Effective HIV Treatment and the Employment of HIV+ Adults

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Objective. To examine whether highly active antiretroviral therapy (HAART) helps HIV-infected patients return to work, remain employed, and maintain hours of work.
Data Source. Longitudinal data from a national probability sample of HIV+ patients older than 18 years old who made at least one visit in the contiguous United States in early 1996.
Study Design. We consider the effect of HAART on three employment outcomes: (1) returning to work within six months of treatment, conditional on not working pretreatment; (2) remaining employed within six months of treatment, conditional on working pretreatment; (3) hours of work conditional on working at the second follow-up survey. We use a bivariate probit model to jointly model employment and treatment with HAART for the first two outcomes and the two-stage least squares method for hours of work. State policies regarding prescription drug coverage are used as instrumental variables for HAART to account for a key source of potential bias—the more severely ill tend to have the most difficulty working, but are also the most likely to be on HAART.
Principal Findings. Our results indicate that HAART increases the probability of remaining employed by HIV patients and hours of work for those working within six months of treatment. In the case of remaining employed, the employment effect (an increase from 58 percent to 94 percent in the probability of remaining employed) is statistically significant and the related incremental income is sizable compared to the incremental costs of HAART. Sensitivity analyses demonstrate that the results are robust to different specifications for insurance coverage.
Conclusions. Patients who are working are more likely to remain employed because of treatment with HAART. HAART prescribed to patients in less advanced stages of the infection may lead to the greatest gain in employment.

Key Words. HIV, employment, HAART, bivariate probit

The vast majority of patients infected with human immunodeficiency virus (HIV) are adults of prime working age. Thus, effective treatments hold promise to not only improve health but also increase the work opportunities of this population. Highly active antiretroviral therapy (HAART) developed in the early 1990s has been shown to reduce the levels of virus in the blood—with commensurate improvements in mortality (Palella et al. 1998). The treatments also have led to better quality of life for patients living with HIV (Egger

et al. 1997; Brechtl et al. 2001); and thus should allow patients to work longer and more productively.

Ideally, one would measure the employment consequences of HAART therapy as part of a clinical trial designed to measure the health benefits. Patients would be randomly assigned to therapy and so labor market outcomes could be compared across the treatment and control groups. But clinical trials rarely track labor market outcomes; and if they do, the highly selected patients and clinical settings limit one's ability to generalize. Patients in clinical trials are often chosen because they are motivated to adhere to therapy or because the risks of mortality or other complications for these patients are low, and they are recruited and treated in nonrepresentative academic settings (Gurwitz, Col, and Avorn 1992). These biases are tolerated for clinical outcomes because the primary research question is whether a drug is effective under the best of circumstances. For policy questions, however, we are often more interested in the consequences of therapy under more "natural" circumstances.

Such questions can be answered in nonrandomized settings, but care must be taken to interpret the data correctly. Access to treatment and subsequent compliance can be associated with unmeasured clinical and social factors that may play a role in individuals' employment decisions as well. For example, patients on HAART may be less severely ill in ways that are difficult to observe, or they may be more motivated to comply with physician orders. Such factors also might make them more likely to be employed. Therefore, direct comparisons of those on HAART and those not on HAART are likely to produce biased estimates of the effect of the treatment.

This article estimates the effect of HAART on patients' employment dynamics using data from a representative sample of HIV+ patients. Our analytic approach explicitly accounts for the possibility that treatment of HAART is affected by more factors than one can observe. More precisely, we use policies affecting coverage of HAART in state health insurance programs as instrumental variables for the treatment of HAART. These policies are

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This research was sponsored by a grant from the Agency for Healthcare Research and Quality (AHRQ). The HIV Cost and Services Utilization Study was conducted under a cooperative agreement between RAND and AHRQ.

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directly related to patients' chances of receiving the advanced therapy, but we assume that they are not directly related to patients' employment outcomes except through the treatment.

In the next section, we provide an overview of the clinical and policy context of the research question addressed in the study; the third section describes our data sources; the fourth section presents our econometric approach. We present results of the estimation in the fifth section and discuss our findings in the final section.

BACKGROUND

The recent development of new classes of drugs—namely, non-nucleoside analogue reverse transcriptase inhibitors (NNRI) and protease inhibitors—added several potent weapons to the HIV arsenal. Recent clinical trials have found that the combination of several antiretroviral drugs—known as highly active antiretroviral therapy or HAART—is most effective in reducing mortality and morbidity among HIV+ patients compared to less-intensive treatment regimens (Palella et al. 1998). A panel of experts recommended HAART to achieve maximum suppression of symptoms for as long as possible (Carpenter et al. 1998). Taken together, all the clinical evidence suggests that HAART could have important employment effects for a population of HIV+ adults in care.

One problem is that patients may not seek treatment immediately. HIV infection can be asymptomatic for eight to nine years, and manifestation of symptoms may directly increase patients' chances of seeking treatment as well as the likelihood that their physicians prescribe the intensive therapy. In fact, although clinical guidelines before 1998 strongly recommended combination therapy for patients during acute primary HIV infection, whether the strategy is appropriate for patients with relatively high CD4+ T cell counts[1] or lower viral load was far less certain (Centers for Disease Control and Prevention 1998). Further, with limited public resources to treat HIV, sicker patients are usually given priority under public assistance programs. As a result, before treatment, patients on HAART are likely to be sicker, and therefore, more likely to have difficulties working than patients not on HAART. This means that patients who receive HAART treatment are sicker in ways that cannot be completely controlled for in the absence of very detailed clinical data (Goldman et al. 2001b). (Even with such data, other factors that are unobservable such as patient motivation may play a role.)

HAART therapy is very expensive, which also limits its use. With average annual costs exceeding $10,000, most patients have to rely on insurance coverage to finance the treatment (Shapiro et al. 1999; Cook et al. 2002). Westmoreland (1999) provides detailed information about the eligibility of HIV/AIDS patients for public insurance programs, of which Medicaid and Medicare may be the most important.

Other programs have been developed to specifically meet the needs of HIV patients. Chief among these is the AIDS Drug Assistance Program (ADAP), which has the greatest number of beneficiaries and provides an important lifeline for low-income HIV patients. The ADAP was established under the Ryan White CARE Act, funded by both federal grants and state discretionary funds. In 1999, ADAP served almost 138,000 clients with a total budget exceeding $800 million (Kaiser Family Foundation 2002). Once eligibility is verified, the patient can fill their prescriptions at either a central or local pharmacy participating in the program.

The importance of public assistance in financing HIV care creates social inefficiencies, since the eligibility rules of many public programs are set in a way such that they discourage employment (Goldman et al. 2001a). Patients who get treated and go back to work risk losing public insurance if their earnings are higher than the income threshold. This type of "welfare lock" is especially worrisome for patients on expensive treatment like HAART, since losing public insurance coverage likely means terminating treatment. The result is that they may be very reluctant to go back to work if they were not already doing so. On the other hand, HAART patients with employer-provided insurance have greater incentives to remain employed than if the availability of insurance is not contingent on one's employment status—a condition often termed "job lock" (Madrian 1994a, b). These competing incentives suggest that one must be careful in analyzing and interpreting the evidence.

DATA

To test whether HAART does have an effect on labor market outcomes, we use data from the HIV Cost and Services Utilization Study (HCSUS). The study population is representative of patients over 18 years old in the contiguous 48 states who made at least one routine visit at a facility other than military, prison, or emergency department facilities in early 1996 (Bozzette et al. 1998). Using a multistage sampling frame, the baseline survey interviewed 2,864 patients between January 1996 and April 1997. Follow-up

interviews were conducted between December 1996 and July 1997 and between August 1997 and January 1998). The sample sizes for the second and third waves are 2,466 and 2,267, respectively, with virtually all the attrition due to mortality. In each wave of HCSUS, patients were shown lists of antiretroviral drugs (including the most recently developed classes) and asked to identify those taken in the previous six months or since the last interview. An indicator for HAART therapy ("HAART") was then constructed by Anderson et al. (2000) based on recommendations published by the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention 1998).[2]

The employment data from HCSUS include whether the individual is working at the time of the interview, and if working, number of hours usually worked per week during the past month. In addition to important sociodemographic information, the HCSUS study also collected HIV-related information that was likely to affect the use of advanced drug therapy and employment, including exposure route, health insurance, disease stage, and count of CD4+ T cells. We also classified insurance in four categories: none, employer-provided insurance, self-purchased private insurance, or public insurance (Medicaid or Medicare).

We focus our analysis on HIV patients who were of prime working age (25 to 54) at the time of the baseline survey and participated in all three waves of HCSUS. Table 1 presents the weighted summary statistics of this population across the three waves.[3] In a cohort of HIV+ adults, one would expect to see health deteriorate in later waves as the disease progresses, and one does as the AIDS rate rises and the average CD4+ counts fall in later waves. Despite somewhat worsening health, the percentage of patients reporting "working now" stayed relatively constant from the baseline to the second follow-up. At the same time, we also see a dramatic increase in the percentage of the population using HAART, suggesting that treatment may have been successful in forestalling less employment of the HIV+ population in the aggregate.

Approximately 40 percent of the sample is working at each wave. These employment rates are low for a population in its prime working years. This likely reflects not only the debilitating effects of illness but also the heterogeneity of the infected population; many HIV+ adults do not have significant work attachment prior to being infected. Table 1 also demonstrates the extent to which HIV/AIDS is a public problem—nearly half the patients in care for HIV are covered by Medicaid or Medicare. Coverage through public insurance rises from 48 percent to 54 percent between baseline and second follow-

Table 1: Weighted Descriptive Statistics of Sampled HIV Patients Aged 25–64 at Baseline

	Baseline		*1st Follow-up*		*2nd Follow-up*	
	Mean	*Std. Err.*	*Mean*	*Std. Err.*	*Mean*	*Std. Err.*
HAART	0.25	0.02	0.40	0.03	0.60	0.02
Demographics						
Age	38.08	0.25	38.10	0.26	38.10	0.26
Nonwhite	0.48	0.03	0.50	0.03	0.50	0.03
Female	0.22	0.03	0.22	0.03	0.22	0.03
Education						
Less than high school	0.23	0.03	0.24	0.03	0.24	0.03
High school diploma	0.28	0.01	0.28	0.01	0.28	0.02
Some college	0.29	0.02	0.29	0.02	0.29	0.02
College degree or higher	0.20	0.03	0.19	0.03	0.19	0.03
Insurance						
Employment-based insurance	0.25	0.03	0.24	0.03	0.24	0.03
Self-bought insurance	0.07	0.02	0.07	0.01	0.06	0.01
Public insurance	0.48	0.04	0.51	0.04	0.54	0.04
Clinical Stage of the Infection						
AIDS	0.37	0.02	0.41	0.02	0.45	0.02
Symptomatic	0.52	0.02	0.53	0.02	0.51	0.02
CD4 lymphocyte count (cells per mm^3)	209.42	9.05	198.21	8.56	181.51	7.75
Employment						
Work now	0.40	0.03	0.42	0.72	0.43	0.56
Hours of work, if working	37.99	0.97	38.10	0.72	38.08	0.56

Source: Authors' calculation using data from the HIV Cost and Services Utilization Study (HCSUS).

Notes: HCSUS is a national probability sample representing adult HIV patients active in care in early 1996.

Statistics are weighted to be nationally representative. For more information on how the weights are constructed, see note 3 or Duan et al. (1999).

up; in part, this can be explained by the program rules for Medicare and Medicaid eligibility, which often require demonstrating a disability (for HIV, late-stage disease).

Our estimation strategy relies on finding factors—that is, instrumental variables—that affect whether a patient receives HAART, but do not affect individual employment decisions (except through their impact on treatment). It is hard to find individual factors such that this would be the case. However, public policies at a larger geographic level seem more promising.

Since ADAPs are administered and (often) funded by states, there is great variation across programs in the types and number of drugs covered.

Often an HIV+ patient is required to contact a local coordinator—perhaps the county public health department—who verifies eligibility. Eligibility rules vary by state; but they are based on meeting the income threshold and demonstrating that the individual does not have health insurance that covers drugs (or that the copayments provide financial hardship). Thus, ADAP covers not only the low-income uninsured but also the underinsured. In fact, in the HCSUS sample 15 percent of the ADAP recipients have Medicare coverage (which does not cover prescription drugs), 20 percent have private insurance, and 25 percent have Medicaid. Only 40 percent of ADAP recipients are uninsured.

We collected data on state-specific policies in 1997 that affect the generosity of coverage. These include a dichotomous variable indicating a limit of three prescriptions per month by the state Medicaid programs (Medicaid HIV Policy Project 1998), and whether the state ADAP covers a non-nucleoside reverse transcriptase inhibitor—the newest class of antiretroviral drugs (Doyle, Jefferys, and Kelly 1997).[4] In 1997, of the 35 states with individuals represented in HCSUS, three states (Texas, South Carolina, and Nevada) had a limit of three prescriptions per month for their Medicaid enrollees. Fourteen states had an ADAP that did not cover any non-nucleoside reverse transcriptase inhibitors (NNRTIs) (Arizona, Colorado, Connecticut, Georgia, Idaho, Louisiana, Maine, Mississippi, Nevada, Oregon, Pennsylvania, South Carolina, Tennessee, and Virginia).

Econometric Approach

It takes an unknown amount of time for the employment benefits of treatment to be realized. In the absence of data about the duration and timing of labor market spells, we take a simple dynamic approach to estimate how treatment affects outcomes. That is, in most of our analyses we ask how employment outcomes change between baseline and the third wave as a function of HAART treatment during the intervening period.[5] We consider three types of outcomes. First, we examine the probability that a patient "returns to work," conditional on individuals not working at baseline. Second, we look at whether individuals "remain employed," that is, conditional on working at baseline, the probability of still working at the second follow-up. Third, we study the effect of HAART on hours of work per week among those who were working at the second follow-up ("hours of work"). We do not look at changes in hours because—unlike work status—there is substantial measurement error in

this variable, and first differencing two noisy measures yields very imprecise results.

Because the conditioning sample is different in each case, we model these outcomes separately. For the continuous outcome of hours of work, we use two-stage least squares. In the first stage, the probability of having HAART is modeled as a linear function of personal characteristics, baseline HIV severity, and our instruments (state policies); in the second stage, hours of work at the second follow-up is modeled as a linear function of the predicted probability of having HAART (derived from the first-stage) and the same individual-level information.[6] For each of the two dichotomous outcomes of "return to work" and "remain employed," we specify a joint, nonlinear model—a bivariate probit—of employment and treatment of HAART.

Bivariate Probit Model

For returning to work and remaining employed, we denote the dichotomous outcome as "Employment" and the dichotomous treatment as "Haart." We make the assumption that both employment and HAART are determined by an underlying continuous index ("Employment*" and "Haart*"). When *Employment** or *Haart** exceed zero, the corresponding outcome takes the value 1 and 0 otherwise. We denote the instrumental variables for HAART (state policies that affect HAART but not employment) as Z and the other personal characteristics (baseline HIV status and sociodemographics) as X. The bivariate probit model then becomes:

$$Employment_i^{F2^*} = \alpha^E + \beta Haart_i^{F1} + X_i'\gamma^E + \varepsilon_i^E; \quad (1)$$

$$Haart_i^{F1^*} = \alpha^H + Z_i^{F1\prime}\delta + X_i'\gamma^H + \varepsilon_i^H. \quad (2)$$

The superscripts "F2" and "F1" serve as reminders that we model employment at the second follow-up survey as a function of treatment preceding the first follow-up survey. We measure treatment using the first follow-up rather than baseline for several reasons. First, treatment rapidly diffused between the baseline and first follow-up survey, soon after the introduction of HAART into clinical practice, and early adopters are likely a highly selected group. Second, there were data problems in the baseline survey that prevented HCSUS from identifying exposure to HAART for some patients (Andersen et al. 2000). Third, it is likely that employment transitions respond more to treatment in the intervening period rather than treatment that could have been up to six months prior to the baseline interview.

We assume a bivariate normal distribution (with the variance normalized to 1 and the correlation coefficient denoted as ρ) as follows:

$$\begin{pmatrix} \varepsilon^E \\ \varepsilon^H \end{pmatrix} \sim BVN\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right). \tag{3}$$

The correlation between ε^E and ε^H captures the correlation between patients propensity to receive HAART and propensity to change employment. As noted previously, there is no way to sign the bias a priori. Greater (unobserved) severity of the disease would probably make someone more likely to receive HAART and less likely to work, suggesting a negative correlation. On the other hand, HIV therapy is complicated, and patients who are very motivated to treat their illness in ways that are unobservable may also be very motivated to work, suggesting a positive correlation (Goldman and Smith 2002).

To identify the model, the vector Z_i^{F1} in the HAART Equation (2) must contain at least one instrumental variable for HAART that does not appear in the employment Equation (1) (Maddala 1983). Finding such variables is difficult at the individual level since any variable that plausibly affects treatment is very likely to affect employment decisions as well. Thus, we use aggregate measures directly affecting access to HAART for patients assisted by public programs. These include: a dummy variable indicating whether the Medicaid program in a patient's home state had a limit of three prescription drugs per month and a dummy variable indicating whether the ADAP in a patient's home state covers NNRTIs in 1997. As shown in Table 1, Medicaid is an important source of health insurance for the HIV+ population. Although ADAP was largely designed to provide drugs for the uninsured, our data show that a nontrivial proportion of individuals with private or public insurance were also covered by ADAP. At the first follow-up of HCSUS, 6 percent of HIV+ individuals with private insurance only, 5 percent of those with Medicaid (but not Medicare), 22 percent of those with Medicare (but not Medicaid), and 5 percent of those with both Medicaid and Medicare reported being covered by ADAP, reflecting insufficient coverage of HIV-related medication under many private or public plans. The proportion among the uninsured is 20 percent. Therefore, restrictions on drug benefits under these two programs should affect access to HAART for a significant part of the HIV+ population receiving care. Further, because HAART is a combination therapy with at least three antiretroviral drugs and NNRTI is one of the two "must-haves" on the therapy, these two coverage policies are likely to be directly correlated with chances of getting the therapy. On the other hand,

since these policies are distinct from means-tested eligibility rules in determining one's eligibility for Medicaid or other public assistance programs, they should not play a direct role in an individual's employment decisions (except via the treatment of HAART).

Dealing with insurance status in this model is difficult. Health insurance both enables treatment and provides incentives (in the case of employment-based insurance) or disincentives (in the case of means-tested public insurance programs) for work, and therefore could be endogenous. One solution would be to jointly model insurance, employment, and treatment, although this would add substantial complexity to the model. As a compromise, we estimate the model both with and without insurance, and we also engage in a series of specification checks. In all cases, the model is then estimated using maximum likelihood.[7]

Predictions

We calculate predicted labor market outcomes (probability of returning to work, probability of remaining employed, and hours of work) conditional on HAART treatment for every individual in the corresponding sample—that is, fitted values assuming HAART treatment and no HAART treatment for everyone in the sample. We then derive weighted averages of the predicted outcomes across all individual patients in each of the three samples as defined by employment status at baseline or second follow-up using the HCSUS analytic weights. The difference of the two mean outcomes within each scenario indicates the marginal effect of HAART on the labor market outcomes of the HIV+ population.

RESULTS

Table 2 provides a summary of employment outcomes by treatment status. Employment rates were higher among HAART users at both baseline and second follow-up. In addition, unadjusted changes in employment—that is, returning to work and remaining employed—were similar for both the treated and untreated. Adjusting for sociodemographic characteristics and CD4 counts does not materially change this finding. On the other hand, hours of work per week among the working at the second follow-up were similar by HAART treatment according to either the unadjusted or the adjusted means (not shown for brevity). The absence of a strong effect of HAART on employment is likely due to selection. The lower panel shows rates of AIDS and

Table 2: Employment and Clinical Outcomes by Treatment Status

	Treatment Status at Wave 2:	
	No HAART (n = 1,259)	*HAART (n = 844)*
Employment		
Working (Wave 1)	36.4%	45.0%
Working (Wave 3)	40.4%	46.4%
Hours of work (Wave 1)	37.2	38.9
Hours of work (Wave 3)	38.2	37.9
Employment Transitions		
Unadjusted		
Returned to work*	14.8%	13.4%
Remained employed**	86.5%	86.9%
Adjusted using probit		
Returned to work*	14.5%	15.4%
Remained employed**	86.6%	86.0%
Clinical measures of HIV severity		
AIDS (Wave 1)	30.6%	47.3%
AIDS (Wave 3)	38.5%	54.4%
CD4 count (Wave 1)	246.3	157.8
CD4 count (Wave 3)	209.3	132.4

Note: Waves 1, 2, and 3 refer to baseline, 1st follow-up, and 2nd follow-up, respectively. Adjusted employment transitions refer to fitted values from single-equation probit regressions of "remained employed" ($n = 800$) and "returned to work" ($n = 1{,}303$) between Waves 1 and 3. Each probit includes measures of HAART status, age, education, risk factors, baseline health, and state unemployment using the same variables included in the employment equation shown in Table 3.

*Working at Wave 3 conditional on not working at Wave 1.

**Working at Wave 3 conditional on working at Wave 1.

average CD4 T-cell counts for the entire analysis sample, that is, both those working and not working at baseline. These statistics indicate that patients treated with HAART in late 1996 and early 1997 were more likely to be in the advanced stage of HIV (AIDS) than those not treated both prior to and after the HAART treatment was reported. They also had much lower CD4 T-cell counts. Since observed disease severity such as CD4 varies substantially between the treated and the nontreated groups, there is every reason to expect that unobserved severity also differs in a nontrivial way. This helps motivate the approach we take.

Table 3 presents the estimated models for the three employment outcomes. The two instrumental variables for HAART use have the expected negative effects in almost all cases. The Wald statistics for the joint significance of the two instrumental variables in predicting HAART receipt are 9.70

Table 3: Parameters Estimates from the Bivariate Probit Model of Employment and Treatment

	Return to Work			*Remain Employed*			*Hours of Work***		
	Coefficient	*S.E.*	*P-value*	*Coefficient*	*S.E.*	*P-value*	*Coefficient*	*S.E.*	*P-value*
Employment Equation									
HAART*	−0.10	1.51	0.95	1.45	0.19	0.00	18.55	15.43	0.23
Demographics									
Ages 25–29	0.72	0.27	0.01	−0.55	0.26	0.04	−4.53	2.63	0.09
Ages 30–34	0.29	0.26	0.28	−0.42	0.25	0.09	−3.19	2.48	0.20
Ages 35–44	0.16	0.24	0.52	−0.43	0.23	0.07	−3.77	2.67	0.16
Ages 45–49	0.12	0.24	0.62	−0.36	0.27	0.19	−5.04	2.97	0.09
Nonwhite	−0.03	0.18	0.87	0.22	0.11	0.04	0.61	1.31	0.64
Female	−0.38	0.14	0.01	−0.18	0.17	0.30	−6.62	1.82	0.00
Education									
High school diploma	0.24	0.14	0.09	0.22	0.18	0.22	6.45	3.29	0.05
Some college	0.40	0.15	0.01	0.11	0.18	0.54	2.73	1.52	0.07
College degree or higher	0.29	0.29	0.32	0.25	0.20	0.22	7.57	2.75	0.01
Risk Factors									
Exposure route—I.V. drug	−0.04	0.19	0.84	0.18	0.24	0.46	9.76	4.49	0.03
Exposure route—Men who have sex with men	0.06	0.15	0.68	0.17	0.16	0.28	0.94	2.14	0.66
Exposure route—Heterosexual	0.25	0.17	0.15	0.16	0.21	0.45	−1.50	2.34	0.52
Exposure route—Other	0.25	0.29	0.40	0.36	0.35	0.32	0.38	3.33	0.91
Baseline Health									
Stage of infection—AIDS	−0.33	0.32	0.30	−0.30	0.17	0.07	−4.53	1.85	0.02
Stage of infection—Symptomatic	−0.18	0.20	0.38	−0.13	0.14	0.35	−0.09	1.62	0.95
CD4 lymphocyte count (100 cells per mm^3)	0.16	0.10	0.10	0.20	0.07	0.01	0.04	0.02	0.03
CD4 squared	−0.01	0.01	0.26	−0.01	0.01	0.31	0.00	0.00	0.02
Other									
State unemployment rate (97–98)	0.02	0.05	0.68	−0.01	0.05	0.86	−0.51	0.56	0.36
Constant	−1.60	0.63	0.01	−0.01	0.41	0.98	27.71	6.99	0.00
HAART Equation									
A limit of 3 prescriptions per month by Medicaid	−0.20	0.19	0.30	0.01	0.17	0.94	−0.03	0.06	0.59
No coverage of NNRTIs by the state ADAP	−0.20	0.12	0.09	−0.37	0.12	0.00	−0.09	0.05	0.06

Demographics									
Age 25–29	0.32	0.20	0.11	0.39	0.25	0.12	0.07	0.08	0.44
Age 30–34	0.33	0.18	0.06	0.30	0.23	0.18	0.07	0.08	0.34
Age 35–44	0.27	0.17	0.11	0.41	0.21	0.06	0.10	0.07	0.15
Age 45–49	0.09	0.19	0.64	0.44	0.24	0.07	0.11	0.08	0.18
Nonwhite	−0.26	0.08	0.00	−0.27	0.10	0.01	−0.05	0.04	0.14
Female	−0.12	0.10	0.25	0.11	0.18	0.55	0.05	0.06	0.43
Education									
High school diploma	0.17	0.10	0.08	0.05	0.19	0.79	−0.16	0.08	0.05
Some college	0.19	0.11	0.07	0.26	0.18	0.16	−0.02	0.05	0.70
College degree or higher	0.45	0.14	0.00	0.34	0.19	0.07	−0.12	0.07	0.08
Risk Factors									
Exposure route—I.V. drug	−0.17	0.14	0.23	−0.42	0.25	0.09	−0.21	0.12	0.08
Exposure route—Men who have sex with men	0.04	0.12	0.72	−0.01	0.15	0.93	0.10	0.06	0.09
Exposure route—Heterosexual	0.01	0.14	0.95	−0.15	0.21	0.49	0.12	0.06	0.04
Exposure route—Other	0.24	0.21	0.25	−0.40	0.34	0.25	0.19	0.06	0.00
Baseline Health									
Stage of infection—AIDS	0.40	0.20	0.04	0.20	0.16	0.21	0.06	0.06	0.31
Stage of infection—Symptomatic	0.07	0.20	0.71	0.23	0.14	0.09	0.06	0.05	0.24
CD4 lymphocyte count (100 cells per mm^3)	−0.15	0.04	0.00	−0.30	0.07	0.00	−0.10	0.02	0.00
CD4 squared	0.01	0.00	0.10	0.01	0.01	0.10	0.00	0.00	0.05
Constant	−0.53	0.28	0.06	−0.10	0.32	0.76	0.46	0.11	0.00
rho	0.09	0.92	0.92	−0.89	0.09	0.00			
N	1,303			800			870		

*Measured at the first follow-up;

**Measured at the second follow-up.

Definition of analysis and prediction samples:
"Return to work": patients who were not working at baseline; "Remain employed": patients who were working at baseline; "Hours of work": patients who were working at the second follow-up.
The reference population in each of the three samples are those of ages 50–54, white, male, with less than high school education, uninsured, exposed to HIV because they are gay and IV drug users, and in asymptomatic stage of HIV.
"rho" is the estimated correlation coefficient of the two error terms in the bivariate probit model—Equation (3).

Table 4: Effects of ADAP Coverage on HAART Receipt

	Average Predicted Probability of HAART Receipt:		
Coverage of NNRTIs by State ADAP	*Return to Work Sample*	*Remain Employed Sample*	*Hours of Work Sample*
No	31%	33%	34%
Yes	38%	46%	44%
P-value for difference	0.09	<.01	0.06

ADAP = AIDS Drug Assistance Program.

Note: Results show mean fitted values for three different subpopulations (not working at baseline, working at baseline, and working at second follow-up respectively) assuming every state ADAP does or does not cover NNRTIs. Predicted values come from first-stage estimates of HAART receipt as shown in Table 3. Values for other covariates are assumed to remain constant.

($p = .01$) in the remain-employed model and 3.8 ($p = 0.15$) in the return-to-work model. One of the variables—coverage of NNRTIs by state ADAP programs—is statistically significant in all three estimated models. More importantly for policy purposes, however, is that this coverage variable explains a large fraction of variation in HAART treatment, as shown in Table 4. This table shows the fitted values for receipt of HAART for three different samples assuming all state ADAP programs either cover or do not cover NNRTIs. This variable has a large effect on HAART receipt in all models. For those working at baseline (the sample for the remain-employed model), state ADAP coverage increases the probability of efficacious treatment from 33 percent to 46 percent.

In terms of the employment equations, for "return to work" (the leftmost panel in Table 2), the coefficient on HAART has a negative sign but is not significantly different from zero, suggesting that HAART had almost no effect in helping the HIV patients return to work by the second follow-up survey. (We do find a positive effect of HAART when we restrict our attention to patients without public assistance, as described below.) The results also show that patients of age 25 to 29 (relative to age 50 or older) and patients with some college education (relative to less than high school education) were significantly more likely, and female patients were significantly less likely, to have returned to work by the end of the study.

For HIV patients who were working at baseline, HAART had a large effect on their chances of remaining employed ($p < 0.01$; the middle panel in Table 3). Older patients were more likely to remain employed. Being nonwhite and having higher CD4 counts were also associated with higher probability of remaining employed. For those who were working at the second follow-up, HAART was associated with 16 additional hours of work per week

Table 5: Effects of HAART in the Base Case and with Specification Checks

	Employment Outcomes					
	Return to Work		*Remain Employed*		*Hours of Work*	
Specification	*w/o HAART*	*w/HAART*	*w/o HAART*	*w/HAART*	*w/o HAART*	*w/HAART*
Base case	0.16	0.14	0.57	0.94	29.7	48.2
	(0.13)	(0.19)	(0.06)	(0.01)	(6.6)	(8.9)
Specification checks						
Add insurance	0.15	0.14	0.58	0.94	31.7	45.8
	(0.10)	(0.19)	(0.07)	(0.01)	(6.1)	(8.2)
Employer-sponsored insurance only*	N/A		0.45	0.95	32.8	50.2
			(0.03)	(0.01)	(6.5)	(6.3)
No participation in welfare programs*	0.22	0.77	N/A		N/A	
	(0.03)	(0.03)				

Notes: Results show the mean predicted values for the three employment outcomes with and without HAART. Sample sizes in the base case are 1,303 for return to work, 800 for remain employed, and 870 for hours of work. For the specification checks, the sample was restricted to the subpopulations as noted. Employer-sponsored insurance and participation in welfare programs are based on reports at either baseline or first follow-up. For employer-sponsored insurance, sample sizes are 409 (remain employed) and 393 hours of work. Information on coverage in previous jobs is unknown so the return to work case cannot be estimated. The sample size for nonparticipants in welfare programs in the scenario of return to work is 210.

(the rightmost panel in Table 3) although the effect was not statistically significant. Being female, having a high school diploma or college, and better baseline health (no AIDS diagnosis and higher CD4 counts) were all associated with increased hours of work.

The upper panel in Table 5 shows the average predicted probabilities associated with HAART use. HAART is associated with a small decrease in the probability of returning to work from 0.16 to 0.14 with relatively large standard errors. When we focus on the group who were working at baseline, the effect of HAART is a highly significant—and substantively important—increase in the likelihood of remaining employed from 57 percent to 94 percent. Finally, for those who were working at the second follow-up, the effect of HAART is an increase in hours of work from 29.7 hours to 48.2 hours per week. This increase, while sizeable, is not statistically significant.

The lower panel of Table 5 shows the results of several specification checks. By adding insurance variables in both the employment and the HAART equation, we derive results that are quite similar to those from the main analysis. This indicates that results are insensitive to the different specifications of the insurance variables. The second specification check is to see if employment-based health insurance would affect patients' chances of

remaining employed or their hours of work because of HAART. It is performed by restricting the analysis sample to patients who reported only employment-based health insurance at baseline or the first follow-up. The results suggest that while the effect of HAART on "remaining employed" is about 10 percentage points larger than in the main analysis, the effect on hours of work is about one hour smaller. We conduct the third specification check by restricting the sample for "return to work" to those who did not participate in public income assistance programs (at either baseline or the first follow-up) including the former Aids for Families with Dependent Children (AFDC), the Supplemental Social Security Income (SSI), and the Social Security Disability Income (SSDI). Conditional on not receiving assistance from any of the three programs, HIV patients in our data are shown to have an increase in the probability of returning to work from 0.09 to 0.16 ($p<0.01$).

Distributional assumptions aside, as in all IV-based studies, the credibility of our study rests on the believability of our instruments. Our state policy instruments could fail in at least two ways. First, the estimators perform poorly if the instruments are only weakly correlated with the treatment variable—that is, treatment with HAART (Nelson and Startz 1990; Bound, Jaeger, and Baker 1995; Staiger and Stock 1997). Thus, we report Wald statistics for the joint significance of our two instruments predicting HAART insurance status. Second, our instruments might be correlated with unobserved determinants of work (like unmeasured health status). The assumption that an instrumental variable is uncorrelated with the outcome measure cannot be directly tested. For these reasons, some researchers have argued that IV estimates in this context should be viewed with caution (Bound, Jaeger, and Baker 1995). However, in our application, it seems clear that patients have little direct influence at an individual level on state policies, so our state policy instruments are prima facie exogenous. This argument is not enough to establish exogeneity, however, if there are unobserved state-level characteristics that determine both work and HAART status. In that case, state policies would be endogenous in our model despite the lack of control by patients over these policies. As an indirect test of this hypothesis, we added a dummy variable for California or New York to our model, since these states seem different in many ways from the others and might yield large fixed effects. The results did not change appreciably and the dummy variable was insignificant.

As a simple welfare analysis, we can impute the incremental earnings for HIV patients who remain employed.[8] The mean hourly wage of patients who were working at both baseline and the second follow-up is $16.60. Since patients work on average about 30 hours per week (and given 50 weeks of

work annually), incremental annual earnings due to HAART are \$9,213 for patients who remain employed (= [0.94 – 0.57]*30 hours per week × 50 weeks × \$16.60 per hour). It should be noted that what we calculate here is an approximation of the incremental earnings by the individuals because of HAART.[9]

DISCUSSION

Our findings suggest that the new pharmacological therapy for the treatment of HIV improves employment outcomes. In particular, HAART is especially effective in helping working patients remain employed. For this group of people, our results suggest that the social cost of providing HAART may be justified solely based on improved productivity. Furthermore, since the group of HIV patients in our sample who did not take HAART could be on other therapies (like mono-, dual, or triple antiretroviral therapies that do not meet the definition of HAART) or with no antiretroviral treatment, treatment with HAART would look more favorable if the incremental earnings are compared to the incremental costs of taking HAART (versus other non-HAART treatment including no treatment).

The heterogeneity in the effect of HAART across the three employment scenarios could be explained in a number of ways. First, it may reflect different responses to the treatment by patients at different stages of HIV infection, since the definitions of the three analysis samples are closely related to baseline severity of the infection. (For example, patients in the "return to work" sample had a much higher rate of AIDS and lower CD4 T-cell counts at baseline than patients in the other two samples; statistics not shown.) Our results suggest that patients in relatively early stages of HIV infection are more likely to see improved functioning when treated with HAART.

Second, the lack of significant results found in the scenarios of "return to work" may reflect the different value placed on work by patients at different stages of HIV. For example, knowing that one has AIDS, and hence very limited life expectancy, may drastically increase patients' preferences for leisure relative to labor/consumption. Therefore, even if functioning were restored to the same extent, it would be much harder to get one AIDS patient back to work than a patient at an earlier stage of the infection.

Third, the three employment scenarios we study are of a very different nature even among the general population. Factors other than physical fitness and functioning—for example, institutional constraints on number of hours of

work—play equally important and sometimes much more important roles in individuals' employment. Thus, all else equal, it would be much harder for a person who is either unemployed or disabled to return to work than for a worker to remain employed. This could be especially true among the HIV+ population because of the stigma and workplace discrimination attached to the disease.

Our specification checks provide some evidence for the existence of HAART-specific employment-lock: the with-and-without-HAART difference in the predicted probability of remaining employed is 10 percentage points larger for patients with employment-based insurance than what is implied by the unrestricted analysis. However, given that our IVs are based on variation in public programs, and HIV patients with employment-based insurance are less likely to be affected by public program coverage policies, this finding deserves more research. On the other hand, while we found almost no effect in the scenario of "return to work" in the main analysis, once we restricted our attention to patients without any program participation, we found a strong positive effect on returning to work. This suggests—not surprisingly—that there may be strong disincentives to work to maintain public assistance.

The 12-month mortality rate of the HIV+ population was 5 percent at the baseline interview and 7 percent at the first follow-up survey (Goldman et al. 2001b). In this paper, we restrict our sample to patients of prime working age who were alive at the second follow-up survey, which, compared to the unrestricted sample, were likely to be healthier or more advantaged in other dimensions. Although we controlled for essential indices of severity of the infection (CD4 T-cell count and stage of the disease) in the model, there might be other differences between those who would and those who would not die that are not measured by clinical or sociodemographic characteristics in the model. Furthermore, since HAART prolongs survival, some of the survivors may be too sick to work in any event. Analyses including these marginal survivors tend to understate the effects of HAART on employment. This might partly explain the lack of effect of HAART on "returning to work."[10] Therefore our results should be interpreted as pertaining to those who are not at great risk of mortality during the course of the survey.

To see how the estimated effect of HAART might be different if we had an unrestricted sample, we include those who died between the baseline and second follow-up survey, and coded their employment status at the second follow-up survey as 0.[11] This would add 188, and 30 observations to the sample of "return to work," and "remain employed," respectively. However,

the estimated effects of HAART on patients' employment outcomes are almost identical as in the original analysis.

The estimated employment effect of HAART applies to a time when the therapy was first introduced. Effects at a later time might be of a different magnitude. On the one hand, better knowledge on effective regimens at a later time makes the therapy more effective, and therefore would lead to larger employment effect. On the other hand, at a later time, there will be more long-term users and fewer first-time users in the user group. If there is decreasing returns to HAART in employment outcome or if there are serious side effects associated with long-term use of HAART, the effect might be smaller than estimated in this study. However, our findings indicate that HAART makes workers more productive.

NOTES

1. CD4+T cell count is a critical measure of the function of a patient's immune system. Depletion of these cells is strongly correlated with the worsening of the HIV infection and risk of developing AIDS (Harrison et al. 1997).
2. HAART was defined as using a protease inhibitor (PI), a non-nucleoside reverse transcriptase inhibitor (NNRTI), or a nucleoside reverse transcriptase inhibitor (NRTI) in various combinations. For example, HAART includes two or more NRTIs in combination with at least one PI or one NNRTI; and one NRTI in combination with at least one PI and at least one NNRTI. Combinations of older drugs such as zidovudine, which is an NRTI, with either a PI or NNRTI were not considered HAART.
3. The final analytic weight is the product of the sampling weight, the multiplicity weight, and the nonresponse weight. The sampling weight adjusts for the probability of being chosen to participate in the study; the multiplicity weight adjusts for patients who could have entered the sample through multiple providers; and the non-response weight adjusts for differential cooperation. More details are given in Duan et al. (1999).
4. Among states that specified monthly limits on number of prescriptions in their Medicaid program, most had a limit of five or six prescriptions per month (these states are California, Florida, Georgia, Mississippi, and North Carolina), and the other three states (Texas, South Carolina, and Nevada) limited monthly prescriptions to three. Of the five states with a limit of five or six prescriptions, California, Florida, and North Carolina had above-average HAART utilization in the HCSUS. Georgia and Mississippi had very few observations in the data. Also, more recent data on state Medicaid coverage policies indicate that for California and Florida, antiretroviral drugs were exempted from the monthly prescription limit. (In a reduced-form probit analysis on the probability of having HAART, the

dichotomous variable indicating a Medicaid limit of five to six prescription drugs is associated with *more* use of HAART.)

5. To maintain consistency with other HCSUS studies, we subsequently refer to the second wave as "first follow-up" and the third wave as "second follow-up." Baseline is, of course, the first wave.
6. We also estimated HAART treatment in the first stage using a probit instead of a linear probability model to maintain consistency with the other outcomes. Using a nonlinear first stage did not change outcomes. Similarly, a log-linear specification for hours worked did not yield substantively different results.
7. What is sometimes seen in the empirical literature is a nonlinear two-step procedure. In the first stage, a probit model for the endogenous treatment variable is estimated as a function of the instrumental variables and other covariates. In the second stage, the predicted probability from the first stage is "plugged-in" to estimate the treatment effect. However, when the outcome variable is dichotomous—unlike in the case where the outcome variable is continuous as in "hours of work"—it has been shown that the two-stage procedure does not, in general, produce the structural parameter of interest with a few notable exceptions (Bhattacharya, McCaffrey, and Goldman 1999). The bivariate probit consistently outperforms the two-step probit procedure if the error terms are specified correctly.
8. When labor supply increases, the incremental earnings are an adequate depiction of welfare change in the labor market only when the labor demand is perfectly elastic (Deleire and Manning 2004). However, given that the HIV+ population is not a large enough group to impact the equilibrium of the labor market dramatically, the employment-related welfare effect of treatment with HAART is not likely to deviate significantly from what is calculated here.
9. The imputed wage rate (derived from reported earnings of those who were working at the second follow-up) is likely to be higher than what would have been received by those not working had they been working with the help of HAART. On the other hand, the assumption of 30 hours of work per week is a conservative one.
10. We thank one of the reviewers for pointing out this potential survivor bias.
11. For those who died by the first follow-up survey (and thus had missing data on HAART treatment at the first follow-up), we coded their treatment with HAART as 1. Such recoding will produce estimates that are conservative relative to the real effects of HAART.

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