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Chronic Illness, Treatment Choice and Workforce Participation

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Choices with respect to labor force participation and medical treatment are increasingly intertwined. Technological advances present patients with new choices and may facilitate continued employment for the growing number of chronically ill individuals. We examine joint work/treatment decisions of end stage renal disease patients, a group for whom these tradeoffs are particularly salient. Using a simultaneous equations probit model, we find that treatment choice is a significant predictor of employment status. However, the effect size is considerably smaller than in models that do not consider the joint nature of these choices.

Keywords: chronic illness, end-stage renal disease, labor force participation

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Introduction

A substantial body of literature has examined interactions between health and the labor market (see Currie and Madrian, 1999, for a review). However, the role of medical care

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in influencing labor market outcomes has received relatively little attention outside the literature on the cost-effectiveness of medical interventions. Even papers that have used instrumental variables techniques to address the endogeneity of health (e.g., Lee, 1982; Haveman et al., 1994; Ettner et al., 1997; Ettner, 2000) have not analyzed how the choice among available medical treatments or the change in available treatments over time can mediate the effects of health on outcomes such as labor force participation, wages, earnings, and hours.

Given the increasing number of individuals with chronic illness and the proliferation of treatment options, the importance of the inter-relationship between treatment choices and employment will continue to grow. For example, projections suggest that the number of individuals suffering from chronic illness will grow from 125 million in 2000 (accounting for 75 percent of health care spending) to 157 million in 2020 (accounting for 80 percent of health care spending) (Wu and Green, 2000). During this period, medical advances such as organ transplantation, minimally invasive surgical techniques, and new drug therapies will present chronically ill patients with new choices that may facilitate labor force participation.

As medical and labor market choices have become increasingly intertwined, policy makers have reacted accordingly. For example, the Americans with Disabilities Act of 1990 requires employers to make "reasonable" accommodations for their workers with health limitations. Likewise, work incentives exist both in the Social Security Disability Insurance (SSDI) program (a 9 month period in which labor market earnings do not reduce benefits and deduction of work-related health expenditures from countable income) and in the Supplemental Security Income (SSI) program (continuation of Medicaid eligibility and less than dollar-for-dollar benefit reductions for beneficiaries with labor market earnings).

In this paper we focus on the extent to which treatment decisions affect labor force participation. Because treatment decisions are specific to clinical conditions, a meaningful analysis of the interactions between treatment and labor market decisions requires a focus on persons with a particular diagnosis. Thus, the analysis is confined to patients with End Stage Renal Disease (ESRD; chronic kidney failure), an area where these choices are particularly relevant and data are well suited for the analysis. Some dialysis methods allow more flexible treatment scheduling to accommodate work or other activities. Thus, it is likely that the desire to work influences the choice of treatment method and vice versa. To address the potential endogeneity of treatment choice and employment, we estimate a simultaneous probit model using instrumental variables to control for the joint nature of these decisions.

The remainder of this paper is organized as follows: a description of employment patterns among ESRD patients, data, methods, results, and the discussion and conclusions.

Employment and Treatment Choices among ESRD Patients

End stage renal disease provides a prime example of a population where employment decisions in the presence of a severe, chronic illness are quite salient. In 1997, there were 378,862 ESRD patients in the United States, 71 percent of which were treated with dialysis (USRDS, 2002). The percentage of patients working drops precipitously upon initiation of dialysis. One study reported that 73 percent of patients worked prior to beginning dialysis but only 24 percent continued to work afterward despite the fact that a non-trivial minority of the non-workers reported being willing and able work (Curtin, Oberley and Sacksteder, 1996). These patients face a variety of impediments to employment including poor physical or emotional functioning, coexisting diseases, concern over loss of benefits relative to earning potential, and, perhaps most importantly, the rigors of undergoing dialysis. The choice of a mode of dialysis can significantly affect the ability to work. Peritoneal dialysis (PD), one form of which requires several daily exchanges of dialysis fluid performed by patients themselves while other forms allow overnight home treatments, is relatively more flexible than in-center hemodialysis (HD). HD typically requires three weekly sessions lasting 3 to 4 hours each. Unlike in-center HD, PD does not require travel to a dialysis center for long treatments and is therefore less likely to disrupt a patient's work schedule. Daily PD treatments can be scheduled, to a degree, around work and other activities on a day-to-day basis at the discretion of the patient.

Not only is ESRD a relatively common disabling condition, but it is also very costly to treat. A diagnosis of ESRD automatically entitles an individual, regardless of age, to Medicare health insurance coverage under the program's disability provisions. Medicare payments per patient year averaged $46,691 in 2000 and totaled $12.4 billion nationwide (USRDS, 2002). The share of total Medicare spending devoted to ESRD patients rose from 4.5 percent in 1991 to 5.8 percent in 2000 (USRDS, 2002). In an attempt to shift more of the costs of ESRD care onto the private sector, Congress recently extended the period during which Medicare would be the secondary insurer from 18 to 30 months for ESRD patients who have employer provided, group health insurance. This policy relies on the ability and willingness of ESRD patients to gain and maintain employment. Further, the total Medicare spending per PD patient was 15% lower than spending per HD patient (USRDS, 2002). Although part of this difference likely reflects the selection of somewhat healthier patients into PD, it also reflects efficiencies such as the lower need for expensive, anti-anemia medication among PD patients. Thus, treatment choice has direct cost implications aside from its impact on employment.

Previous research on employment of dialysis patients has appeared primarily in the medical literature (e.g., Wolcott and Nissenson, 1988; Julius et al., 1989; Kutner, Borgan and Fielding, 1991; Holley and Nespor, 1994; Curtin, Oberley and Sacksteder, 1996). Most of these studies find that PD patients are more likely to be employed than HD patients. However, the literature has ignored the endogeneity of treatment choice despite the likelihood that patients who desire employment tend to choose PD. Thus, no causal inference can be drawn and the literature cannot inform efforts to improve the availability of PD. Further, most of this literature has considered the role of earnings potential only indirectly through the effects of variables such as education.

Data

The data for this study were derived from Wave II of the United States Renal Data System's (USRDS) Dialysis Morbidity and Mortality Study (DMMS-II). This survey, funded by the National Institutes of Health, was administered during 1996. The sample is designed to be representative of all incident (newly treated) dialysis patients in the United States during 1996. Twenty five percent of all U.S. dialysis units were randomly chosen. Within each chosen unit, a random sample of patients over the age of 18 who initiated chronic dialysis treatment during 1996 was drawn. Treatment modality (HD or PD) was defined on the 60th day following the initiation of dialysis, consistent with the conventional clinical definition of the initial stable dialysis modality. 4011 patients were included. For each patient, a set of core clinical and demographic information was abstracted from medical records. In addition, each patient was given a lengthy survey which included items on quality of life, pre-dialysis medical care, choice of dialysis modality, and employment. For a detailed description of DMMS-II, see USRDS (1997).

Patients under age 23 or over age 64 were excluded from our analysis. The lower restriction ensures that almost all included patients have completed their education and the upper restriction reflects the rarity of employment among ESRD patients over age 64. Unfortunately, the response rate for the lengthy patient questionnaire was low. Only 628 of 2275 (28%) of patients in our age range completed the employment portion of the questionnaire and, hence, had the wage data necessary to include them in our models. Respondents were somewhat younger and had fewer comorbid conditions than non-respondents. Thus, our estimates do not necessarily reflect the entire, working age dialysis population. Rather, they may better reflect a somewhat healthier than average subset of the population for whom employment issues are most likely to be salient.

Methods

Both dependent variables are binary (dialysis modality and employment). Further, because desire to work is likely to influence the choice of modality and vice versa, dialysis modality is an included endogenous variable on the right hand side of the employment equation and employment is an included endogenous variable on the right hand side of the dialysis modality equation. Thus, we estimate a simultaneous probit model (Maddala, 1983). The structural model for each dependent variable is a probit:

$$\begin{aligned} P^* &= \alpha_P + \beta_P X_P + \gamma_P E + u_P \\ P &= 1 \quad \text{if } P^* > 0 \\ P &= 0 \quad \text{otherwise} \end{aligned} \tag{1}$$

and

$$\begin{aligned} E^* &= \alpha_E + \beta_E X_E + \gamma_E P + u_E \\ E &= 1 \quad \text{if } E^* > 0 \\ E &= 0 \quad \text{otherwise} \end{aligned} \tag{2}$$

where P^* and E^* are index variables representing the desire for peritoneal dialysis and employment respectively and P and E are the associated indicator variable for the observed choices.

Estimation follows a two-stage procedure. In the first stage, probit maximum likelihood is used to estimate a reduced form equation for dialysis modality using all exogenous variables as predictors. Predicted dialysis modality is substituted for P in the second stage, where the structural equations are also estimated by probit maximum likelihood. The estimating equations for dialysis modality and employment are specified as follows:

$$P = \alpha_P + \beta_P X_P + \gamma_P \hat{E} + u_P$$
$$E = \alpha_E + \beta_E X_E + \gamma_E \hat{P} + u_E$$

where X_P and X_E are matrices of exogenous variables influencing the choice of modality and employment, respectively. Variables common to X_P and X_E include hourly wage, demographics (e.g., age, sex, marital status, living conditions), and comorbid conditions (e.g., cardiovascular conditions, diabetes, cancer, HIV infection or AIDS, chronic pain, general health assessment). Covariance matrices and standard errors are adjusted for the inclusion of estimated covariates in the second stage of the estimation (Maddala, 1983).

We employ a novel method to characterize potential wages for non-working kidney dialysis patients. The patient survey asked for the actual wage of those who were employed. For those not employed, the survey asked for the wage they thought they would receive if they were to take a job. Hence, we have a direct estimate of the earnings potential of non-workers that can be used to circumvent the problem of unobserved wages. Since most working age dialysis patients were employed shortly before initiating dialysis, non-workers are likely to have a reasonable basis for estimating their earning power. The distribution of anticipated wages for non-workers has face validity as it is similar to the distribution of actual wages, but with a lower median. To further establish the plausibility of these responses, we estimated a wage equation for workers and then entered the characteristics of non-workers to determine their predicted wage. Non-workers' predicted wages were indeed lower than the average wage of employed patients and quite similar to the self-reported, anticipated wages.

Several instrumental variables were used to identify the effect of dialysis modality on employment. These variables are hypothesized to influence modality choice but not employment (except through their impact on modality). Distance from the patient's residence to the nearest hemodialysis facility will determine the relative convenience of hemodialysis (which requires 3 trips weekly to a dialysis center) vs. peritoneal dialysis (which does not require regular trips to a dialysis center). Instrumental variables based on distance to providers have previously been used in other contexts (e.g., McClellan, McNeil and Newhouse, 1994). Beliefs about clinical effectiveness of the different dialysis modalities are also used as instruments because they would be expected to influence modality choice for reasons unrelated to the desire to maintain the patient's own employment. We use the patient's opinion at the start of dialysis as to which modality provides longer survival. We also use variables indicating whether the patient was first informed of their abnormal kidney function less than one week before initiating dialysis and whether a patient first saw a nephrologist (kidney specialist) less than one month or not at all before initiating dialysis. These indicators of pre-ESRD care are expected to influence modality because patients who lack adequate time to plan for the modality choice and undergo the self-care training required for PD generally select HD. A final instrument is the extent of burden the patient reports that HD would pose for other members of their family (e.g., patient would be expected to be more likely to choose PD if they had to rely on family members to transport them to and from an HD center).

To identify the effect of employment on choice of modality, indicators of local economic conditions (unemployment rate and its square and median income in the patient's zip code) were used as instruments. Descriptive statistics for all variables are reported in Table 1.

In addition to the two-stage estimates, we also estimate the employment and modality equations without accounting for endogeneity. These "naïve", single equation models allow us to determine impact of ignoring endogeneity on the estimated effect of dialysis modality choice on the employment decision and vice versa. Several specification tests were performed, including Hausman tests for exogeneity, overidentification tests, and tests of the power of the instrumental variables.

Results

a. Naïve Model

Estimates of the naïve employment equation that treats dialysis modality as exogenous are reported in the first column of Table 2. Consistent with previous estimates of the impact of modality on employment, PD patients are much more likely to work. For a patient with the median characteristics for all explanatory variables other than dialysis modality, the model predicts a 51.3% probability of employment for a PD patient vs. a 32.2% probability for an HD patients. In relative terms, PD patients are 59.2% more likely to be employed than are HD patients.

Likewise, the naïve modality choice model that treats employment as exogenous (first column of Table 4) predicts that employed patients are more likely to choose PD as their method of dialysis. Again at the sample medians for all other explanatory variables, the model predicts that an employed patient has a 77.7% probability of choosing PD whereas an unemployed patient has only a 64.8% chance of choosing PD, representing a 19.9% relative increase in the probability of PD.

b. Two-Stage Results

We performed several specification tests for the instruments and the assumption of exogeneity. First, the instruments should be correlated with the endogenous variable in the first-stage equation. The variables excluded from the second stage employment model had the expected signs and were significant both individually ($p < 0.05$ in t-tests) and jointly (likelihood ratio test $p < 0.01$) in the first stage dialysis modality model. The variables excluded from the second stage modality choice model only attained marginal significance in the first stage employment model (two of three significant at the $p < 0.01$ level), but were jointly significant ($p < 0.05$). Second, the explanatory power of the first-stage equations was good, with pseudo-R^2 of 0.71 in the PD equation and 0.53 in the employment equation. Third, the instruments should not predict the second stage equations significantly better than using only the predicted value of the included endogenous variable. To test the overidentifying restrictions, we determined (1) whether a two-stage probit model including the instruments in the second stage fit the data significantly better than a model including

Table 1. Descriptive statistics for newly treated dialysis patients, ages 23–64, 1996 ($n = 602$).

Variable[a]	Mean	s.d.[b]
Peritoneal dialysis (%)	60.8	–
Employed (%)	45.2	–
Age (years)	45.6	10.8
Female (%)	47.3	–
Hispanic (%)	9.1	–
Black (%)	31.4	–
Other race (%)	7.3	–
Education (%) (College graduate)		
Less than 12 years	13.8	–
High school graduate	34.9	–
Some college	24.3	–
Not reported	7.6	–
Married (%)	55.7	–
Live alone (%)	15.1	–
Hourly wage ($)	12.4	7.8
Health status (%) (Good)		
Excellent	3.2	–
Very good	14.0	–
Fair	34.9	–
Poor	7.6	–
Not reported	2.5	–
Limited in activities of daily living (%)	24.9	–
Economic indicators for zip code of patient residence		
Median annual household income ($1000)	29.6	10.5
Unemployment (%)	7.4	4.2
Distance from patient residence to nearest hemodialysis facility (miles)	6.9	10.7
Predialysis medical care (%) (Other)		
Told of abnormal kidney function within one week of start of dialysis	8.6	–
First saw nephrologist within one month of start of dialysis	11.0	–
Hemodialysis is a burden to my family (%) (Neutral)		
Strongly agree	10.0	–
Agree	18.8	–
Disagree	19.8	–
Strongly disagree	11.5	–
Don’t know	23.1	–
The treatment that helps patients live longer is (%) (HD and PD are about the same):		
HD	5.3	–
PD	17.3	–
Don’t know	59.6	–

[a]For variables with more than two categories, the omitted group (in brackets) is the reference group for all models.
[b]Reported only for continuous variables.

Table 2. Results from employment models.[a]

Variable	Single Equation Model Estimated Coefficient	Single Equation Model p-value	Two-Stage Model Estimated Coefficient	Two-Stage Model p-value
PD[b]	0.494	<0.01	0.152	<0.01
Age	0.063	0.15	0.060	0.17
Age squared	−0.001	0.06	−0.001	0.08
Female	0.038	0.75	0.031	0.80
Hispanic	−0.051	0.82	−0.015	0.95
Black	−0.182	0.22	−0.150	0.32
Other race	−0.301	0.19	−0.270	0.24
Education (versus college graduate)				
Less than 12 years	−0.592	<0.01	−0.547	0.02
High school graduate	−0.670	<0.01	−0.634	<0.01
Some college	−0.464	0.01	−0.451	0.02
Not reported	−0.406	0.10	−0.385	0.11
Married	0.207	0.13	0.197	0.15
Live alone	0.221	0.22	0.231	0.19
Hourly wage	0.014	0.09	0.014	0.09
Health status (versus good)				
Excellent	0.629	0.08	0.660	0.06
Very good	0.327	0.07	0.353	0.05
Fair	−0.281	0.04	−0.273	0.05
Poor	−0.522	0.04	−0.501	0.05
Not reported	0.758	0.05	0.741	0.05
Limited in activities of daily living	−0.190	0.18	−0.178	0.21
Diabetes (versus no diabetes)				
Yes, as primary cause of ESRD	−0.121	0.36	−0.114	0.38
Yes, but not primary cause of ESRD	−0.128	0.73	−0.115	0.76
Peripheral vascular disease	−0.443	0.02	−0.445	0.02
HIV or AIDS	−1.207	0.04	−1.209	0.04
Instrumental variables				
Median annual household income in patient zip code ($1000)	0.014	0.06	0.014	0.06
Unemployment rate in patient zip code	−0.077	0.14	−0.077	0.14
Unemployment rate squared	0.004	0.08	0.004	0.07

[a]Both models also include the following clinical variables as covariates: coronary heart disease/coronary artery disease, other heart disease, cerebrovascular accident, chronic obstructive pulmonary disease, neoplasm and severe or very severe bodily pain.
[b]PD is a binary variable in the single equation model and a continuous variable (the likelihood of the individual selecting PD in the two-stage model.

just the predicted values of the endogenous right-hand side variables, and (2) whether single equation models including the instruments fit significantly better than the restricted models that exclude the instruments (see Bollen, Guilkey and Mroz, 1995). The instruments for PD passed these overidentification tests. The selected instruments for employment, median zip code income and zip code unemployment rate and its square, were not significant in the second-stage PD equation. However, another potential instrument, the actual or anticipated wage, while not quite significant in the second stage ($p = 0.16$) was a significant predictor in the naïve, single equation model ($p = 0.04$). Although we expected that wage would only influence modality choice through its effect on employment, it may be the case that wage proxies for omitted characteristics that make a patient more likely to choose PD. For example, since PD requires significant patient responsibility for self-care, higher earning power may reflect generally higher levels of function that make it more likely a patient can accept such responsibility. Therefore, to be conservative, we did not exclude wage from the second stage modality choice equation. Finally, Hausman tests reject exogeneity in both equations as the error terms from first-stage equations were significant predictors in the second stage equations (both at the $p < 0.01$ level of significance). Because our instruments passed the previous diagnostic tests, these Hausman tests are valid (Hausman, 1978).

The second stage, structural equations are presented in Table 2 for employment, alongside the naïve model that ignores endogeneity. The changes in the relative probability of working associated with key variables are reported in Table 3. Table 4 presents the second stage, structural equations for dialysis modality alongside the naïve model, and Table 5 reports changes in the relative probability of working associated with key variables. Predicted PD from the first stage increased the likelihood of employment, but the magnitude of the effect is considerably smaller than in the naïve model. Recall that in the naïve model, the absolute probability of employment was about 20 percentage points higher among PD patients than among HD patients and the relative increase was nearly 60%. In the two-stage model, the absolute increase is only 6 percentage points (46.6% for PD patients vs. 40.6% for HD), representing a 14.7% relative increase in the probability of working. The coefficient on predicted employment is very precisely estimated ($p < 0.01$). Thus, we can conclude that although peritoneal dialysis does have a causal effect on dialysis patients' ability to participate in the labor force, the magnitude of this effect is relatively small in absolute terms and much smaller than the effect implied by the naïve model and most previous estimates in the literature which, like the naïve model, ignored endogeneity.

There are several other notable findings with respect to employment. As expected, patients with higher actual or anticipated wages were more likely to work (1.3% per $1 higher average wage). Thus, for every one standard deviation ($7.80) increase in hourly earning potential, the point estimate indicates a 10.1% relative increase in the probability of employment. This estimate can provide some guidance to policymakers trying to predict the response of labor supply among chronically ill workers with respect to wage subsidies or phase-out of cash and non-cash benefits as a function of earnings, but it should be kept in mind that the sample here appears somewhat younger and healthier than all dialysis patients and that the effects of wages were not very precisely estimated ($p = 0.09$). In addition, those with college educations and better overall health status were more likely to work. Older patients

Table 3. Marginal effects of key variables on employment.[a]

Variable	Relative Change in Probability of Working (%)[b]	*p*-value
	Single, Equation Model	
PD	59.2	<0.01
	Two-Stage Model	
PD (predicted)	14.7	<0.01
Wage (per $1)	1.3	0.09
Age (per 10 years)	−23.6	<0.01[c]
Education (versus college graduate)		
Less than 12 years	−35.1	0.02
High school graduate	−40.5	<0.01
Some college	−29.0	0.02
Health status (versus good)		
Excellent	54.8	0.06
Very good	30.4	0.05
Fair	−23.0	0.05
Poor	−40.5	0.05
Peripheral vascular disease	−36.1	0.02
HIV or AIDS	−79.8	0.04
Instrumental variables		
Median income in zip code (per $5,000)	6.4	0.06
Unemployment in zip code (per 1%)	−1.4	0.18[c]

[a]Both models also include as covariates the remaining variables listed in Table 2.
[b]Computed at the mean for all other patient characteristics. The relative change for all continuous variables used the probability at the mean value as the base.
[c]Based on a LR test of the joint significance of the linear and quadratic terms.

and those with a variety of comorbid conditions, including peripheral vascular disease and HIV/AIDS were significantly less likely to work.

Turning to the model of the choice of dialysis modality, predicted employment from the first stage increased the likelihood of choosing PD, but not significantly. Compared to the naïve model, which showed a 19.9% relative increase in the probability of PD choice among those who were employed, the point estimate from the second-stage model shows only an insignificant 6% relative increase in PD use (Table 5). Thus, after accounting for the endogeneity of employment and treatment choice, it does not appear likely that a "beneficial spiral" could be initiated by encouraging employment, which would increase use of PD, leading to further increases in employment.

PD was significantly less likely to be chosen by black patients and by patients with histories of coronary disease. Patients who lived further from a hemodialysis facility were significantly more likely to choose PD. The changes in the relative probability of working associated with these variables are reported in Table 4.

Table 4. Results from modality choice models.[a]

	Single Equation Model		Two-Stage Model	
Variable	Estimated Coefficient	*p*-value	Estimated Coefficient	*p*-value
Working[b]	0.382	<0.01	0.131	0.71
Age	−0.008	0.88	−0.007	0.89
Age squared	0.000	0.84	0.000	0.87
Female	0.126	0.36	0.117	0.41
Hispanic	−0.229	0.33	−0.247	0.29
Black	−0.594	<0.01	−0.589	<0.01
Other race	−0.253	0.34	−0.249	0.38
Education (versus college graduate)				
Less than 12 years	−0.411	0.12	−0.429	0.22
High school graduate	−0.298	0.16	−0.293	0.37
Some college	−0.494	0.03	−0.489	0.11
Not reported	0.128	0.67	0.116	0.73
Married	0.132	0.41	0.128	0.47
Live alone	0.060	0.76	0.057	0.80
Hourly wage	0.019	0.04	0.018	0.16
Health status (versus good)				
Excellent	−0.133	0.71	−0.139	0.75
Very good	−0.160	0.46	−0.144	0.56
Fair	−0.051	0.75	−0.040	0.84
Poor	−0.494	0.06	−0.478	0.18
Not reported	0.029	0.95	0.049	0.93
Limited in activities of daily living	−0.323	0.04	−0.308	0.09
Diabetes (versus no diabetes)				
Yes, as primary cause of ESRD	−0.009	0.96	−0.021	0.90
Yes, but not primary cause of ESRD	0.426	0.30	0.456	0.28
Coronary heart disease/coronary artery disease	−0.493	<0.01	−0.470	0.02
Instrumental variables				
Distance from patient residence to nearest hemodialysis facility	0.015	0.06	0.015	0.06
Predialysis medical care (versus other)				
Told of abnormal kidney function within one week of start of dialysis	−0.585	0.01	−0.590	0.01
First saw nephrologist within one month of start of dialysis	−0.477	0.03	−0.460	0.04
Hemodialysis is a burden to my family (versus neutral)				
Strongly agree	0.734	0.03	0.698	0.03
Agree	−0.539	0.01	−0.524	0.01

(*Continued on next page*.)

Table 4. (*Continued*).

Variable	Single Equation Model		Two-Stage Model	
	Estimated Coefficient	*p*-value	Estimated Coefficient	*p*-value
Disagree	−0.780	<0.01	−0.769	<0.01
Strongly disagree	−0.987	<0.01	−0.977	<0.01
Don't know	0.456	0.03	0.461	0.04
Treatment that helps patients live longer is: (versus they are about the same)				
HD	−1.490	<0.01	−1.448	<0.01
PD	1.805	<0.01	1.805	<0.01
Don't know	−0.318	0.06	−0.306	0.07

[a]Both models also include the following clinical variables as covariates: peripheral vascular disease, HIV or AIDS, other heart disease, cerebrovascular accident, chronic obstructive pulmonary disease, neoplasm and severe or very severe bodily pain.
[b]Working is a binary variable in the single equation model and a continuous variable (the likelihood of the individual working) in the two-stage model.

Discussion and Conclusions

There is a large literature on the interactions between health status and labor market behavior, and a growing portion of this literature has begun to treat health status as endogenous. However, to our knowledge this is the first paper that has attempted to model the endogeneity between actual medical treatment choices and labor market behavior.

As our data on ESRD patients illustrate, a significant number of chronically ill patients are employed, often despite major comorbidities. Understanding predictors of employment and barriers to employment can guide policy-makers in facilitating employment. For example, the quadratic effect of age shows that employment probability, controlling for all other factors in the model, is maximized for dialysis patients in their early thirties. Advancing age (even at ages where most of the general population remains employed), poor health status, lower education, and lower earning power all substantially decreased the likelihood of employment. Earning power could be influenced by the structure of tax, subsidy and in-kind transfer programs, but the other factors cannot be directly influenced by policy. However, an awareness of the importance of these factors can help identify programs such as employment counseling or vocational rehabilitation that may lower some of the barriers to employment and can help target programs to individuals with the greatest potential for workforce participation.

A key barrier to labor force participation among patients with chronic diseases, including dialysis patients, is the convenience of scheduling treatment. In the case of dialysis, the use of the relatively more flexible PD has declined in recent years and substantial regional variations in use exist (USRDS, 2001). The reasons for this decline have been debated in the clinical community. A number of potentially modifiable, structural factors have been suggested as causes of the overall decline and regional variations in the use of PD. These

Table 5. Marginal effects of key variables on modality choice.[a]

Variable	Relative Change in Probability of Selecting PD (%)[b]	p-value
Single Equation Model		
Employed	19.9	<0.01
Two-Stage Model		
Employed (predicted)	6.0	0.71
Black	−25.4	<0.01
Coronary heart disease/coronary artery disease	−21.7	0.02
Instrumental variables		
Distance to nearest hemodialysis facility (per 1 mile)	0.7	0.06
Predialysis medical care (versus more intensive care)		
Told of abnormal kidney function <1 week of dialysis	−27.7	0.01
First saw nephrologist <1 month of dialysis	−21.0	0.04
Hemodialysis is a burden to my family (versus neutral)		
Strongly agree	18.1	0.03
Agree	−22.6	0.01
Disagree	−34.7	<0.01
Strongly disagree	−45.1	<0.01
Don't know	13.5	0.04
The treatment that helps patients live longer is (versus the same):		
HD	−73.4	<0.01
PD	38.4	<0.01

[a]Both models also include as covariates the remaining variables listed in Table 4.
[b]Computed at the mean for all other patient characteristics. The relative change for distance to nearest HD facility used the probability at the mean distance as the base.

factors include the relative profitability of the modalities under Medicare reimbursement policy, a growing scarcity of nurses and physicians with extensive PD experience, late referral to specialty care resulting in limited time to plan modality choice, and the fact that many dialysis centers currently offer their patients only HD have been suggested as contributing to the decline (Mendelssohn, 2002; Nissenson, 2002). As a result, it is possible that impediments to access to PD have impaired labor force participation in this chronically ill population.

Previous estimates of the relationship between treatment choices and employment ignored endogeneity. In the case of dialysis, we find that accounting for endogeneity of treatment choice implies that the relatively more flexible (and hence work-friendly) modality (PD) does facilitate employment, but to a lesser extent than would be implied by either the naïve model or previous literature that has ignored this endogeneity problem. Most of the effect of PD on employment in the naïve model arises from endogenous selection of PD by those patients who wish to maintain employment rather than from the ability of PD to ease work scheduling. Hence, the causal impact of the availability of PD on patients' ability to maintain employment is substantially smaller than prvious estimates have implied. Hence, there is little potential for a shift towards PD or other home-based treatments to yield large increases in the percentage of dialysis patients holding employer-provided health insurance, which would enable the Medicare program to reduce outlays through its secondary payer provisions.

Quality of life considerations are receiving increasing attention in both clinical research and clinical decision-making, suggesting that the scope for employment preferences to influence treatment decisions, and vice versa, will rise. Interactions between health care choices and employment will continue to become more important as the "baby boom" generation ages and medical research continues to expand the number of conditions for which a variety of treatment options exist. For example, treatment advances are transforming many forms of cancer from acute illnesses into chronic conditions. Over 5 million Americans are survivors of cancer who have lived with their disease for at least 5 years (Beyer, 1995). New cancer treatments often require ongoing therapy, sometimes on a regular schedule and sometimes at unpredictable intervals based on the course of the disease. Many cancer patients face a choice between more intensive but time limited therapies (e.g., bone marrow transplantation) and less intensive therapies with longer duration. These therapies often involve side effects such as fatigue that can directly impact ability or desire to work independent of the time actually spent seeking care. Thus, joint treatment and labor market decisions similar to those faced by the dialysis patients in this study are increasingly relevant to individuals with other clinical conditions and understanding these decisions will become crucial to understanding labor market behavior.

References

Beyer, D. A. (1995). "Cancer is a Chronic Disease." *Nurse Practitioner Forum* 6(4), 201–206.

Bollen, K. A., D. K. Guilkey and T. A. Mroz. (1995). "Binary Outcomes and Endogenous Explanatory Variables: Tests and Solutions with an Application to the Demand for Contraceptive use in Tunisia." *Demography* 32, 111–131.

Currie, J. and B. Madrian. (1999). "Health, Health Insurance and the Labor Market." In O. Ashenfelter and D. Card (eds.), *Handbook of Labor Economics*, vol. 3. Elsevier Science, pp. 3309–3416.

Curtin, R. B., E. T. Oberley and P. Sacksteder. (1996). "Friedman A. Differences between Employed and Nonemployed Dialysis Patients." *American Journal of Kidney Diseases* 27(4), 533–540.

Ettner, S. L. (2000). "The Relationship between Labor Market Outcomes and Mental and Physical Health: Exogenous Human Capital or Endogenous Health Production?" In Salkever and Sorkin (eds.), *The Economics of Disability, Series on Research in Human Capital and Development*. JAI Press.

Ettner, S. L., R. Frank and R. Kessler. (1997). "The Impact of Psychiatric Disorder on Labor Market Outcomes." *Industrial and Labor Relations Review* 51(1), 64–81.

Hausman, J. A. (1978). "Specification Tests in Econometrics." *Econometrica* 49, 1251–1271.

Haveman, R., B. Wolfe, B. Kreider and M. Stone. (1994). "Market Work, Wages and Men's Health." *Journal of Health Economics* 13, 163–182.

Holley, J. L. and S. Nespor. (1994). "An Analysis of Factors Affecting Employment of Chronic Dialysis Patients." *American Journal of Kidney Diseases* 23(5), 681–685.

Julius, M., J. D. Kneisley, P. Carpentier-Alting, V. M. Hawthorne, R. A. Wolfe and F. K. Port. (1989). "A Comparison of Employment Rates of Patients Treated with Continuous Ambulatory Peritoneal Dialysis vs. In-Center Hemodialysis (Michigan End-Stage Renal Disease Study)." *Archives of Internal Medicine* 149(4), 839–842.

Kutner, N. G., D. Brogan and B. Fielding. (1991). "Employment Status and Ability to Work Among Working-Age Chronic Dialysis Patients." *American Journal of Nephrology* 11(4), 334–340.

Lee, L. (1982). "Health and Wages: A Simultaneous Equation Model with Multiple Discrete Indicators." *International Economic Review* 23, 199–221.

Maddala, G. S. (1983). *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

McClellan, M., B. J. McNeil and J. P. Newhouse. (1994). "Does More Intensive Treatment of Acute Myocardial Infarction in the Elderly Reduce Mortality? Analysis Using Instrumental Variables." *Journal of the American Medical Association* 272, 859–866.

Mendelssohn, D. C. (2002). "Reflections on the Optimal Dialysis Modality Distribution: A North American Perspective." *Nephrology News and Issues* 16, 26–29.

Nissenson, A. R. (2002). "What Other Factors Influence Modality Choice?" *Nephrology News and Issues* 16, 27–28

United States Renal Data System. (1997). "USRDS 1997 Annual Data Report." National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD.

United States Renal Data System. (2001). "USRDS 2001 Annual Data Report." National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD.

United States Renal Data System. (2002). "USRDS 2002 Annual Data Report." National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD.

Wolcott, D. L. and A. R. Nissenson. (1988). "Quality of Life in Chronic Dialysis Patients: A Critical Comparison of Continuous Ambulatory Peritoneal Dialysis (CAPD) and Hemodialysis." *American Journal of Kidney Diseases*, 11(5), 402–412.

Wu, S. and A. Green. (2000). *Projection of Chronic Illness Prevalence and Cost Inflation*. Santa Monica, California: RAND Health.

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