	−0.27
95%[a]	50.5	—	46.6	—	27.6	—	4.8	—	6.6	—
Individual deductible	48.9	−0.60	44.3	−0.84	25.4	1.08	4.6	−0.27	8.4	+1.65

NOTE: Standardized population consists of all participants present at enrollment. t statistics are adjusted for intrafamily and intertemporal correlation.

[a]The standard errors are 2.1 percent for the probability of any use, 2.1 percent for diagnosis and prevention, 1.6 for restoration, 0.7 percent for prosthodontia, and 0.7 percent for endodontia/periodontia.

THE EFFECT OF INCOME ON THE USE OF DENTAL SERVICES

Table 7 presents estimates of the effect of income on the use of dental services, assuming that each person initially enrolled in the Study is on either the free or the 95-percent plan. The results are for the upper and lower thirds of the HIE distribution of income. On all of these measures of the use of dental services, higher income leads to higher use. The differences are greater for the probability of any use than for either the number of visits or annual expenses. The lower response of expenses is the result of fact that expenses per user fall as income increases.

The response to cost sharing is greater for the low-income than high-income groups. The low-income group has 46 percent more visits on the free than on the 95-percent plan. By comparison, the high-income group has only 26 percent more visits. Although this difference

Table 7

PREDICTED STEADY-STATE ANNUAL USE OF DENTAL SERVICES BY INCOME TERTILES FOR A STANDARD POPULATION

	Low Income		High Income		
Plan	Mean	t vs. 95%	Mean	t vs. 95%	t vs. Low
Free					
Prob. any use (%)	57.8	5.91	74.7	4.59	9.17
Visits/enrollee	1.69	4.75	2.05	3.31	4.43
Expenditure ($)	237	2.76	253	3.23	1.02
95% plan					
Prob. any use (%)	39.8	—	61.3	—	6.04
Visits/enrollee	1.16	—	1.63	—	3.44
Expenditures ($)	161	—	175	—	0.61

NOTE: Standardized population is all participants present at enrollment. t statistics are adjusted for intrafamily and intertemporal correlation. Expenditures in January 1984 dollars. Low-income group had family incomes below $19,700 in January 1984 dollars, while high-income group had family incomes above $28,700.

is not significant at conventional levels ($p = 0.18$, two-tailed), it is much larger than one would expect at random.[2]

Expenditures are much less responsive to income than visits or the likelihood of any use of dental services.

OTHER SUBEXPERIMENTS

The HIE had a number of subexperiments to test for methods effects. Some participants were randomly assigned to take an entry dental and medical examination; the remainder were not examined so that we could detect any resulting stimulus on use. Participants were randomly assigned to three- and five-year terms of participation to test for the effect of duration of coverage on health outcomes (use of services, health status, and health habits). Finally, participants were randomly assigned to fill out health diaries on a biweekly or weekly basis or not at all, to test for a stimulus from filling out health diaries.

[2]If we use the data from all plans, the contrast is significant ($t = -2.09$, $p = .04$). This is based on using the ln(max(coinsurance rate, 1)) rather than plan dummies for the free, 25, 50, and 95-percent plans.

These experimental treatments did not have a significant or an appreciable effect on the use of dental services.[3]

COMPARING DENTAL AND OTHER HEALTH SERVICES

Dental services are significantly more responsive (e.g., a larger percentage drop in use for a given increase in cost sharing) to cost sharing during the first year of dental coverage than are other outpatient health services ($p = 0.001$), but are significantly less responsive during

Table 8

DENTAL CARE RESPONSE TO COST SHARING VERSUS OTHER OUTPATIENT CARE: RATIO OF PLAN AVERAGE TO 95-PERCENT PLAN AVERAGE

(95% Plan = 100)

Nondental/Dental Coinsurance Rates	First Year of Dental Coverage		Second Year of Dental Coverage	
	Nondental	Dental	Nondental	Dental
Free/free	200	252	177	152
25/25	145	158	128	109
25/50	144	181	122	98
50/50	111	118	105	112
95/95	100	100	100	100
Individual deductible	143	163	124	94

NOTE: "Nondental" comprises outpatient medical care, mental health care, drugs, and supplies. Second year of dental coverage sample excludes adults on three-year pay plans in Dayton. The response on each plan is stated as a percentage of the response on the 95-percent plan.

[3]Those with an examination at entry had 2 percent more visits during the middle years ($t = 0.58$) and 2 percent more visits during the middle years of the study ($t = 0.48$) than those without an examination at entry. Those enrolled for three years had 1 percent fewer visits during the entry year of the study ($t = -0.19$) and 3 percent more visits during the middle years of the study ($t = 0.67$) than those assigned to the five-year group. Those assigned to fill out weekly health diaries had 9 percent more visits in the entry year ($t = 0.83$) and 8 percent more in the middle years ($t = 0.77$) than those who filled out diaries biweekly. Those not assigned to fill out diaries had 6 percent more visits during the entry year ($t = 0.84$) and 11 percent more visits during the middle years of the study ($t = 1.37$).

the second year ($p = 0.001$); see Table 8.[4] Other health services include outpatient medical and mental health services, drugs and supplies.

[4]The test is based on the five plans that have the same coinsurance rates for dental and other health services. We exclude the plan with a 25-percent coinsurance rate for medical care and a 50-percent coinsurance rate for dental and outpatient mental health care. The test requires that each individual act as his own control. With this technique, we would be comparing the dental and other health services response without adjusting for the differential coverage. We do not feel that the omission of the 25/50 plan affects the conclusion, because the remaining contrasts are so consistent with a greater response in the first year for dental than nondental services and less response in the second year.

IV. DISCUSSION

EFFECT OF COST SHARING

In this report, we have examined the effect of cost sharing on visits and expenditures for dental services by a sample of the nonaged and noninstitutionalized population. From this analysis, we conclude that:

- Insurance plans with lower coinsurance rates have higher use of dental services. During the second year of the study, dental expenses per enrollee were 46 percent higher with free care than with a catastrophic insurance plan (95-percent coinsurance rate subject to an upper limit on out-of-pocket health expenses). Most of the response to cost sharing occurred between free care and a 25-percent coinsurance rate plan, subject to an upper limit on out-of-pocket expenses. Smaller (insignificant) decreases resulted from plans with even higher coinsurance rates.
- Two-thirds of this response to cost sharing was in the probability of any use of dental services. Very little of the response was in the number of visits per user. Nearly one-quarter was in the mix of services and cost per visit. For example, prosthodontia was more responsive to cost sharing than other dental services.
- A plan with a small individual deductible ($150 per person or $450 per family per year on all forms of outpatient health services, followed by free care) had the same effect on use as a 95-percent plan with upper limits on family out-of-pocket expenses of up to $1000 per year.
- Dental services show less response to cost sharing in steady state than do other outpatient health services.
- Higher-income groups appear to be less sensitive to cost sharing than low-income groups.

We also found evidence of transitory responses to changes in insurance coverage:

- The response to cost sharing was more dramatic in the first year of dental coverage than in the second year. For example, the increase in expenses per enrollee between the free and 95-percent plans was nearly twice as large in the first year as in the second. Transitory surges in demand were also evident on the intermediate cost-sharing plans.

- There was a smaller surge in demand for the free and 25-percent plans as individuals left the study.
- During the first year of dental coverage, dental services were more responsive to cost sharing than other outpatient health services.

Observed responses are, of course, to the insurance plan taken as an entity. At this time, we have not determined how much of the response is due to the coinsurance rate and how much is due to the upper limits (the deductible and the MDE).

COMPARISONS WITH OTHER STUDIES

The results from the HIE can be compared with those of other, nonexperimental, studies. First, the HIE data show a 31 percent increase in expenses between the 25-percent and free plan. Using insurance premium data, Phelps and Newhouse (1974) estimated a 30-percent increase between a 20-percent coinsurance plan and free care; this extrapolates to a similar 37-percent increase between a 25-percent coinsurance plan and free care. Using employer group insurance data on use of dental services, Grembowski and Conrad (1984) estimated a 36-percent increase in dental expenditures between a coinsurance plan of 20 percent and free care for basic dental services.[1] The difference between the HIE estimate and the other two is attributable in part to the presence of free care beyond the catastrophic limit on out-of-pocket expenses on HIE plans. As a result, the HIE estimate should be smaller than the others. Nevertheless, the differences between the HIE and other estimates are small, and in the case of Grembowski and Conrad (1984) not statistically significant.

Second, the HIE data have an annual visit rate of 1.4 billed visits per enrollee (or approximately 1.6 if no-charge visits are included) for both the 50-percent and the 95-percent plans. Using data from the 1978 and 1979 National Health Interview Surveys, the NCHS (1982) found 1.7 visits for those under 65 years of age. Using data from a 1977 national probability sample, Rossiter (1983), found 1.3 visits for those under 65. Thus, the HIE estimate on the 95-percent plan falls between those of two national surveys during a period with little dental insurance. Rossiter (1983) estimates that 20 percent of the expenses were reimbursed by private health insurance or Medicaid; the NCHS (1982) estimate is 25 percent.

[1]Basic services exclude oral surgery, prosthodontia, periodontia, and orthodontia.

The experimental estimate of 1.4 billed visits (or approximately 1.6 visits if no-charge visits are included) on the 50-percent and 95-percent plans is also very close to the 1.56 visits per person for the population initially enrolled in the study (see Table 2).

Third, the HIE has 46-percent higher expenses on free care than on a 95-percent plan with a catastrophic limit on out-of-pocket expenses. Phelps and Newhouse (1974) give estimates of 80-to-96-percent higher expenses with free care (e.g., full coverage) than with no insurance. The HIE response should be smaller because the 95-percent plan provides free care beyond the maximum dollar expenditure (MDE). During the second year of the study, slightly less than a third of the families on the 95-percent plan exceeded their MDEs. Hence, the 95-percent-plan response is an amalgam of the response to a 95-percent coinsurance rate below the MDE and to free care above it.

Our data suggest that the estimates of the response to cost sharing in the literature may depend strongly on the measure of use that is employed. In Tables 3 and 4, there is greater response to insurance plan for expenditures than for visits or for the likelihood of having any use of dental services. Nearly one-quarter of the total response to plan is in cost per visit, while three-quarters is in the number of visits per enrollee. To the extent that we are interested in predicting premiums for dental insurance or the cost of public programs (e.g., Medicaid dental benefits), using visits or the likelihood of any use is a misleading indicator of dollars spent.

THE EFFECT OF INCOME ON THE USE OF DENTAL SERVICES

As noted earlier, annual dental expenditures are much less responsive to income than are visits or the likelihood of any use of dental services. Part of the reason has to do with the mix of services. The more common but less expensive services (diagnostic, preventive, and restorative work) increase significantly as income increases. Because these services are purchased by a large number of people, they make the overall probability of use increase with income.

In contrast, the less common but more expensive services (prosthodontic, endodontic, and periodontic treatment) are not responsive to income. (We did not cover orthodontia, which may be an exception to this generalization.) Because these services account for a large fraction of dental expenses, the expenditures on all dental services exhibit little response to income.

The lack of an income response for prosthodontic, endodontic, and periodontic treatment may be due to three causes. First, the number of users is so small that we may lack precision on any income effects, if such effects exist. Second, some of these service categories (e.g., prosthodontics) comprise a mix of different services, some of which may be positively and others negatively related to income. For example, we might expect dentures to be negatively related to income but fixed bridges to be positively related. Unfortunately, we do not have enough observations to test such a hypothesis.

Third, our inability to detect a major and consistently significant income effect on expenditures could result from the presence of an income-related limit on out-of-pocket expenses (MDE). Because a lower-income family is more likely to reach its (lower) MDE than is a higher-income family, a lower-income family is more likely to receive free care beyond the MDE (Newhouse et al., 1981, 1982). This mixture of some care with a positive out-of-pocket cost and some care for free tends to dilute the income responsiveness.

Nonetheless, our data suggest that estimates in the literature of how income affects the use of dental services may depend on the measure of use employed.

POLICY IMPLICATIONS

The HIE data indicate that as dental coverage increases in generosity, the use of dental services increases dramatically. Even if our only concern were the changes in the steady-state use of dental services, we could expect to see as high as 46-percent increases in dental use as people went from a minimal (catastrophic coverage only) dental plan to more generous coverage, with most of the response to cost-sharing occurring between 25-percent and 0-percent coinsurance rates. Although the experiment did not measure use by individuals without dental coverage, we would expect a considerable increase in use if uncovered individuals became covered by a catastrophic insurance plan such as the 95-percent plan. On such a plan, roughly one-third of the individuals would receive some additional care free for part of the year, and their demand would increase.

However, the steady state is not the only concern for either public-policy analysts or insurance companies. The transition to the steady state is important. We observed a very large surge—a doubling of the plan differences in demand in the first year of the study relative to the second. If there were major changes in dental coverage for a large percentage of the population, we could expect a major surge in aggregate

demand. Increases in dental service prices, and queues to appointments, could result. Given the magnitude of our transitory and steady-state estimates, it may be desirable to phase in changes in dental benefits rather than make large-scale, one-shot changes.

Our analysis provides only partial insight into the desirability of different insurance coverage for dental and other health services (e.g., medical care). One economic argument for discriminatory insurance treatment presumes a different price response, with the service which is less price-responsive being more generously covered. This minimizes the social losses from the overconsumption of services that occurs when patients purchase services that cost them less out-of-pocket than it costs society to produce. Ignoring elements of risk, the optimal insurance policy will have lower coinsurance rates and deductibles for services that are less sensitive to out-of-pocket charges (Baumol and Bradford, 1970; Arrow, 1971; Pauly, 1968; Zeckhauser, 1965).

Our results on relative response to cost sharing have mixed implications for policy. The higher dental response in the first year argues for higher dental than medical coinsurance rates, while the lower steady-state dental response argues for lower dental than medical coinsurance rates, if responsiveness to cost sharing were the *sole* concern. However, arguments in either direction can be made on other grounds. These include relative riskiness[2] (the riskier health problem or the health problem with the larger financial loss will receive better coverage),[3] efficacy of treatment (the more cost-effective service receives better coverage), and income distribution concerns.

Although this report does not address these issues directly, we should note that the history of dental insurance may provide some insights. First, dental insurance is usually much less generous than

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[2]We use riskiness in the very limited sense that neither the insurance carrier nor the enrollee can predict *well* the decline in health status. (Accidents and heart attacks are examples.)

Another form of uncertainty is often confused with riskiness. This is the case where the insurance carrier cannot predict who will use the service but the enrollee knows whether he will or not. (An example is the likelihood of using maternity benefits.) In such a case, health insurance redistributes income from enrollees who know that they will not use the service to those who know that they will, with the insurance policy acting as the redistribution mechanism.

The extent to which dental care falls into the latter category may partially explain why, when the matter is left to their own discretion, private insurance carriers have not provided equal coverage. If only those who desired to use services enrolled, expenditure would be spread only over users, and premiums would necessarily be high, perhaps substantially decreasing the demand for insurance.

[3]Families are more likely to insure against larger than smaller financial risks, although both risks may be equally costly in a group. For example, a family may find the small risk of accidental injury with its large dental costs less acceptable than the more likely but smaller financial loss associated with caries.

insurance for other health services (e.g., medical and mental health care). Second, dental coverage is usually on a par with medical coverage only for accidental injury. Third, dental coverage (except accidental) was typically added well after other health services were covered—and largely during a period of inflation. As individuals were pushed into higher tax brackets, taking income in kind as a fringe benefit (e.g., insurance coverage) rather than as cash became more appealing.

This reasoning suggests that unless there is a separate cap for dental services, an overall cap on the amount employers can contribute tax free to health insurance plans will lead to a larger reduction in demand for dental insurance than for medical insurance. Using HIE data on dental, drug, physician, and inpatient utilization, Phelps (1983) argued that a cap on the tax subsidy of employer contributions for fringe benefits (e.g., health insurance) will cause larger reductions in insurance coverage for dental care and drugs than for physician and inpatient care.

Our conclusions about the effect of cost sharing on the use of dental services are positive, not normative. To evaluate the desirability of more or less generous dental insurance, we also need to know how variation in cost sharing affects oral health status. A companion report (Bailit et al., 1985) examines the effect of cost sharing on oral health status.

Appendix A

BENEFITS FOR DENTAL SERVICES ON HIE PLANS

According to the terms described in your Benefits Statement, the plan provides coverage for the following dental services provided by a dentist and his staff:

1. Diagnostic—necessary procedures to assist the dentist in evaluating existing conditions in order to determine the required dental treatment, including examination, X-rays, and other diagnostic services.
2. Preventive—necessary procedures to prevent the occurrence of oral disease, including prophylaxis (cleaning), topical application of fluoride, instruction in oral hygiene techniques, space maintainers, and other preventive services.
3. Restorative—necessary amalgam and synthetic/composite restorations. Necessary crowns and jackets are covered when teeth cannot be restored with the above materials. Gold foil and platinum materials are *excluded* from coverage.
4. Oral surgery—necessary procedures for surgical extractions, trauma, and other dental surgery, including pre- and post-operative care.
5. Endodontics—necessary procedures for treatment of disease of the pulp chamber and pulp canal, including root canal filling, related surgical procedures, and other endodontic services.
6. Periodontics—necessary procedures for the treatment of the tissues supporting the teeth, including surgical treatment, deep scaling and curettage, and other periodontic services.
7. Orthodontics—all orthodontic procedures are *excluded* from coverage, except those necessary *preventive* (interceptive) procedures, such as space maintainers and appliances necessary to eliminate later orthodontic treatment.
8. Prosthodontics—necessary procedures for the construction of fixed bridges, partial and full dentures, and the repair of prosthetic appliances, with the following restriction: The Plan *excludes* from coverage any fixed bridge involving seven or more units. However, the Plan will pay toward the fee for an excluded fixed bridge the amount it would have paid had

dentures been elected instead. The Plan covers replacement of dentures or fixed bridges, *but* the plan *does not* cover replacement of any satisfactory denture or fixed bridge.

Prior authorization is required for the following:

(a) For any treatment plan exceeding $500.00 (except in the case of emergency), or
(b) For any replacement of crowns, bridges, or dentures.

The plan also *includes* any necessary dental service that is *not excluded* in the above description of covered dental services. With respect to Section M, Dental Services, the term "necessary" is defined as necessary for dental health, that is, needed for efficient function and/or reasonable appearance. The final determination of necessary dental services and the decision concerning whether a denture or bridge is "satisfactory" is made by the plan administrator, based on the recommendation of a plan dental consultant, a dentist whose decision is based on information provided by the practitioner.

The plan shall not provide coverage for cosmetic dental services except for the repair of physical damage caused by accidental injury incurred after the effective date of the plan, or where an accident prior to the effective date necessitated cosmetic dental services which, for medical reasons, could not have been performed before the effective date. In case of accidents before the effective date, prior authorization will be required for cosmetic dental services.

Appendix B

STATISTICAL METHODS

To study the effect of cost sharing on the use of dental services, we will examine the response of participants in terms of their annual number of visits and annual expenditures for dental care. Rather than rely on the more common analysis of variance (ANOVA) or analysis of covariance techniques (ANOCOVA), we have used a two-part model for dental expenditures and a negative binomial regression model for dental visits. These choices were dictated by two characteristics of the use of dental services as measured by either visits or expenses. First, a large proportion of the HIE participants use no dental services. In any one year, only three out of five people used any dental services. Second, the distribution of expenses and visits among users is very skewed.

These characteristics imply that ANOVA and ANOCOVA techniques would yield imprecise (though unbiased) estimates of the effects of cost sharing on the use of dental services, even for a fairly large sample size such as that in the HIE. As Duan, Manning, Morris, and Newhouse (1983) have shown for use of medical services, a model that exploits the characteristics of the distribution of utilization can provide more precise estimates.

In this appendix, we describe our statistical methods. The topics include: the two-part model for estimating dental expenditures, the negative binomial regression model for estimating dental visits, and testing for differences in response over time or over dental services.

TWO-PART MODEL FOR DENTAL EXPENSES

We use two equations to model the distribution of dental expenses. The first is a probit equation for the probability that a person will receive any dental service during a year. This equation separates users from nonusers and therefore addresses the first characteristic described above. The second equation is a linear regression for the logarithm of total annual dental expenses of users. The log transformation of annual expenses for the group of users reduces dramatically, but does not eliminate, the undesirable skewness in the distribution of expenses among users described above as the second characteristic. We

therefore expect the estimates from this model to be more robust than those that might be obtained from ANOVA and ANOCOVA models on untransformed expenses.

More formally, the first equation is a probit equation for the dichotomous event of zero versus positive dental expense:

$$I_{1i} = x_i\beta_1 + \epsilon_{1i}, \tag{B.1}$$

$$(\epsilon_{1i} \mid x_i) \sim N(0, 1)$$

where dental expense is positive if $I_{1i} \geq 0$, 0 otherwise; and x_i is a row vector of given individual characteristics (e.g., plan and age).

The second equation is a linear model on the log scale for positive dental expenses *if* the person receives any dental services:

$$\ell n(DENTALS\$_i \mid I_{1i} \geq 0, x_i) = x_i\beta_2 + \epsilon_{2i}, \tag{B.2}$$

where $E(\epsilon_{2i} \mid x_i, I_{1i} \geq 0) = 0$, x_i is a row vector of given individual characteristics and ϵ_{2i} is i.i.d. For the last equation, the error is not assumed to be normally distributed.

The likelihood function for this model is multiplicatively separable because of the way the conditional densities are calculated. (The separability does *not* depend on any assumption of independence between errors in the two equations. In fact, the errors may be correlated.) Separability implies that estimating the two equations by maximum likelihood *separately* provides the global full-information maximum-likelihood estimates; see Manning et al. (1981), and Duan et al. (1983, 1984). We therefore estimate the two equations separately.

If the error term ϵ_2 in the (log) expense equation was normally distributed, then the expected dental expense would be

$$E(DENTALS\$_i) = p_i \exp(x_i\beta_2 + \sigma^2_{\epsilon 2}/2) \tag{B.3}$$

where

$$p_i = Prob._i(DENTALS\$_i > 0) = \Phi(x_i\beta_1),$$

$$\Phi = normal\ c.d.f.,$$

and where the factor $exp(\sigma^2/2)$ is the adjustment in the mean for retransformation in the second (or conditional) equation if ϵ_2 were normally distributed. However, the normal assumption for ϵ_2 is not satisfied for the dental expense data, because the residual distribution is appreciably skewed. As a result of this nonnormality, the factor $[exp(\sigma^2/2)]$ is not the correct adjustment in the mean for the retransformation from the logarithmic scale to the untransformed

dollar scale and would lead to statistically inconsistent predictions of the mean expenditure. In the case of dental expenses, the normal retransformation estimates would be biased downwards.

Instead of the normal retransformation, we use the smearing estimates developed by Duan (1983). The smearing estimate, a nonparametric estimate of the retransformation factor $\sigma = E(\exp(\epsilon_2))$, is the sample average of the exponentiated least squares residuals. The smearing estimate is statistically consistent for the retransformation factor if the error distribution does not depend on the characteristics x.

A consistent estimate of the expected expense for dental services is therefore provided by

$$E(DENTALS\$_i) = \hat{p}_i \exp(x_i\hat{\beta}_2)\hat{\varphi} \quad \text{(B.4a)}$$

where

$$\hat{\varphi} = \sum \exp(\ell n\ Y_i - x_i\hat{\beta}_2)/n \quad \text{(B.4b)}$$

where $\hat{\beta}_2$ is a consistent estimate of β_2.

We have used a heteroscedastic version of the smearing estimate. Our data exhibit heteroscedasticity by age group, site, and insurance plan. Because a homoscedastic retransformation would provide biased predictions of expenditures, we have allowed the smearing estimate to depend linearly on age group, site, age group interacted with site, and insurance plan.

The econometric literature provides an additional class of models for continuous but limited dependent variables. These models include the Tobit model (Tobin, 1958), the Adjusted Tobit model (van de Ven and van Praag, 1981), and sample selection models (Maddala, 1983). Like our two-part model, these models are two-equation models, with an equation (typically a probit) for whether there is a positive amount, and another equation for the level of the positive amount. These models differ from ours in that they explicitly model the correlation between the probability of any use and the level of use. For example, the Adjusted Tobit Model is

$$I_i = x_i\delta_i + \eta_{1i} \quad \text{(B.5a)}$$

$$w_i = x_i\delta_2 + \eta_{2i} \quad \text{(B.5b)}$$

$$\begin{aligned} \ell n(\$) &= w_i \text{ if } I_i > 0 \\ &= -\infty \text{ if } I_i = \leq 0 \end{aligned} \quad \text{(B.5c)}$$

where

$$\eta = N\left(0,\sum\right), iid \tag{B.5d}$$

$$\sum = \begin{pmatrix} 1 & \sigma\rho \\ \sigma\rho & \sigma^2 \end{pmatrix} \tag{B.5e}$$

We have chosen the two-part model over the Adjusted Tobit for several reasons. First, we see no conceptual reason why it is necessary to model the correlation between the two equations to get a consistent estimate of the population mean by plan. In this case, the correlation coefficient is a nuisance parameter. There is ample precedent for excluding such parameters in conditional likelihood estimation (McCullogh and Nelder, 1983; Duan et al., 1985). Second, as we have shown elsewhere, our model is not necessarily inconsistent in the presence of correlated errors across equations (Duan et al., 1984). Third, a split sample analysis of medical expenditures (Duan et al., 1984) suggests that the two-part model was neither significantly worse nor significantly better than either the full-information maximum-likelihood (FIML) or limited-information maximum-likelihood (LIML) versions of the two-part model. Fourth, that same analysis showed that the LIML estimate of ρ is unstable, in large part because the Mills ratio used in LIML was highly collinear with the independent variables in the second equation (B.5b). Fifth, this collinearity in fact raises the problem that one cannot distinguish the LIML version of the Adjusted Tobit from a two-part model, especially if there is some nonlinearity (e.g., a quadratic term) or garden variety heteroscedasticity in the data.

Sixth, we rejected the Adjusted Tobit Model because it relies on a strong set of distributional assumptions; for example, see Eq. (B.5d). If those assumptions are not met, the estimates of plan effects will be inconsistent. For example, the FIML varient is known to be extremely sensitive to minor departures from the underlying distributional assumptions. Unfortunately, one cannot test the *full* set of distributional (in our example, normality and i.i.d) assumptions imbedded in the Adjusted Tobit Model. To do so would require observing use by those who do not use.

Finally, even if the true model is an Adjusted Tobit model, we can obtain a two-part model which fits the data well. In a Monte Carlo study, Manning et al. (1986) show that by adding a quadratic term to the level of use equation, one can eliminate the bias from ignoring the selection effect, if it exists. In the case where both the likelihood of any use and the level of use equations contain the same covariate(s), they show that the data do not allow the analyst to distinguish the

Adjusted Tobit model from a two-part model with an empirically derived specification if the true model is Adjusted Tobit.

For a fuller discussion of these issues, see Duan et al. (1983, 1984, 1985), Maddala (1983), and Manning et al. (1986).

NEGATIVE BINOMIAL MODEL FOR DENTAL VISITS

We used a model based on the negative binomial distribution to estimate the response of dental visits to cost sharing.[1] The negative binomial distribution is an appealing model for visits because it can yield a large proportion of zero visits and a skewed distribution of positive use; thus, the model can address the two characteristics of dental use mentioned earlier. The negative binomial model is more appealing for visits than a two-part model because the negative binomial model has discrete outcomes, while the two-part model has continuous outcomes. The negative binomial regression model is more appealing than a Poisson regression because the variance of dental visits exceeds the mean; data from a Poisson distribution should have equal mean and variance.

The negative binomial model can be generated from an underlying Poisson model. Let each individual's (i's) visits be drawn independently from a Poisson distribution with rate λ_i:

$$p(admits = n \mid \lambda_i) = \lambda_i^n \exp(-\lambda_i)/n! \qquad \text{(B.6)}$$

If different individuals have different rates that are sampled from a Type III (gamma) distribution,

$$p_{\alpha,\beta}(\lambda_i) = [\beta^\alpha \Gamma(\alpha)]^{-1} \lambda^{\alpha-1} \exp[-\lambda/\beta], \qquad \text{(B.7)}$$

where λ, α, and β are all greater than zero, then the observed number of visits follow a negative binomial distribution where

$$prob(visits = n) = \binom{\alpha + n - 1}{\alpha - 1} \left(\frac{\beta}{1+\beta}\right)^{\alpha} \left(\frac{1}{1+\beta}\right)^{n} \qquad \text{(B.8)}$$

(Johnson and Kotz (1969), pp. 124-125). The expected value for the sample and mean and variance of annual visits are

$$E(visits) = \alpha/\beta \qquad \text{(B.9)}$$

$$Var(visits) = \alpha(1 + \beta)/\beta^2.$$

As long as β is positive, the variance exceeds the mean.

[1]See Johnson and Kotz (1969), pp. 122–142, for a fuller description of the negative binomial distribution.

In the results below, we assume that the parameters α and β can be expressed as linear combinations of observed individual characteristics. The log of the parameter α is a function of site. The log of the parameter β is a linear combination of all characteristics

$$\ell n \beta = - x_i \beta_i, \tag{B.10}$$

where x_i is row vector of given individual characteristics, including an intercept.

CORRELATION IN THE RESPONSES

Although we have observations for several thousand person-years of data, we do not have that number of *independent* observations. The error terms in our equations exhibit substantial positive correlations among family members and over time for individuals. These correlations exist in both the two-part model and in the negative binomial regression model. Failure to account for these correlations in the analysis would yield statistically inconsistent estimates of the standard errors. As a result, the inference statistics (t, F, and χ^2) calculated in the usual way (without adjusting for these correlations) would be too large. In the results presented above, we have corrected the inference statistics for this positive correlation. This correction is similar to that of the random-effects least-squares model, or equivalently, intracluster correlation model. The correction method is fully described by Rogers (1983), based on prior work by Huber (1967).

TESTING FOR TRANSITORY DEMAND

Instead of using the standard F test for equality in the parameter estimates over time, we applied a test that controls for the positive correlation in use over time—a high use in the first year is likely to be followed by a high use in the second year.

For the surge at the outset of the study, we examine the difference between first- and second-year expenditures and visits by insurance plan. If there is a surge at entry, the average difference will be positive. To test for a surge at exit, we examine the difference between the last and the second to the last year of dental coverage by plan. By using differences, each person acts as his own control.

These tests exclude the Dayton adults on the pay plans who were enrolled for three years. Because of the delayed introduction of dental coverage for this group, they have only two years of dental coverage. Hence, we cannot distinguish entry and exit surges for this group.

Appendix C

PARAMETER ESTIMATES

Table C.1

EXPLANATORY VARIABLES

Dental insurance plan—Indicator (0,1) variables[a]	
FREE	Free care (no out-of-pocket cost)
D25	25% coinsurance rate[b]
D50	50% coinsurance rate[b]
IDP	Individual Deductible plan
Other Subexperiments—Indicator (0,1) variables	
NOHR	No health report filed[c]
WEEKLY	Weekly health report filed[c]
TERM3	Three-year enrollment[d]
TOOKPHYS	Took entry examination[e]
Site[f]	
DAY	Dayton, Ohio
FIT	Fitchburg, Mass.
FRA	Franklin Co., Mass.
CHA	Charleston, S.C.
GEO	Georgetown Co., S.C.
Age/sex—Indicator (0,1) Variables[g]	
A1	$0 \le$ age < 5
A2	$5 \le$ age < 12
A3	$1 \le$ age < 18
FADULT	$18 \le$ age and female
Socioeconomic variables	
LNINC	Log family income in 1967 $
LNINC2	lninc squared
AFDC	Indicator for Aid to Families with Dependent Children
MISINC	Indicator for missing income
EDLTHS	Indicator for education < 12 years[h]
SOMCOL	Indicator for $12 <$ education < 16 years[h]
COLL	Indicator for education ≥ 16 years[h]

Table C.1—continued

Other Variables	
Y3	Indicator for year 3 of dental coverage[i]
Y4	Indicator for year 4 of dental coverage[i]
LFAM	Log family size
BLACK	Indicator for being black
Interactions	
INCFREE	FREE * LNINC
INCD25	D25 * LNINC
INCD50	D50 * LNINC
INCIDP	IDP * LNINC

[a]The 95-percent plan is the omitted group.

[b]Subject to an upper limit of at most $1000 in out-of-pocket expenses.

[c]Filing biweekly is the omitted group.

[d]Enrollment for 5 years is the omitted group.

[e]Not receiving the entry examination is the omitted group.

[f]Seattle, Wash., is the omitted site.

[g]Males aged 18 or older are the omitted group.

[h]Twelve years of completed education is the omitted group. Children assigned the variable for the mother, if present; otherwise, the male head of household.

[i]Used only for the middle or steady years. The second year is the omitted year.

Table C.2

PROBIT REGRESSION FOR ANY DENTAL USE:
ENTRY YEAR

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	−1.5658E−01	1.927E−01	−0.81
DAY	−8.9372E−02	8.967E−02	−1.00
FIT	1.3190E−01	8.240E−02	1.60
FRA	2.3251E−01	7.918E−02	2.94
CHA	−4.4967E−01	1.070E−01	−4.20
GEO	−2.2984E−01	1.049E−01	−2.19
NOHR	9.3865E−02	8.031E−02	1.17
WEEKLY	6.7822E−03	1.083E−01	0.06
TERM3	−3.2522E−02	5.036E−02	−0.65
TOOKPHYS	3.6000E−02	4.620E−02	0.78
FREE	6.0001E−01	1.961E−01	3.06
D25	−1.6635E−01	2.795E−01	−0.60
D50	−2.5936E−01	2.301E−01	−1.13
IDP	−1.2383E−01	2.582E−01	−0.48
A1	−7.4027E−01	6.223E−02	−11.90
A2	3.7270E−01	5.535E−02	6.73
A3	2.9029E−01	6.120E−02	4.74
FADULT	1.8154E−01	3.700E−02	4.91
LNINC	2.4154E−03	1.222E−01	0.02
LNINC2	4.5939E−02	3.299E−02	1.39
AFDC	1.4956E−02	1.016E−01	0.15
MISINC	−3.1589E−01	8.251E−02	−3.83
EDLTHS	−2.6032E−01	5.339E−02	−4.88
SOMCOL	7.1580E−02	6.055E−02	1.18
COLL	2.2481E−01	6.583E−02	3.42
LFAM	9.3101E−03	4.647E−02	0.20
BLACK	−4.9448E−01	8.137E−02	−6.08
INCFREE	−4.2322E−02	9.652E−02	−0.44
INCD25	1.4659E−01	1.385E−01	1.06
INCD50	2.1304E−01	1.144E−01	1.86
INCIDP	8.8681E−02	1.274E−01	0.70

Table C.3

PROBIT REGRESSION FOR ANY DENTAL USE:
STEADY STATE

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	−4.3557E−01	1.745E−01	−2.50
DAY	9.5624E−03	8.990E−02	0.11
FIT	2.0390E−01	8.155E−02	2.50
FRA	4.4385E−01	7.570E−02	5.86
CHA	−1.4426E−01	9.196E−02	−1.57
GEO	−2.2278E−02	9.460E−02	−0.24
NOHR	4.7415E−02	7.261E−02	0.65
WEEKLY	1.6693E−01	1.074E−01	1.55
TERM3	1.2651E−02	5.040E−02	0.25
TOOKPHYS	7.4167E−02	4.333E−02	1.71
FREE	6.0509E−01	1.769E−01	3.42
D25	−5.9930E−02	2.493E−01	−0.24
D50	−3.2106E−01	2.439E−01	−1.32
IDP	−1.1423E−01	2.178E−01	−0.52
A1	−5.8384E−01	5.682E−02	−10.28
A2	5.5176E−01	5.057E−02	10.91
A3	4.0292E−01	5.116E−02	7.88
FADULT	3.0365E−01	3.490E−02	8.70
LNINC	−7.2595E−02	1.068E−01	−0.68
LNINC2	1.0437E−01	2.867E−02	3.64
AFDC	−3.6776E−02	9.308E−02	−0.40
MISINC	−2.2515E−01	7.965E−02	−2.83
EDLTHS	−2.4450E−01	5.251E−02	−4.66
SOMCOL	2.0260E−02	5.859E−02	0.35
COLL	3.5709E−01	5.826E−02	6.13
Y3	−1.6376E−02	4.110E−02	−0.40
Y4	−1.6084E−02	4.490E−02	−0.36
LFAM	−5.0609E−02	4.283E−02	−1.18
BLACK	−4.0291E−01	7.870E−02	−5.12
INCFREE	−7.7700E−02	8.779E−02	−0.89
INCD25	5.8343E−02	1.239E−01	0.47
INCD50	1.5645E−01	1.215E−01	1.29
INCIDP	3.5895E−02	1.097E−01	0.33

Table C.4

PROBIT REGRESSION FOR ANY DENTAL USE:
EXIT YEAR

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	−1.2502E−01	1.825E−01	−0.69
DAY	−2.7662E−03	9.901E−02	−0.03
FIT	1.0641E−01	8.833E−02	1.20
FRA	7.6812E−02	8.023E−02	0.96
CHA	−1.8258E−01	1.132E−01	−1.61
GEO	−3.5910E−02	1.145E−01	−0.31
NOHR	−2.3418E−02	8.664E−02	−0.27
WEEKLY	−4.2949E−02	1.167E−01	−0.37
TERM3	−3.9887E−02	5.338E−02	−0.75
TOOKPHYS	1.7558E−01	4.829E−02	3.64
FREE	5.2582E−01	1.943E−01	2.71
D25	4.4428E−01	3.034E−01	1.46
D50	3.6747E−02	2.386E−01	0.15
IDP	−1.5123E−01	2.347E−01	−0.64
A1	−5.6778E−01	6.868E−02	−8.27
A2	3.8109E−01	5.605E−02	6.80
A3	3.4145E−01	5.769E−02	5.92
FADULT	2.4025E−01	3.751E−02	6.41
LNINC	−1.8083E−01	1.158E−01	−1.56
LNINC2	9.8419E−02	3.399E−02	2.90
AFDC	−1.1405E−01	1.061E−01	−1.07
MISINC	−2.4070E−01	8.481E−02	−2.84
EDLTHS	−3.9587E−01	5.570E−02	−7.11
SOMCOL	−4.1476E−02	6.144E−02	−0.68
COLL	3.3158E−01	6.738E−02	4.92
LFAM	1.1321E−02	4.626E−02	0.24
BLACK	−5.4527E−01	8.669E−02	−6.29
INCFREE	6.9643E−02	9.673E−02	0.72
INCD25	−5.8054E−02	1.495E−01	−0.39
INCD50	8.2747E−02	1.192E−01	0.69
INCIDP	1.1869E−01	1.176E−01	1.01

Table C.5

ORDINARY LEAST SQUARES REGRESSION FOR LOG (ANNUAL EXPENDITURES, IF ANY): ENTRY YEAR

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	5.7219E+00	2.427E−01	23.58
DAY	−4.8468E−01	9.748E−02	−4.97
FIT	−2.9541E−01	8.311E−02	−3.55
FRA	−4.5607E−01	7.995E−02	−5.70
CHA	−1.3342E−01	1.331E−01	−1.00
GEO	−3.8690E−01	1.273E−01	−3.04
NOHR	6.4088E−02	9.333E−02	0.69
WEEKLY	1.1474E−01	1.306E−01	0.88
TERM3	−9.4920E−03	5.223E−02	−0.18
TOOKPHYS	−1.4067E−02	5.095E−02	−0.28
FREE	1.7503E−01	2.372E−01	0.74
D25	−1.8366E−01	4.359E−01	−0.42
D50	4.5584E−02	3.651E−01	0.12
IDP	−3.3960E−01	3.281E−01	−1.04
A1	−1.4588E+00	8.851E−02	−16.48
A2	−9.4096E−01	5.800E−02	−16.22
A3	−7.0911E−01	6.684E−02	−10.61
FADULT	−1.9346E−01	5.255E−02	−3.68
LNINC	2.4541E−02	1.498E−01	0.16
LNINC2	−7.8056E−02	3.932E−02	−1.99
AFDC	1.1438E−02	1.095E−01	0.10
MISINC	2.8502E−02	1.133E−01	0.25
EDLTHS	1.1617E−01	6.516E−02	1.78
SOMCOL	−5.5916E−02	5.919E−02	−0.94
COLL	−1.4255E−01	6.684E−02	−2.13
LFAM	3.2195E−02	5.567E−02	0.58
BLACK	6.1564E−01	1.180E−01	5.22
INCFREE	1.4317E−01	1.100E−01	1.30
INCD25	1.9802E−01	1.971E−01	1.00
INCD50	4.9858E−02	1.713E−01	0.29
INCIDP	2.6174E−01	1.539E−01	1.70

Table C.6

ORDINARY LEAST SQUARES REGRESSION FOR
LOG (ANNUAL EXPENDITURES, IF ANY):
STEADY STATE

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	5.5797E+00	2.008E−01	27.79
DAY	−3.3422E−01	6.712E−02	−4.98
FIT	−4.7823E−01	6.938E−02	−6.89
FRA	−4.6249E−01	6.439E−02	−7.18
CHA	−2.5240E−01	9.574E−02	−2.64
GEO	−5.2169E−01	8.834E−02	−5.91
NOHR	−7.1282E−03	7.639E−02	−0.09
WEEKLY	−4.5360E−02	9.046E−02	−0.50
TERM3	8.7880E−02	5.276E−02	1.67
TOOKPHYS	−1.4726E−02	3.986E−02	−0.37
FREE	−1.0511E−01	2.014E−01	−0.52
D25	1.2610E−01	3.102E−01	0.41
D50	−1.4807E−01	3.261E−01	−0.45
IDP	−9.8231E−02	2.681E−01	−0.37
A1	−1.1712E+00	6.574E−02	−17.82
A2	−7.1346E−01	4.739E−02	−15.06
A3	−4.7804E−01	5.172E−02	−9.24
FADULT	−7.8744E−02	4.432E−02	−1.78
LNINC	−1.5193E−01	1.164E−01	−1.31
LNINC2	−5.8653E−03	2.943E−02	−0.20
AFDC	2.9967E−02	9.509E−02	0.32
MISINC	6.4409E−02	9.409E−02	0.68
EDLTHS	1.4156E−01	5.104E−02	2.77
SOMCOL	−6.2295E−02	4.620E−02	−1.35
COLL	−1.7629E−01	5.141E−02	−3.43
Y3	−8.8200E−02	4.382E−02	−2.01
Y4	−5.9671E−02	4.881E−02	−1.22
LFAM	3.3171E−02	4.405E−02	0.75
BLACK	4.0688E−01	8.556E−02	4.76
INCFREE	1.3417E−01	9.216E−02	1.46
INCD25	−8.6111E−03	1.407E−01	−0.06
INCD50	9.6519E−02	1.508E−01	0.64
INCIDP	6.5594E−02	1.240E−01	0.53

Table C.7

ORDINARY LEAST SQUARES REGRESSION FOR
LOG (ANNUAL EXPENDITURES, IF ANY):
EXIT YEAR

VARIABLE	COEFFICIENT	SD(COEFF)	T	CO-LINEAR
INTERCEPT	5.4039E+00	2.188E−01	24.70	0.000
DAY	−4.4015E−01	8.482E−02	−5.19	0.588
FIT	−3.1140E−01	8.232E−02	−3.78	0.341
FRA	−5.7536E−01	6.901E−02	−8.34	0.370
CHA	−2.7876E−01	1.246E−01	−2.24	0.478
GEO	−4.9854E−01	1.177E−01	−4.24	0.670
NOHR	−1.6584E−02	9.190E−02	−0.18	0.605
WEEKLY	1.5855E−02	1.040E−01	0.15	0.523
TERM3	−2.4299E−03	4.957E−02	−0.05	0.158
TOOKPHYS	1.1538E−03	4.662E−02	0.02	0.085
FREE	1.3008E−01	2.145E−01	0.61	0.972
D25	4.9264E−01	3.622E−01	1.36	0.925
D50	8.9196E−02	2.881E−01	0.31	0.959
IDP	−4.3813E−02	2.723E−01	−0.16	0.962
A1	−1.2560E+00	7.757E−02	−16.19	0.124
A2	−7.1344E−01	5.387E−02	−13.24	0.212
A3	−4.8682E−01	6.003E−02	−8.11	0.250
FADULT	2.1231E−03	5.117E−02	0.04	0.244
LNINC	−5.1102E−02	1.340E−01	−0.38	0.944
LNINC2	−1.0926E−02	3.353E−02	−0.33	0.900
AFDC	4.8448E−02	1.108E−01	0.44	0.315
MISINC	6.7626E−03	1.098E−01	0.06	0.174
EDLTHS	2.0291E−01	6.702E−02	3.03	0.259
SOMCOL	−3.2405E−02	5.722E−02	−0.57	0.209
COLL	−2.2158E−01	5.514E−02	−4.02	0.210
LFAM	1.1457E−02	5.049E−02	0.23	0.351
BLACK	4.8554E−01	1.123E−01	4.33	0.420
INCFREE	9.8068E−02	1.038E−01	0.94	0.976
INCD25	−1.5753E−01	1.684E−01	−0.94	0.923
INCD50	2.0588E−02	1.391E−01	0.15	0.958
INCIDP	9.5478E−02	1.289E−01	0.74	0.962

Table C.8

SMEARING FACTOR FOR ENTRY YEAR

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	2.0046E+00	2.483E−01	8.07
A1	−6.3325E−01	2.392E−01	−2.65
A2	−8.6541E−01	1.444E−01	−5.99
A3	−5.5006E−01	2.072E−01	−2.66
DAY	9.9458E−01	4.591E−01	2.17
FIT	4.2578E−01	3.530E−01	1.21
FRA	6.3387E−01	3.825E−01	1.66
CHA	1.0683E+00	4.434E−01	2.41
GEO	3.3403E−01	3.248E−01	1.03
FREE	2.4119E−01	2.392E−01	1.01
D25	3.3034E−01	3.455E−01	0.96
D50	5.9077E−01	3.936E−01	1.50
IDP	4.9035E−01	3.023E−01	1.62
DAY1	−1.0567E+00	5.735E−01	−1.84
DAY2	−8.2082E−01	4.891E−01	−1.68
DAY3	−1.1380E+00	5.780E−01	−1.97
FIT1	3.3735E−01	6.006E−01	0.56
FIT2	−4.8394E−01	3.807E−01	−1.27
FIT3	−7.1645E−01	4.635E−01	−1.55
FRA1	−9.1896E−01	5.555E−01	−1.65
FRA2	−6.2651E−01	4.124E−01	−1.52
FRA3	−1.4156E−01	8.286E−01	−0.17
CHA1	−2.1063E+00	5.221E−01	−4.03
CHA2	−9.9242E−01	4.532E−01	−2.19
CHA3	−4.6392E−01	5.889E−01	−0.79
GEO1	4.9838E−01	1.128E+00	0.44
GEO2	−1.7874E−01	3.896E−01	−0.46
GEO3	−6.8970E−02	4.815E−01	−0.14

Table C.9

SMEARING FACTOR FOR STEADY STATE

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	2.5013E+00	2.316E−01	10.80
A1	−1.2646E+00	1.338E−01	−9.45
A2	−9.0169E−01	1.362E−01	−6.62
A3	−9.2155E−01	1.433E−01	−6.43
DAY	3.9571E−01	2.659E−01	1.49
FIT	4.7776E−01	3.585E−01	1.33
FRA	4.4516E−01	3.954E−01	1.13
CHA	8.7013E−01	4.404E−01	1.98
GEO	6.1997E−01	3.368E−01	1.84
FREE	−1.7651E−01	2.229E−01	−0.79
D25	−8.2812E−02	2.805E−01	−0.30
D50	−5.7837E−02	3.565E−01	−0.16
IDP	−1.3136E−01	3.414E−01	−0.38
DAY1	4.0249E−01	7.627E−01	0.53
DAY2	−5.3306E−01	2.854E−01	−1.87
DAY3	−3.7208E−01	3.017E−01	−1.23
FIT1	8.6331E−01	8.418E−01	1.03
FIT2	−6.6074E−01	3.658E−01	−1.81
FIT3	−3.5485E−01	4.353E−01	−0.82
FRA1	3.3271E−01	5.427E−01	0.61
FRA2	−4.8639E−02	4.053E−01	−0.12
FRA3	6.1390E−01	6.588E−01	0.93
CHA1	−9.5485E−01	4.689E−01	−2.04
CHA2	−1.2507E+00	4.452E−01	−2.81
CHA3	6.5581E−01	6.753E−01	0.97
GEO1	8.4214E−01	7.279E−01	1.16
GEO2	−5.9490E−01	3.887E−01	−1.53
GEO3	−8.6273E−02	4.412E−01	−0.20

Table C.10

SMEARING FACTOR FOR EXIT YEAR

VARIABLE	COEFFICIENT	SD(COEFF)	T
INTERCEPT	2.3213E+00	2.619E−01	8.86
A1	−1.1921E+00	1.778E−01	−6.71
A2	−1.0860E+00	1.616E−01	−6.72
A3	−8.9503E−01	1.650E−01	−5.42
DAY	2.8489E−02	3.257E−01	0.09
FIT	5.2995E−01	4.610E−01	1.15
FRA	3.0600E−01	3.054E−01	1.00
CHA	7.6919E−01	4.046E−01	1.90
GEO	8.4409E−01	4.240E−01	1.99
FREE	1.0819E−01	2.343E−01	0.46
D25	−3.1787E−02	2.762E−01	−0.12
D50	−2.5354E−02	2.964E−01	−0.09
IDP	3.3694E−02	2.935E−01	0.11
DAY1	8.3863E−02	3.928E−01	0.21
DAY2	9.0141E−02	3.264E−01	0.28
DAY3	2.5485E−01	3.382E−01	0.75
FIT1	−2.8803E−01	5.141E−01	−0.56
FIT2	−1.1029E−01	4.884E−01	−0.23
FIT3	−5.3688E−01	4.960E−01	−1.08
FRA1	−3.1839E−01	3.381E−01	−0.94
FRA2	−2.6942E−01	3.317E−01	−0.81
FRA3	3.9162E−01	8.711E−01	0.45
CHA1	−1.1798E+00	4.323E−01	−2.73
CHA2	−8.2715E−01	4.135E−01	−2.00
CHA3	−1.0615E+00	4.560E−01	−2.33
GEO1	1.6314E+00	9.306E−01	1.75
GEO2	−7.7709E−01	4.230E−01	−1.84
GEO3	−4.5970E−01	5.300E−01	−0.87

BIBLIOGRAPHY

Amemiya, T., "Regression Analysis When the Dependent Variable is Truncated Normal," *Econometrica*, 1973; 41:997–1017.

Arrow, K. J., *Essays in the Theory of Risk-Bearing*, Markham Publishing Co., Chicago, 1971.

Bailit, H. L., J. P. Newhouse, R. H. Brook, et al., "Does More Generous Dental Insurance Coverage Improve Oral Health? A Study of Patient Cost-Sharing," *Journal of the American Dental Association*, 1983; 110:701–707.

Baumol, W. J., and D. F. Bradford, "Optimal Departures from Marginal Cost Pricing," *American Economic Review*, 1970; 60:265–283.

Benham, L., A. R. Maurizi, and M. Reder, "Migration, Location and Remuneration of Medical Personnel: Physicians and Dentists," *Review of Economics and Statistics*, 1968; 50(3):332–347.

Brook, R. H., J. E. Ware, A. Davies-Avery, et al., "Overview of Adult Health Status Measures Fielded in Rand's Health Insurance Study," *Medical Care* (Supplement), 1979; 17:1–131.

Brook, R. H., J. E. Ware, W. H. Rogers, et al., "Does Free Care Improve Adults' Health? Results from a Randomized Controlled Trial," *New England Journal of Medicine*, 1983; 1426–1454. Also, The Rand Corporation, R-3055-HHS, 1984.

Clasquin, L. A., *Mental Health, Dental Services, and Other Coverage in the Health Insurance Study*, The Rand Corporation, R-1216-OEO, 1973.

Clasquin, L. A., and M. E. Brown, *Rules of Operation for the Rand Health Insurance Study*, The Rand Corporation, R-1602-HEW, 1977.

Conrad, D. A., "Dental Care Demand: Age-Specific Estimates for the Population 65 Years of Age and Over," *Health Care Financing Review*, 1983; 4:47–57.

Cragg, John G., "Some Statistical Models for Limited Dependent Variables with Applications to the Demand for Durable Goods," *Econometrica*, 1971; 59:829–844.

Davies, A. R., and J. E. Ware, *Measuring Health Perception in the Health Insurance Experiment*, The Rand Corporation, R-2711-HHS, 1980.

Duan, N., "Smearing Estimate: A Nonparametric Retransformation Method," *Journal of the American Statistical Association*, 1983; 78:605–610.

Duan, N., W. G. Manning, C. N. Morris, and J. P. Newhouse, "Choosing Between the Sample-Selection Model and the Multi-part Model," *Journal of Business and Economic Statistics*, 1984; 2(3):283–289.

Duan, N., W. G. Manning, C. N. Morris, and J. P. Newhouse, "A Comparison of Alternative Models for the Demand for Medical Care," *Journal of Economic and Business Statistics*, 1983; 1(2):115–126. Also, The Rand Corporation, R-2754-HHS, 1982.

Duan, N., W. G. Manning, C. N. Morris, and J. P. Newhouse, "A Response to Maddala," Draft, April 1985.

Dunning, J. M., *Dental Care for Everyone*, Harvard University Press, Cambridge, 1976.

Feldstein, P., *Financing Dental Care: An Economic Analysis*, D. C. Heath and Company, Lexington, Mass., 1973.

Grembowski, D., and D. A. Conrad, "Insurance Effects on Employer Group Dental Expenditures," *Medical Care*, 1984; 22:501–510.

Grembowski, D., D. A. Conrad, and P. Milgrom, "Utilization of Health Services in the United States and Insured Population," *Journal of Public Health*, 1985; 75:87–89.

Grossman, M., *The Demand for Health: A Theoretical and Empirical Investigation*, Columbia University Press, New York, 1972a.

Grossman, M., "On the Concept of Health Capital and the Demand for Health," *Journal of Political Economy*, 1972b; 80:223–255.

Hay, J. W., and J. Olsen, "Let Them Eat Cake: A Note on Comparing Alternative Models for the Demand of Medical Care," *Journal of Business and Economic Statistics*, 1984; 2:279–282.

Health Insurance Association, *Sourcebook of Health Insurance Data: 1982–1983*, Washington, D.C., 1983.

Heckman, J. J., "Sample Selection Bias as a Specification Error," *Econometrica*, 1979; 47:153–161.

Holtmann, A. G., and E. O. Olsen, Jr., "The Demand for Dental Care: A Study of Consumption and Household Production, *Journal of Human Resources*, 1976; 11–4:546–560.

Huber, P. J., "The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions," *Fifth Berkeley Symposium, 1965*, University of California Press, Berkeley, 1967, pp. 221–233.

Johnson, N. L., and S. Kotz, *Discrete Distributions*, Houghton Mifflin Company, Boston, 1969.

Keeler, E. B., J. P. Newhouse, and C. E. Phelps, "Deductibles and the Demand for Medical Care Services: The Theory of a Consumer Facing a Variable Price Schedule under Uncertainty," *Econometrica*, 1977; 45:641–656.

Keeler, E. B., J. E. Rolph, et al., *The Demand for Episodes of Medical Treatment: Interim Results from the Health Insurance Experiment*, The Rand Corporation, R-2829-HHS, 1982.

Kuderle, R. T., "The Implications of Foreign Dental Coverage for U.S. National Health Insurance," *Journal of Health Politics, Policy and Law*, 1981; 5:653–689.

Maddala, G. S., *Econometrics*, McGraw-Hill Book Company, New York, 1977.

Maddala, G.S., *Limited Dependent, and Qualification Variables in Econometrics*, Cambridge University Press, 1983.

Manning, W. G., C. N. Morris, J. P. Newhouse, et al., "A Two-Part Model of the Demand for Medical Care: Preliminary Results from the Health Insurance Study," in J. van der Gaag and M. Perlman (eds.), *Health, Economics, and Health Economics*, North-Holland Publishing Co., Amsterdam, 1981.

Manning, W. G., Jr., and C. E. Phelps, "The Demand for Dental Care," *Bell Journal of Economics*, 1978a; 10:503–525.

Manning, W. G., Jr., and C. E. Phelps, *Dental Care Demand: Point Estimates and Implications for National Health Insurance*, The Rand Corporation, R-2157-HEW, 1978b.

Manning, W. G., H. L. Bailit, B. Benjamin, and J. P. Newhouse, "The Demand for Dental Care: Evidence from a Randomized Trial in Health Insurance," *Journal of the American Dental Association*, 1985; 110:895–902.

Maurizi, A. R., *Public Policy and the Dental Care Market*, American Enterprise Institute, Washington, D.C., 1975.

McCullogh, P., and J. A. Nelder, *Generalized Linear Models*, Chapman and Hall, London, 1983.

Morris, C. N., "A Finite Selection Model for Experimental Design of the Health Insurance Study," *Journal of Econometrics*, 1979; 11(1):43–61.

Morris, C. N., "Nonresponse Issues in Public Policy Experiments, With Emphasis on the Health Insurance Study," in *Incomplete Data in Sample Surveys*, Vol. 3, Session 7, Academic Press, New York, 1983, pp. 313–325.

Morris, C. N., *Sample Selection in the Health Insurance Experiment: Comparing the Enrolled and Nonenrolled Populations*, The Rand Corporation, N-2354-HHS, 1985.

National Center for Health Statistics, *Dental Visits Volume and Interval Since Last Visit: United States, 1978 and 1979*, DHHS Publication No. (PHS) 82–1566, 1982.

Newhouse, J. P., "A Design for a Health Insurance Experiment," *Inquiry*, 1974; 11:5–27.

Newhouse, J. P., "The Erosion of the Medical Marketplace," in R. Scheffler (ed.), *Advances in Health Economics and Health Services Research*, JAI Press, 1979.

Newhouse, J. P., W. G. Manning, C. N. Morris, et al., "Some Interim Results from a Controlled Trial of Cost Sharing in Health Insurance," *New England Journal of Medicine*, 1981; 305(25):1501–1507. Also, The Rand Corporation, R-2847-HHS, 1982.

Newhouse, J. P., and C. E. Phelps, "New Estimates of Price and Income Elasticities of Medical Care Services," in R. Rosett (ed.), *The Role of Health Insurance in the Health Services Sector*, National Bureau of Economic Research, New York, 1976.

Newhouse, J. P., C. E. Phelps, and M. S. Marquis, "On Having Your Cake and Eating It Too: Econometric Problems in Estimating the Demand for Health Services," *Journal of Econometrics*, 1980; 13(3):365–390.

Newhouse, J. P., C. E. Phelps, and W. B. Schwartz, "Policy Options and Impact of National Health," *New England Journal of Medicine*, 1974; 290(24):1345–1359.

Newhouse, J. P., V. Spolsky, B. Feldman, et al., "Controlled Trial in Dental and Medical Insurance," *Journal of the American Dental Association*, 1983; 106:173–177.

Newman, J., and O. Anderson, *Patterns of Dental Service Utilization in the United States: A Nationwide Social Survey*, Center for Health Administration Studies, University of Chicago, Research Series No. 30, 1972.

Olsen, R., "The Analysis of Two-Variable Models When One of the Variables Is Dichotomous," unpublished manuscript, Economics Department, Yale University, 1975.

Pauly, M. V, "The Economics of Moral Hazard," *American Economic Review*, 1968; 58:231–237.

Phelps, C. E., "Taxing Health Insurance: How Much is Enough?" *Contemporary Issues* (forthcoming). Also, The Rand Corporation, P-6915, 1983.

Phelps, C. E., and J. P. Newhouse, *Coinsurance and the Demand for Medical Services*, The Rand Corporation, R-964-1-OEO/NC, 1974.

Poirier, Dale J., and P. A. Ruud "On the Appropriateness of Endogenous Switching," *Journal of Econometrics*, 1981; 16:249–256.

Rogers, W. H., and J. P. Newhouse, "Measuring Unfiled Claims in the Health Insurance Experiment," in L. Berstein, H. E. Freement, and P. H. Ross (eds.), *Collecting Evaluation Data: Problems and Solutions*, Sage Publications, Beverly Hills, 1985.

Rogers, W. H., "Analyzing Complex Survey Data," unpublished Rand paper, 1983.

Rossiter, L., "Expenditures for Dental Services: Findings from the National Medical Care Expenditure Survey," *Journal of the American Dental Association*, 106:189–193, 1983.

Rowe, N. H., et al., "The Effect of Age, Sex, Race, and Economic Status on Dental Caries Experience of the Permanent Dentition," *Pediatrics*, 1976; 57(4):457–461.

Searle, S. R., *Linear Models*, John Wiley & Sons, Inc., New York, 1971.

Theil, H., *Principles of Econometrics*, John Wiley & Sons, Inc., New York, 1971.

Tobin, J., "Estimation of Relationships for Limited Dependent Variables," *Econometrica*, 1958; 26:24–36.

Upton, C. and W. Silverman, "The Demand for Dental Services," *Journal of Human Resources*, 1972; 7(2):250–261.

U.S. Bureau of the Census, "Money Income in 1973 of Families and Persons in the United States," Series P-60, No. 97, January 1975.

van de Ven, W.P.M.M., and B.M.S. van Praag, "Risk Aversion and Deductibles in Private Health Insurance: Application of an Adjusted Tobit Model to Family Health Care Expenditures," in J. van der Gaag and M. Perlman (eds.), *Health, Economics, and Health Economics*, North-Holland Publishing Company, New York and Amsterdam, 1981.

Zeckhauser, R. J., "Medical Insurance: A Case Study of the Trade-Off Between Risk Spreading and Appropriate Incentives," *Journal of Economic Theory*, 1970; 2:10–26; 1965; 12:63–70.

Zeckhauser, R. J., "The Demand for Deductibles in Private Health Insurance: A Probit Model With Sample Selection," *Journal of Econometrics*, 1981; 17:229–252.

RAND/R-3225-HHS