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An Analysis of Short-Term Alcoholism Treatment Cost Functions

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A number of alcohol treatment studies have documented variations in the average cost of treating alcoholics. However, these studies have provided little explanation for these variations. In this study, three major issues in the measurement of alcoholism treatment costs are investigated: 1) choice of treatment location, i.e., inpatient versus outpatient; 2) interaction of treatment locations in the estimation of costs; 3) impact of type of alcohol problem and comorbidities on treatment costs. The study includes an integrated framework that jointly estimates treatment location and treatment costs conditional on treatment location, concentrating on short-term alcoholism treatment and using insurance claims data to specify a 6-month period beginning with each individual's first treatment for alcoholism. The different treatment types subsumed in the categories *alcohol abuse* and *alcohol dependence* are also addressed. Results indicate that comorbidities are crucial in determining treatment location. Once treatment location is determined, however, their effects on treatment costs, while measurable, are statistically insignificant. Partial treatment effects, conditional on treatment location, differ substantially from full treatment effects, which are determined jointly with treatment location. Key words: alcoholism; comorbidities; costs and cost analysis; treatment location; utilization. (Med Care 1992; 30:795–810)

Previous alcoholism treatment studies have documented differences among alcoholics in the average costs for treatment, but they have not provided a great deal of explanation for these differences. In this study, we investigate three major issues in the measurement of alcoholism treatment costs:

1) Predictors of choice of treatment location, i.e., inpatient versus outpatient;

2) Interaction of treatment locations in the estimation of costs;

3) Impact of type of alcohol problem (abuse or dependence) and various comorbidities on treatment costs.

We address all of these aspects in an integrated framework that estimates jointly the treatment location and the treatment costs, conditional on treatment location. The evaluation concentrates on short-term alcoholism treatment, using insurance claims data to

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specify a 6-month period beginning with each individual's first treatment for alcoholism. (Other studies[1,2] provide a description of the overall analytical approach and a treatment of longer-term alcoholism treatment.) For analytic purposes we treat comorbidities and the type of alcohol problem as independent variables affecting the location of treatment and costs. We recognize, however, that these diagnoses may be affected by the location of care.

We distinguish between *partial* effects and *full* effects. Partial effects are defined as those effects estimated conditional on treatment location. These differ substantially from full effects, which are defined as the combination of partial effects determined jointly with treatment location.

The study begins with a brief review of comorbidities and cost functions. The general model and specific cost functions are then described. The results section focuses on the distinctions between the modeling of treatment location and treatment cost, and distinguishes between partial and the full effects. We close with conclusions and policy implications.

A Brief Review of the Literature

Although there is considerable evidence that alcoholics and their family members use more health care resources and incur higher health care costs than nonalcoholics,[3–6] few studies have systematically considered the factors that contribute to different rates of utilization and costs among alcoholics. Studies focusing on differences in costs between alcoholics and nonalcoholics may overlook the wide variations in costs and utilization among alcoholics.

One possible explanation for varying health care costs among alcoholics is the location where treatment is provided, i.e., inpatient and/or outpatient settings. Several studies have emphasized the cost advantage of the outpatient location, showing that an outpatient setting can provide both treatment of alcoholism[7–8] and detoxification[9–10] at lower cost than the inpatient setting with no difference in outcomes. In an extensive review, Miller and Hester[11] conclude that controlled research consistently shows that inpatient care does not provide better outcomes than outpatient care and that longer lengths of inpatient stay offer no treatment advantages over shorter inpatient stays in terms of outcomes for alcoholics. These outcomes are variously measured as number of medical complications, future social and interpersonal stability, or psychological well-being. While these studies show that costs for the same type of treatment are less at the outpatient setting, they do not consider how treatment location may affect the alcoholism treatment and other health care one receives, or the factors that encourage some people to receive inpatient or outpatient care.

Another possible influence on the health care costs of individuals with alcohol problems is the type of alcohol problem that is being treated. While alcohol abuse and alcohol dependence are sometimes considered as different degrees of severity,[12] research by Hasin et al.[13] suggests that alcohol abuse and alcohol dependence represent distinct conditions with different outcomes. These findings suggest that these two conditions should be analyzed separately in terms of costs of treatment.

Comorbidities may also influence alcoholism treatment costs. It is well established that alcoholism frequently occurs in conjunction with other illnesses.[14–15] Psychiatric and other substance abuse disorders are some of the most frequently noted comorbidities of alcohol problems. Although psychiatric and other substance abuse disorders have been shown to occur with alcohol disorders in community surveys,[16–20] these comorbidities are especially prominent among patients being treated for alcohol disorders.[16,21–25]

The impacts of psychiatric disorders on utilization and costs have not been studied

directly, but these conditions have frequently been examined as potential risk factors for readmission to an inpatient facility by alcoholics or in terms of their impact on outcomes. A number of studies[15,26–27] report poorer outcomes for alcoholics who also have a psychiatric comorbidity. Slater[28] concluded that alcoholics who were rehospitalized had more depression than those who did not receive subsequent inpatient care. However, Booth et al.[29] reported no association between psychological variables and recidivism when severity of alcohol problems was considered. While these studies suggest that alcoholics with psychiatric illnesses and drug problems will experience higher utilization, none of these studies related their findings to the cost of treatment.

In summary, previous research has determined that alcoholics incur higher health care costs than nonalcoholics, and that the setting where health care is provided affects costs. In addition, it has been established that alcoholism is frequently accompanied by other illnesses including psychiatric illnesses and drug abuse. However, the effect of the type of alcohol problem and comorbidities on locus of care or their contribution to the total medical care costs of alcoholics has received little attention.

Methods

Cost Functions

This analysis addresses several issues that can affect the measurement of treatment costs. Specifically, we:

1) estimate cost functions separately for inpatient and outpatient care;

2) model the choice of different locations or combinations of locations and the cost functions, as separate, albeit related, processes;

3) consider the possible influence of comorbidities and different types of alcohol problems on both the treatment choice and the treatment costs;

We characterize the cost function of alcoholism treatment in two stages. The first stage involves the choice of the treatment location. The second, the cost functions, treats the treatment cost as conditional on the treatment location. In each stage, we determine the effect of the type of alcohol problem and the comorbidities. For example, patients diagnosed with certain comorbidities may be much more likely to receive either 1) some inpatient, or 2) outpatient-only treatment. Once in that treatment location, the comorbidity may have little effect on the cost of second stage treatment. Yet, clearly the comorbidity is important in the first stage choice of treatment.

Our model uses two treatment branches to compare individuals who had some inpatient treatment with those who had none. Branch 1 includes inpatient treatment only and mixed inpatient-outpatient treatment; this branch is referred to as *some-inpatient* (SI) care. Branch 2 is *outpatient-only* (OO).

The general cost function of alcoholism treatment is:

$$C = f\,D + (1-f)\,E \qquad (1)$$

where f refers to the probability of outpatient-only treatment, (1−f) to the probability of some-inpatient treatment, D to the costs if outpatient-only treatment is used, and E to the costs if some-inpatient treatment is used. Probability f is estimated in the first stage; costs for the two treatment branches (D and E) are estimated in the second.

The first stage involves treatment choice f. Letting the some-inpatient branch equal 0, and the outpatient-only branch equal 1, then:

$$f = f(M), \qquad (2)$$

where M is the vector of comorbidities. The binomial choice is estimated using logit analyses. (Maddala[30] is a standard reference for discrete choice models such as logit.)

In the second stage of the model we specify cost functions D and E for the two treatment branches. D, or outpatient-only, is specified as:

$$D = D(M, O), \qquad (3)$$

where O is the number of outpatient events. E is the sum of inpatient costs E_I, and outpatient costs E_O, in the some-inpatient treatment branch. It is disaggregated by inpatient events I, and outpatient events O, such that:

4) $E = E_I(M, I, O) + E_O(M, I, O)$.

By substituting (2), (3), and (4) into (1), we get:

5) $C = f(M)D(M, O) + [1 - f(M)][E_I(M, I, O) + E_O(M, I, O)]$.

Total costs, then, are a function of inpatient treatment, I, outpatient treatment O, and comorbidities M. Treatment effects refer to the percent changes in total cost elicited by 1% changes in the amount of treatment. We can derive the following expressions for full treatment effects:‡

6) weighted *full* outpatient treat. effect
$= \text{Prob (OO)} \times (\textit{part.}\ \text{OUT treat. eff.})_D \times (D/C) + \text{Prob (SI)} \times (\textit{part.}\ \text{OUT treat. eff.})_{EO} \times (E_O/C) + \text{Prob (SI)} \times (\textit{part.}\ \text{INP treat. eff.})_{EI} \times (E_I/C)$

7) weighted *full* inpatient treat. effect
$= \text{Prob (SI)} \times (\textit{part.}\ \text{OUT treat. eff.})_{EO} \times (E_O/C) + \text{Prob (SI)} \times (\textit{part.}\ \text{INP treat. eff.})_{EI} \times (E_I/C)$

The weighted effects are interpreted as follows. The full treatment effect in (6) and (7), measured in visits and/or days, is related to:

partial effects on the inpatient D, and the outpatient (E_O and E_I) cost functions,

probability of treatment for each branch, and

the relative costs of D, E_O, and E_I.

Thus, if the probability of treatment for any location in either branch is low, or the relative cost in a location is low, these components will have low weights in calculating the *full* effects.

The full outpatient effect is based on the outpatient care that occurs in both treatment branches. Inpatient events do not enter the outpatient-only cost function, however. Thus neither the cost, nor the probability associated with the outpatient-only treatment branch, is relevant to the estimation of the full inpatient treatment effect.

Comorbidity effects examine the impacts of comorbidities M on treatment costs, and can be interpreted as the presence ($m_i = 1$) or absence ($m_i = 0$) of condition m_i. As noted in (5), comorbidities influence total costs by changing the treatment location (typically from less expensive outpatient to more expensive inpatient locations), or by changing the treatment costs at the chosen location. We measure sizes and directions (+ or −) of comorbidity effects by characterizing the comorbidities and their treatments in the regression analysis.

This analytical framework regarding treatment location should be distinguished from the important statistical concerns regarding selection bias. We note here that *treatment location*, in and of itself, may influence total costs because the underlying treatments differ. *Selection bias* addresses errors that may be correlated with the selection criteria. We address the treatment of selection bias in the following section.

Econometric Methods

This section briefly discusses estimation of the treatment effects. It is crucial to address the joint determination of treatment branch f with the treatment costs D, E_O, and E_I. These are addressed in the Appendix.

For the treatment effects, the costs of the events are aggregated in each period. In each period, each person has numerous treatment events V of various types (e.g., in-

‡ In economic terms, the effects are standard elasticity measures. The full mathematical derivation of these and other measures are available from the senior author on request.

patient i and outpatient o). Increased numbers of events presumably increase total costs. Other variables may include individual-specific demographics M. Estimation of the cost function also requires the capability to detect nonlinearities in the function. We propose a function that uses interactive and quadratic terms. Cost function A, for example, refers to total cost (measured logarithm of dollars) for alcoholism treatment in the treatment period:§

$$8)\quad A = \omega_0 + \omega_i V_i + \omega_o V_o + \theta_{ii} V_i^2 + \theta_{oo} V_o^2 + \theta_{io} V_i V_o + \gamma M + \alpha\lambda + \epsilon$$

In this function, parameters ω relate treatment (numbers of events) to costs, and parameters θ represent interactions among types of visits, and parameters γ represent individual-specific demographics.¶ Variable λ (with coefficient α) represents the correction for selection bias from the treatment location regression. The effect of V_i on A, for example, is determined by differentiating and rearranging the cost function.‖

Although number of visits is an appropriate measure of treatment for outpatient care, number of admissions is not directly comparable for inpatient care, because admissions may vary in length from as few as 1 to as many as 30 days. We therefore measure inpatient use by number of days treated, controlling for the number of admissions. Ignoring other variables, consider the regression:

$$9)\quad A = \alpha_0 + \alpha_1 \text{ days} + \alpha_2 (\text{days/admission}).$$

The effect of number of inpatient days on A is $(\alpha_1 + \alpha_2/\text{admissions}) \times \text{days}$.

§ The logarithmic specification was found preferable to the linear specification, using a Box-Cox test.

¶ The θ terms, indicating the importance of the interactions, are found to be significant in all cases.

‖ Differentiating with respect to V_i yields $(w_i + 2\theta_{ii}V_i + \theta_{io}V_o)$, which is then multiplied (in log form) by V_i to obtain the treatment effect. *All* effects are calculated by adding the effects of 1% changes in V_i and V_o.

Data Sources and Preparation

The study population was identified from health insurance claims of a large Midwestern manufacturing company from January 1980 to June 1987. To ensure comparability, we included only individuals who met these criteria:

1) At least one inpatient or outpatient treatment (by one of a variety of providers) with the International Classification of Diseases, 9th Revision (ICD-9) diagnosis of 303 (alcohol dependence syndrome), 305.0 (alcohol abuse) or 291 (alcoholic psychoses) was received during the study period.

2) An active or retired company employee during the study period.

3) All coverage under a fee for service plan with no services reimbursed by Medicare. Benefits included comprehensive coverage of alcoholism treatment (including 365 inpatient days/year and outpatient services) and did not change during the study period.

There were 873 subjects that met these criteria. They were mostly male (94.5%), hourly (89.6%) workers. The mean age at the time of the first alcoholism treatment was 37.6 years. (More than 75% of the individuals were less than 45 years of age when treatment was initiated.) The majority of the workers were employed in plants located in three different areas in the Midwest. The remaining 20% were employed in a variety of small enterprises scattered throughout the Midwest.

A period of 6 months beginning with the first occurrence of a primary or secondary diagnosis for treatment of alcohol dependence (ICD-9 303), alcohol abuse (ICD-9 305.0), or alcoholic psychosis (ICD-9 291) was defined as the alcoholism treatment period.# The population was divided between those who were treated only for alcohol

The short term should theoretically be the length of the first major treatment episode. Because most initial episodes were 6 months or less in preliminary analysis, we used a 6-month period to encompass the short term. Full episode analysis is beyond the scope of the project, but research in progress considers sensitivity of results to our definition of a short-term episode.

TABLE 1. Monthly Costs and Utilization of Alcoholism Treatment

	Total Costs and Utilization	Alcoholism Treatment Costs and Utilization	Alcoholism as % of Total
All diagnoses			
Inpatient costs	$583	$491	84.22
Outpatient costs	$103	$66	64.08
No. of inpatient days	2.37	2.15	90.72
No. of inpatient admissions	0.14	0.11	78.57
No. of outpatient visits	0.85	0.37	43.53

abuse (19.2%) and those who had dependence or alcoholic psychosis at any time during the 6-month calendar period when they received an alcohol diagnosis (80.8%). Dependence and alcoholic psychoses were combined because the small number of patients with alcoholic psychosis (n = 28) prohibited a separate analysis for this category and because a majority of these individuals (n = 16) also had a diagnosis of dependence.

Costs and utilization were determined for inpatient and outpatient (noninpatient) health care events. An inpatient event consisted of all services provided between and including the first and last dates of a hospital admission that involved at least an overnight stay. Total charges for all of these services represented the costs of that admission.

An outpatient event consisted of all services incurred on the same day as a visit to a hospital outpatient department, emergency room, or provider's office, that did not coincide with an inpatient admission. These outpatient events included all psychiatric care, not associated with an inpatient admission, and same-day hospital stays. Charges for all services incurred on the day of an outpatient visit were included in the cost of that outpatient event. All costs were adjusted to 1985 dollars with the Medical Care Index of the Consumer Price Index.**

Events were also defined with reference to alcoholism treatment. An alcoholism treatment event was defined by a diagnosis code of 303, 305.0, or 291 appearing for any service associated with that event. All other events were considered as nonalcoholism events and excluded from this analysis. Counts of events and charges associated with alcoholism treatments reflect these definitions. We recognize that these may understate the alcoholism incidence as some alcoholics may never receive a formal diagnosis.

Descriptive Analyses

Tables 1 through 3 describe the sample by breaking costs into several categories. Table 1 provides cost and utilization information for each place of service during the alcoholism treatment period. These data show that alcoholism treatment accounted for 84.2% of inpatient charges and 90.7% of inpatient utilization (Inpatient Days), but less than 50% of outpatient utilization (Outpatient Visits), during the treatment period.

Cost functions are modeled as separate processes depending on whether an individual had some-inpatient or outpatient-only treatment.†† Table 2 shows that 59.6% (the sum of the first 2 percentages in column 3) of the study group received inpatient treatment for alcohol dependence or alcohol abuse in the 6 months after the first diagnosis of an alcohol problem. Individuals with an alcohol dependence problem were more

** To compare costs among treatment types it was appropriate to use the same deflator, rather than separate deflators for inpatient and outpatient care.

†† An earlier study[1] considered inpatient and outpatient costs in one equation. *F*-tests on the equality of coefficients of the cost functions indicated that they should be estimated separately. The results are available from the senior author on request.

TABLE 2. Distribution of Individuals by Location of Treatment and Type of Alcohol Problem

	Dependence		Abuse		Total	
Location of Treatment	No.	%	No.	%	No.	%
Inpatient, only	332	47.1	32	19.0	364	41.7
Inpatient and outpatient	144	20.4	12	7.1	156	17.9
Outpatient, only	229	32.5	124	73.8	353	40.4
Total	705	100.0	168	100.0	873	100.0

likely to receive inpatient care than those who were treated only for alcohol abuse (67% and 26%, respectively).

For the comorbidity analysis, individuals were identified depending on the type of alcohol problem and comorbidity which they exhibited during the 6-month calendar period corresponding to their first AT event. Three categories of drug and mental illness comorbidities were considered: drug abuse or drug dependence (ICD-9 codes of 292, 304, 305.1–305.9), nondrug or nonalcoholic psychoses (ICD-9 codes of 290, 293–299), and nonpsychotic mental disorders (ICD-9 codes of 300–302, 306–319). Various combinations of drug and psychiatric comorbidities led to 16 possible categories of treatment for alcohol abuse and dependence.‡‡

Table 3 shows that 36.4% of the population incurred treatment for drug problems or mental disorders during the calendar period corresponding to their diagnosis for an alcohol problem. During this period, slightly more than 5% of the alcoholics were identified with a drug abuse or dependence problem, but no mental disorders; 10% were treated for nonalcohol or nondrug psychosis; and 21% were treated for nonpsychotic mental disorders. (This count includes approximately 3% of the total group who received a diagnosis of drug abuse in addition to a mental disorder diagnosis during this diagnosis period.)

Table 3 also shows how comorbidities are distributed for the two categories of alcohol problems. It suggests that comorbidities occur slightly more often with alcohol dependence than with alcohol abuse. Individuals with dependence exhibit higher rates of both psychosis and drug problems than individuals whose alcohol problems are limited to nondependent abuse.

Results

Prediction of Treatment Location

This section identifies the factors that predict treatment location and determine the probability of some-inpatient or outpatient-only treatment. Table 4 shows the choice of treatment location estimated with a binomial logit model. Predictors include type of alcohol problem (abuse or dependence), drug and psychiatric comorbidities, chronological time period when alcoholism treatment began, age, sex, and employee group (wage or salaried).

The presence of an abuse diagnosis (ALCABU = 1) indicates a higher probability of outpatient-only treatment (positive coefficient in the logit). Holding ALCABU (the type of alcohol problem) constant, we then address comorbidities. Patients with drug problems or psychosis diagnoses have significantly higher probabilities of assignment to inpatient treatment (significantly negative coefficients). Age, sex, and group do not significantly affect treatment location. The chronological time within the study period

‡‡ Two other categories of comorbidities were used as controls in the analysis. Chronic liver disease (DLIVER) was defined by ICD-9 code 571. DALCREL consisted of pellagra (265.2), alcoholic polyneuropathy (357.5), alcoholic cardiomyopathy (425.5), alcoholic gastritis (535.3), or portal hypertension (572.3) incurred at any time during the treatment period.

TABLE 3. Number and Percent of Individuals by Type of Alcohol Problem and Comorbidity Category

Comorbidity Category	Dependence		Abuse		Total	
	No.	%	No.	%	No.	%
No comorbidity	447	62.96	112	66.27	559	63.59
Drug	40	5.63	5	2.96	45	5.12
Psychosis	35	4.93	2	1.18	37	4.21
Psychosis and other mental	34	4.79	10	5.92	44	5.01
Other mental disorder	129	18.17	37	21.89	166	18.89
Drug and psychosis	2	0.28	0	0.00	2	0.23
Drug, psychosis, other mental	6	0.85	0	0.00	6	0.68
Drug and other mental disorder	17	2.39	3	1.78	20	2.28
Total	710	100.00	169	100.00	879	100.00

when the first alcoholism treatment occurred (higher value of ATPER refers to a late classification) has a significant coefficient. This suggests that patients whose first diagnosis of an alcohol problem occurred early in the study period were more likely to be hospitalized than those whose first diagnoses were late in the study period. Inserting the variable means into the logit equation leads to probabilities of 0.399 for outpatient-only and 0.601 for some-inpatient treatment.

Cost Functions

After determining treatment location, we estimate cost functions for the two treatment branches (Table 5). Inpatient and outpatient cost functions are estimated separately for the some-inpatient branch and an outpatient cost function is estimated for the outpatient-only branch. The dependent variable is the logarithm of total costs and the explanatory variables include the number of events and events squared, the type of alcohol problem, comorbidities, and sociodemographic characteristics.

TABLE 4. Logit Regression for Treatment Location

Variable	Coefficient	T-Ratio
ONE	−0.48136	−0.951
ALCABU	1.67521	8.465[a]
DDRUG	−0.97062	−3.688[a]
DPSYCH1	−0.80252	−2.901[a]
DPSYCH2	−0.20877	−1.118
DLIVER	−1.09907	−1.838[b]
DALCREL	−0.70782	−0.885
ATPER	0.06628	3.277[a]
AGE	−0.00812	−0.952
SEX	0.05054	0.146
GROUP	−0.13380	−0.538
Log-likelihood	−522.02	

[a] Significant at 0.01 level.
[b] Significant at 0.10 level.

Consider first the equation of outpatient costs in the outpatient-only treatment branch (Regression 1). The R^2 is 0.338. Numbers of outpatient visits are significant, both linearly and quadratically. The selection parameter λ is significant at the 0.10 level, indicating the necessity of our correction. Conditional on receiving outpatient-only treatment, only drug abuse, among all comorbidities, has significant cost impacts.

Cost functions for inpatient and outpatient care in the branch with some-inpatient treatment are also estimated in Table 5 (Regressions 2 and 3). The inpatient cost regression (Regression 2) has an R^2 of 0.701. The numbers of inpatient admissions, the number of days, and days per visit are significant. None of the comorbidities are significant and there is no indication of selection bias. The outpatient cost regression in this treatment branch has explanatory power similar to the inpatient regression (R^2 = 0.787); again, there is no indication of selection bias. With the exception of psychosis,

TABLE 5. Cost Regressions for Alcoholism Treatment

Regression 1 – Outpatient Only			Regression 2 – SI Inpatient			Regression 3 – SI Outpatient	
Variable	Coefficient	T-ratio	Variable	Coefficient	T-ratio	Coefficient	T-ratio
LAMBDA	−3.87802	−1.793[a]	LAMBDA	−0.57625	−0.675	−1.78494	−0.807
ONE	9.06712	4.096[b]	ONE	5.95447	10.096[b]	−0.09166	−0.060
AOV2	0.29292	8.492[b]	AIV2	1.19217	5.154[b]	2.44320	4.072[b]
AOV2S	−0.00790	−4.423[b]	AIV2S	−0.10436	−2.437[c]	−0.30413	−2.739[b]
ALCABU	−3.02445	−2.295[c]	AOV2	0.03239	1.322	1.87407	29.476[b]
DLIVER	1.13288	1.046	AOV2S	−0.00253	−1.779[a]	−0.08696	−23.536[b]
ATPER	−0.10237	−1.848[a]	AIOV2	−0.00751	−0.617	−0.08582	−2.717[b]
DDRUG	2.07179	2.290[c]	ALCABU	0.27039	0.488	1.17157	0.815
DPSYCH1	1.18386	1.154	ADDAYS	−0.01442	−1.947[a]	−0.04832	−2.515[c]
DPSYCH2	0.08205	0.342	ADDPV	0.07458	9.298[b]	0.04898	2.354[c]
DALCREL	0.06358	0.059	ATPER	0.03525	1.800[a]	0.03202	0.630
AGE	0.01104	1.142	DDRUG	−0.11646	−0.468	−0.39711	−0.615
SEX	0.02114	0.078	DPSYCH1	0.04955	0.235	−0.67857	−1.905[a]
GROUP	0.09873	0.426	DPSYCH2	0.08541	1.065	0.12352	0.594
			DALCREL	−0.10217	−0.405	−0.67117	−1.025
			DLIVER	0.09892	0.347	−0.84169	−1.182
			AGE	0.00254	0.761	−0.00758	−0.874
			SEX	−0.05448	−0.552	−0.28806	−1.126
			GROUP	−0.03953	−0.457	−0.28400	−1.265
N	353		N	520		520	
R^2	0.338		R^2	0.701		0.787	

[a] Significant at 0.10 level.
[b] Significant at 0.01 level.
[c] Significant at 0.05 level.

none of the comorbidities are significant. Thus, although drug and psychiatric comorbidities contributed to the choice of treatment location, they had insignificant effects on the costs, *given* treatment location.

Partial Effects

This section presents the partial effects of treatment on costs for alcohol abuse and alcohol dependence in each treatment branch. (The regressions from Table 5 did not distinguish by type of alcohol problem, measuring utilization by the total number of outpatient visits and inpatient days.) Because utilization varies for alcohol abuse and alcohol dependence, total costs and treatment effects are calculated separately for these two types of alcohol problems. Table 6 provides the utilization figures that are used in these calculations.

Table 7 begins with a baseline case with no confounding comorbidities. A 1% increase in treatment in the outpatient-only branch for someone with alcohol dependence implies a 0.899% increase in outpatient costs, evaluated at the mean of 3.60 events. For alcohol abuse a 1% increase implies a 0.850% increase in outpatient costs, using a mean of 3.88 events. These partial effects, conditional on treatment location, suggest slightly decreasing average costs as

TABLE 6. Mean Utilization by Treatment Location and Type of Alcohol Problem

	Abuse	Dependence
Outpatient visits		
Outpatient only	3.605	3.878
Outpatient and inpatient	0.500	1.155
Inpatient admissions	1.136	1.137
Inpatient days	16.727	21.805
Days/admission	15.045	20.239

TABLE 7. Calculation of Total Effects

	Dependence	Abuse
Expected costs		
Some inpatient		
Inpatient costs	$3,621.94	$2,286.39
Outpatient costs	$5.56	$1.61
Outpatient only	$391.17	$177.88
Total	$2,381.31	$663.66
Probabilities		
Some inpatient	0.6149	0.2302
Outpatient only	0.3851	0.7698
Partial effects		
Outpatient-only branch		
Effect of outpatient care on outpatient costs	0.899	0.850
Some-inpatient branch		
Effect of inpatient care on inpatient costs	1.116	0.857
Effect of outpatient care on outpatient costs	1.820	0.845
Effect of inpatient care on outpatient costs	−0.114	−0.087
Effect of outpatient care on inpatient costs	0.021	0.011
Full effects		
Effect of inpatient treatment on total costs	1.044	0.679
Effect of outpatient treatment on total costs	0.079	0.184
Total effect	1.123	0.864

the number of outpatient visits increases. That is, a 1% increase in the number of outpatient visits leads to less than a 1% increase in total costs.

Regression parameters from Table 5 (Regressions 2 and 3) are used for the inpatient and outpatient cost functions for the some-inpatient treatment branch. With an abuse diagnosis a 1% increase in inpatient treatment increases inpatient costs by 0.857%. A 1% increase in outpatient visits for abuse increases outpatient costs by 0.845%. These partial effects suggest that average costs, under an abuse diagnosis, decrease as treatment increases.

The partial treatment effects for alcohol dependence indicate a somewhat different pattern than is shown for abuse. A 1% increase in inpatient care increases inpatient costs by 1.116%, and a 1% increase in outpatient visits increases outpatient costs by 1.820%. Therefore, both average inpatient costs and average outpatient costs increase as treatment increases.

Full Effects

The calculation of full treatment effects for inpatient and outpatient treatment as described by equations (6) and (7) is also presented in Table 7. These calculations depend on the partial effects described above, the probabilities of being in either some-inpatient or outpatient-only treatment, and predicted costs.

For dependence, the predicted costs (in 1985 dollars) of inpatient and outpatient treatment in the some-inpatient branch are $3,621.94 and $5.56 (implying minimal use of outpatient care in the some-inpatient branch). In the outpatient-only treatment branch, predicted costs are $391.17. The total predicted cost of $2,381.31 is the weighted sum from equation (1), where the weights are the probabilities of being in each branch (0.385 and 0.615).

A 1% increase in outpatient treatment increases *total* costs by only 0.079% while a similar increase in inpatient admissions increases total costs by 1.044%. A 1% increase in both inpatient and outpatient treatment (an increase of 1% in total events) implies a cost increase equal to the sum of the two, or 1.123%. The small effect of outpatient treatment in this example reflects a relatively small (0.385) probability of being in the outpatient-only treatment branch, and the relatively small contributions of $391.17 and $5.56 to total costs for outpatient care, compared to the probability of 0.615 and costs of $3,621.94 associated with inpatient care. Thus, changes in outpatient costs and the outpatient treatment effects have little importance in the determination of full effects.

Next, we compare full effects under an abuse diagnosis with those just presented for a dependence diagnosis. The predicted

costs for abuse (again in 1985 dollars) are $2,286.39 and $1.61 in the inpatient treatment branch and $177.88 in the outpatient-only branch. The resulting $663.66 is the weighted sum as noted in equation (1). The partial effects and the probabilities of being in the outpatient-only (0.770), and some-inpatient treatment branches (0.230) are used in this calculation. A 1% increase in outpatient and inpatient utilization for abuse treatment increases total costs at these 2 settings by 0.184% and 0.679%, respectively. A 1% increase in both, or a 1% increase in the total number of events, implies a 0.864% increase in total costs. The larger full outpatient effect for abuse reflects both the higher probability of being in the outpatient-only branch (0.770) and its larger share of total treatment cost.

These results suggest that short-term alcoholism treatment is cheaper (less than 30% of the cost) for persons with an abuse diagnosis, than for those with a dependence diagnosis. With abuse, the less expensive outpatient care is often used instead of inpatient care. Abuse also yields decreasing average costs as utilization increases. With abuse the total effect of 0.864 implies an 8.6% increase in total costs, given a 10% increase in utilization. This contrasts with the total effect of 1.123 for treatment of a dependence diagnosis, an 11.2% increase in total costs, given a 10% increase in utilization.

The different measures for abuse and dependence suggest aggregation problems when measuring costs. Recall that the full treatment effect for abuse was 0.864, and for dependence, 1.123. One can rewrite the cost function T as:

$$10) \qquad T = h[AB] + (1 - h)[DE]$$

where AB is cost for abuse treatment and DE is cost for dependence treatment. Parameter h (1−h) represents probability, or frequency, of abuse (dependence) treatment. Similarly to equations (6) and (7), we can derive the effect of events x on total costs T for abuse or dependence (available from the senior author on request).

Substituting from the worksheet in Table 7 yields a total treatment effect of 1.107 for alcoholism treatment, regardless of the type of alcohol problem. This lies between the abuse effect of 0.864 and the dependence effect of 1.123. It is closer to the latter because dependence is more frequently diagnosed and is costlier to treat; hence the weights are higher.

This decomposition indicates the analytical problems of aggregating abuse and dependence. We have noted that abuse has slightly decreasing average costs, and that dependence has slightly increasing average costs. Aggregating them implies mistakenly that alcoholism treatment leads to increasing average costs, and hence any treatment leads to incrementally higher costs. This is not the case, however.

Impacts of Comorbidities

This section investigates the impacts of differing comorbidities on treatment location and costs. (Although we consider treatment location and costs as dependent on diagnosis, we recognize that patients who receive only outpatient care may be more likely to be given alcohol abuse diagnoses. Determining whether diagnosis drives treatment or treatment drives diagnosis is beyond the scope of this research.) Comorbidities are treated as binary (0, 1) variables and compared with the baseline case when no comorbidity is present, which was discussed above. Intensity of treatment is controlled by holding constant both the number of events and the length of the admission for inpatient care. Differences between costs may then be attributed jointly to the type of comorbidity and to the intensity of the treatment.

Table 8 introduces the drug abuse/dependence comorbidity DDRUGP. Probabilities are calculated from the logit regression in Table 4. The probability of some-inpa-

TABLE 8. Total Treatment Effects and Expected Costs for Alcoholism Treatment

Period 2 Diagnoses	Total Treatment Effect	Probability of Inpatient Treatment	Total Treatment Costs ($)	Expected Inpatient Costs ($)	Expected Outpatient Costs ($)
No comorbidities					
Abuse, only	0.864	0.230	663.66	526.36	137.30
Dependence	1.123	0.615	2,381.32	2,227.27	154.05
Drug diagnoses					
Abuse, only	0.864	0.441	1,383.20	1,145.72	237.48
Dependence	1.129	0.808	3,187.37	3,069.95	117.42
Drug and psychoses					
Abuse, only	0.866	0.638	2,219.40	2,078.43	140.97
Dependence	1.135	0.904	3,982.78	3,931.93	50.84

tient treatment in the presence of drug dependence increases from 0.230 for alcohol abuse without a comorbidity, to 0.441 for abuse with the drug comorbidity. With alcohol dependence, the increase is from 0.615 to 0.808. The introduction of a drug diagnosis raises costs from $663.66 to $1,383.20 for abuse and from $2,381.32 to $3,187.37 for dependence.

Interestingly enough, total treatment effects hardly change with the introduction of a drug comorbidity even though their component parts do. Because inpatient care is considerably more expensive than outpatient care, a shift toward more care involving some-inpatient treatment leads measured effects to approach the values of 0.857 for alcohol abuse, and 1.116 for alcohol dependence, which are displayed in Table 7. As a result, even though the incidences of care and the total costs change, the total effects change little.§§ Irrespective of the incidence of comorbidities, abuse diagnoses are related to decreasing average cost treatment; dependence diagnoses are related to increasing average cost treatment.

Another comparison examines the effect of a psychosis DPSYCH1 when it is introduced *in addition to* drug diagnoses for both abuse and dependence diagnoses. The probability of receiving some-inpatient treatment again increases for both abuse (from 0.441 to 0.638) and dependence (from 0.808 to 0.904). Costs also increase from $1,383.20 to $2,219.40 for abuse and from $3,187.37 to $3,982.78 for dependence. For this analysis we combine equations (1) and (4) to get:

$$11) \quad C = [fD + (1 - f)E_0] + [(1 - f)E_1]$$

The first term in the square brackets can be interpreted as *expected outpatient costs* (probability of utilization multiplied by predicted costs), and the second term can be interpreted as *expected inpatient costs*.

With more comorbidities, the probability of outpatient-only treatment falls; hence there is a higher weight on inpatient and outpatient costs in the branch with *some-inpatient care* and a lower weight on costs in the *outpatient-only* branch. Because inpatient costs are generally much larger than outpatient costs in either branch, and because outpatient costs in the branch with *some-inpatient care are* typically less than costs in the *outpatient-only* branch, the increased probability of inpatient care leads to a relative and absolute decrease in *expected outpatient* costs.

Note, for example, that the addition of drug and psychosis diagnoses increase expected inpatient costs (in the case of abuse, from $526.36 to $2,078.43) but that ex-

§§ This is most apparent at the initiation of alcoholism treatment, when inpatient treatment is more probably relative to outpatient care. Full treatment effects vary considerably more in the long term for both alcoholism and nonalcoholism treatments.

pected outpatient costs remain virtually constant (moving from $137.30 to $140.75), and their share of total costs falls. The difference is more severe for dependence: the addition of drug and psychoses diagnoses increase expected inpatient costs from $2,227.27 to $3,931.93, but *reduce* expected outpatient costs from $154.05 to $50.84.

Conclusions and Observations

This study provides a unified framework for estimating alcoholism treatment location, short-term alcoholism treatment costs, and the associated effects. The method involves the two-stage modeling of treatment location and treatment costs, with specific attention directed toward the characterization of comorbidities occurring jointly with alcoholism treatment.

The two-stage analysis identified several variables that are related to the costs of alcohol treatment only through their influence on the choice of a treatment location. A diagnosis of dependence, psychiatric and drug comorbidities, and the initiation of alcoholism treatment early in the study period all increase the likelihood of inpatient treatment, with its higher costs. Once in a treatment branch (some-inpatient or outpatient-only) these variables have little effect on cost.

These findings point to the need for further research about how the diagnosis of comorbidity and type of alcohol problem (abuse vs. dependence) is related to decisions about the location of care. Two hypotheses might be considered. First, a history of mental illness and drug problems may, in itself, encourage providers to hospitalize patients. For example, the National Association of Private Psychiatric Hospitals[31] lists social and personal instability and psychiatric problems as criteria for inpatient treatment for alcoholism. The outpatient setting, on the other hand, is more appropriate for persons with stable social and personal characteristics.

A second hypothesis is that comorbidities are more likely to be diagnosed as part of the treatment when hospitalized than when receiving outpatient care. With opportunities to observe patients 24 hours a day, a well-trained hospital staff may identify symptoms not recognized in outpatient treatment that involves fewer hours of observation. Comorbidities may also represent transient symptoms associated with acute intoxication stages of inpatient treatment[32] that are less likely to occur during outpatient treatment.

Our results confirm that the type of alcohol problem is a major contributing factor to treatment costs through its association with treatment location. An alcohol dependence diagnosis is much more likely to be associated with inpatient treatment and thus with higher treatment costs. A mental disorder and/or drug abuse comorbidity with the alcoholism have additional impact on this relationship. Such comorbidities, through their joint impacts on treatment location and subsequent costs, increase expected alcoholism treatment costs by as much as 72% to 88% (depending on the comorbidity) for abuse, and 22% to 28% (from a much higher base) for alcohol dependence.

It is important to disaggregate an analysis by the type of alcohol problem, abuse or dependence. Failing to disaggregate can lead to incorrect inferences about the overall costs of treatment. In the short term covered by this analysis, abuse has slightly decreasing average costs and dependence has slightly increasing average costs. Treating dependence and abuse as one category would imply mistakenly that all alcoholism treatment leads to increasing average costs when this is not true for abuse.

It is surely not surprising that treatment for dependence is considerably more costly than treatment for abuse. The location decision is most heavily influenced by this diagnosis; abuse implies outpatient treatment only, whereas dependence is more likely to require some-inpatient treatment. Not only

is the dependence (and by implication, inpatient) treatment more costly, but the inpatient costs also increase at higher rates than do outpatient costs. These findings alone are reason to urge that, where severity of the condition permits, outpatient settings be substituted for inpatient settings.

Comorbidities raise the probability of both inpatient treatment and of increased treatment costs. Starting with abuse or dependence, comorbidities increase costs by between $500 and $1,500 for the 6-month period alone. Research in progress addresses whether the comorbidities increase costs for same-period nonalcoholism treatment and/or subsequent alcoholism and nonalcoholism treatment. It also considers the comorbidity-related linkages between the incidence and costs of short-term and long-term treatment.

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References

1. Goodman AC, Holder HD, Nishiura E. Alcoholism treatment offset effects: A cost model. Inquiry 1991;28:117.

2. Goodman AC, Holder HD, Nishiura E, et al. Long Term Treatment Cost Functions. Detroit, MI: Wayne State University, 1991.

3. Hankin JR, Oktay JS. Mental Disorder and Primary Care: An Analytical Review of the Literature. Washington, DC: National Institute of Mental Health, DHEW publication no. ADM 78-661, 1979. (National Institute of Mental Health Series D).

4. Holder HD, Hallan JB. Impact of alcoholism treatment on total health care costs: A six-year study. Adv Alcohol Subst Abuse 1986:6:1.

5. Holder HD, Blose JO. Alcoholism treatment and total health care utilization and costs: A 4 year longitudinal analysis of federal employees. JAMA 1986;256:1456.

6. Forsythe AB, Griffiths B, Reiff S. Comparison of utilization of medical services by alcoholics and nonalcoholics. Am J Public Health 1982;72:600.

7. McLachlan JFC, Stein RL. Evaluation of a day cLinic of alcoholics. J Stud Alcohol 1982;43:261.

8. Longabaugh R, McCrady B, Fink E, et al. Cost effectiveness of alcoholism treatment in partial vs inpatient settings. J Stud Alcohol 1983;44:1049.

9. Hayashida M, Alterman AI, McLellan AT, et al. Comparative effectiveness and costs of inpatient and outpatient detoxification of patients with mild to moderate alcohol withdrawal syndrome. New Engl J Med 1989;320:358.

10. Beshai NN. Providing cost efficient detoxification services to alcoholic patients. Public Health Rep 1990;105:475.

11. Miller WR, Hester RK. Inpatient alcoholism treatment: who benefits? Am Psychol 1986;41:794.

12. Wallen J. Case mix and treatment patterns of Medicaid and privately insured psychiatric patients in short-term general hospitals. U.S. Department of HHS, NCHSR and Health Care Technology Assessment, Hospital Studies Program, 1986. Washington, DC: U.S. Department of Health and Human Survices, DHHS publication no. (PHS) 87-3402. (Hospital Cost and Utilization Project Research Note 9).

13. Hasin DS, Grant BF, Endicott J. The natural history of alcohol abuse: Implications for definitions of alcohol use disorders. Am J Psychiatry 1990;147:1537.

14. Stinson FS, Williams GD, Bertolucci D, et al. Alcohol-related morbidity, 1979–1984. Alcohol Health Res World 1986/87;11:56.

15. Mendelson JH, Babor TF, Mello NI, et al. Alcoholism and prevalence of medical and psychiatric disorders. J Stud Alcohol 1986;47:361.

16. Regier DA, Farmer ME, Rae DS, et al. Comorbidity of mental disorders with alcohol and other drug abuse. JAMA 1990;264:2511.

17. Robins LN, Helzer JE, Przybeck TR, et al. Alcohol disorders in the community: a report from the epidemiologic catchment area. In: Rose RM, Barrett J, eds. Alcoholism: Origins and Outcome. New York: Raven Press, Ltd, 1988.

18. Helzer HE, Przybeck TR. The co-occurrence of alcoholism with other psychiatric disorders in the general population and its impact on treatment. J Stud Alcohol 1988;49:219.

19. Bromet EJ, Parkinson DK, Curtis C, et al. Epidemiology of depression and alcohol abuse/dependence in a professional and managerial work force. J Occup Med 1990;32:989.

20. Gelberg L, Linn LS, Leake BD. Mental health, alcohol and drug use, and criminal history among homeless adults. Am J Psychiatry 1988;145:191.

21. Hasin DS, Grant BF, Endicott J. Severity of alcohol dependence and social/occupational problems: relationship to clinical and familial history. Alcohol Clin Exper Res 1988;12:660.

22. Putnam SL. Alcoholism morbidity and careseeking: the inpatient and ambulatory service utilization and associated illness experience of alcoholics and matched controls in a health maintenance organization. Med Care 1982;20:97.

23. Johannessen DJ, Cowley DS, Walker RD, et al. Prevalance, Onset, and Clinical Recognition of Panic States in Hospitalized Male Alcoholics. Am J Psychiatry 1989;146:1201.

24. Ross HE, Glaser FB, Germanson T. The preva-

lence of psychiatric disorders in patients with alcohol and other drug problems. Arch Gen Psychiatry 1988;45:1023.

25. Powell BJ, Penick EC, Othmer E, et al. Prevalance of additional psychiatric syndrome among male alcoholics. J Clin Psychiatry 1982;43:404.

26. McLellan AT, Luborsky L, Woody GE, et al. Predicting response to alcohol and drug abuse treatments: role of psychiatric severity. Arch Gen Psychiatry 1983;40:620.

27. Rounsaville BJ, Dolinsky ZS, Babor TF, et al. Psychopathology as a predictor of treatment outcome in alcoholics. Arch Gen Psychiatry, 1987;44:505.

28. Slater EJ, Linn MW. Predictors of rehospitalization in a male alcoholic population. Am J Drug Alcohol Abuse 1983;9:211.

29. Booth BM, Yates WR, Petty F, et al. Patient factors predicting early alcohol-related readmissions for alcoholics: role of alcoholism severity and psychiatric comorbidity. J Stud Alcohol 1991;52:37.

30. Maddala GS. Limited Dependent and Qualitative Variables in Econometrics. New York: Cambridge University Press, 1983.

31. National Association of Private Psychiatric Hospitals Task Force on Alcoholism, National Association of Private Psychiatric Hospitals. White paper on inpatient treatment for alcoholism. The Psychiatric Hosp 1989;20:129.

32. Brown SA, Shuckit MA. Changes in depression among abstinent alcoholics. J Stud Alcohol 1988; 49:412.

Appendix A. The Two Stage Estimation of Treatment Location and Treatment Costs

The two-stage estimation model is written as follows:

$$f = \alpha M + \epsilon_1 \tag{A.1}$$

$$D = \beta_0 V_0 + \beta_1 M + \epsilon_2 \tag{A.2}$$

$$E_0 = \delta_0 V_0 + \delta_1 V_0 V_i + \delta_3 M + \epsilon_3 \tag{A.3}$$

$$E_I = \zeta_1 V_0 + \zeta_2 V_i + \zeta_3 V_0 V_i + \zeta_4 M + \epsilon_4 \tag{A.4}$$

The major econometric problem here involves the possible correlation of error term ϵ_1, from the selection equation, with error terms ϵ_2, ϵ_3, or ϵ_4. Heckman's well-known exposition notes that failure to address this problem can lead to biased estimation of parameters in the second stage of the analysis, and provides a method to address the selection bias problem. We use his method as discussed in Maddala[30] in testing for such selection bias.

Appendix B. Variable Glossary

LAMBDA, λ	Selection factor
ONE	Intercept
AIV2	Number of inpatient visits for alcoholism treatment in study period.
AIV2S	Number of inpatient visits *squared.*
AOV2	Number of outpatient visits for alcoholism treatment in study period.
AOV2S	Number of outpatient visits for alcoholism treatment in study period *squared.*
AIOV2	Product of inpatient and outpatient visits for alcoholism treatment in study period.
ALCABU	Type of alcohol problem during study period. 0 = Dependence (ICD-9 303) or Alcoholic Psychosis (ICD-9 291); 1 = only alcohol abuse (ICD-9 305.0).
ADDAYS	Number of hospital days for alcoholism treatment during study period.
ADDPV	Average number of days per hospital stay for alcoholism treatment.
ATPER	Chronological 6-month period (1–15) from January 1, 1980 to July 1, 1987 of first alcoholism treatment.
DDRUG	Drug diagnoses (ICD-9 292, 304, 305.1–305.9) at any time during study period.
DPSYCH1	Nondrug or nonalcoholic psychosis (ICD-9 290, 293–299) at any time during study period.
DPSYCH2	Other mental disorder diagnosis at any time during study period.
DLIVER	Chronic liver disease and cirrhosis (ICD-9 571) at any time during study period.
DALCREL	Other alcoholic-related diagnoses (ICD-9 265.2, 357.5, 425.5, 535.3, 572.3) during study period.
AGE	Age at first alcoholism treatment in study period.
SEX	1 = Male, 0 = Female
GROUP	Employee segment: 1 = Wage, 0 = Salary