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Health, Medical Innovation and Disability Insurance: A Case Study of HIV Antiretroviral Therapy

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Paper No. 182
September 2015

ISSN: 1525-3066

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Abstract

This study examines the effect of health on SSDI outcomes. The effect is identified by a new antiretroviral therapy to treat the human immunodeficiency virus. Administrative data on SSDI applications come from the Disability Research File. According to the analysis, the new therapy had an immediate and persistent effect on program entry. By 1997, the therapy decreased applications by 35.2 percent and new awards by 36.7 percent. Among existing beneficiaries, the therapy decreased program exits through death, but did not substantially increase program exits for work. By 1999, the therapy increased HIV-related expenditures by $43.6 million.

JEL No. H51, I18

Keywords: Health, HIV, Social Security, Disability Insurance

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*The author thanks Kimberly Burham, Jeffrey Kubik, Timothy Moore, and David Pattison for helpful comments and suggestions. The author also thanks Patrice Cole for valuable data assistance. This research is supported by a personnel agreement between Syracuse University and the Social Security Administration. The views herein are the authors and do not reflect those of the Social Security Administration.

I. Introduction

During the past three decades, the US Social Security Disability Insurance (SSDI) program more than tripled in size, increasing from 2.66 disabled worker beneficiaries in 1985 to 8.95 million in 2014.[1] This growth – described by Autor and Duggan (2006) as a "fiscal crisis unfolding" – has raised questions about whether the program targets the disabled population effectively. Central to these questions are whether disabled worker beneficiaries are truly unable to work and, if so, whether the inability to work is due to health versus non-health factors, such as the demand for low-skilled labor.[2] To address these questions, this study examines the effect of health on SSDI outcomes, including the choice to apply for and receive SSDI benefits. If disabled worker beneficiaries are unable to work, and if the inability to work is due to health, then health should be an important determinant of SSDI outcomes.

To identify the effects of health, this study focuses on a specific yet effective medical innovation: a new antiretroviral therapy introduced in late 1995 and early 1996 to treat the human immunodeficiency virus, or HIV. The effects of health are measured by changes in SSDI outcomes when the therapy was introduced. The empirical strategy has been described by Currie and Madrian (1999) as the "production function" approach to identification, as changes in health are derived from specific inputs of the health production process.[3]

[1] Figures on the number of beneficiaries come from the Social Security Administration Annual Statistical Supplement 2015 (Table 5.D3).

[2] Studies on the employment effects of SSDI benefits include Bound (1989); Chen and van der Klaauw (2008); French and Song (2014); Parsons (1980); Singleton (2012); and von Wachter, Song, and Manchester (2011).

[3] Currie and Madrian (1999) recommend the production function approach to identify the effects of health on labor market outcomes. As an example, Garthwaite (2012) examines the labor-supply effects of Cox-2 inhibitors, anti-inflammatory drugs marketed under the brand names Vioxx, Celebrex, and Bextra.

HIV causes acquired immunodeficiency syndrome, or AIDS. By weakening the immune system, AIDS increases the likelihood of opportunistic infections, cancers, and ultimately death. Before antiretroviral drugs, HIV was essentially untreatable, and AIDS was rapidly fatal (Institute of Medicine 2010). In 1981, when HIV was first reported in the US (CDC 2001), life expectancy after an AIDS diagnosis was just six months (Satriano, Berkman and Remien 2005). By 1995, 215 thousand people in the US lived with AIDS, and 50 thousands deaths were attributable to AIDS (CDC HIV Surveillance Report 2001), the eighth leading cause of death (CDC National Vital Statistics 1998). The effect of HIV/AIDS on the SSDI program was non-trivial. In 1994, approximately 33,000 disabled workers were awarded SSDI benefits for HIV/AIDS, representing five percent of all new SSDI beneficiaries that year.[4]

Health outcomes dramatically improved after the introduction of new antiretroviral drugs. These drugs formed the basis of a highly active antiretroviral treatment, or HAART. To illustrate the effect of HAART on aggregate mortality, **Figure 1** plots the annual number of AIDS-related deaths from 1991 to 2001. As shown, deaths climbed steadily during the early 1990s, reaching 50 thousand deaths in 1995. However, deaths declined sharply in 1996, just after HAART was introduced. From 1995 to 1997, AIDS-related deaths declined by 57.4 percent.[5] HAART also improved functional health, including the capacity and propensity to work (Goldman and Bao 2004).

[4] The figure is derived from the Annual Statistical Report on the Social Security Disability Insurance Program, 2000 (Table 18). In 1994, 36,087 new SSDI awards for disabled workers were attributable to infectious and parasitic diseases, but approximately 3,394 awards were not attributable to HIV/AIDS. To calculate the latter estimate, the number of awards for infectious and parasitic diseases was averaged across years 1985 to 1989, when new awards for HIV/AIDS had been categorized as "other".

[5] Duggan and Evans (2008) find similarly large effects of AR drugs on mortality using individual level data from Medicaid and Medicare.

This study examines how improvements in health, identified by HAART, affected the SSDI program. On one hand, improvements in health should decrease benefit receipt, either by decreasing program entry among existing workers or increasing program exit among existing beneficiaries. On the other hand, improvements in health may increase benefit receipt by decreasing program exits through death. Thus, the effect of health on the size of the SSDI program is ambiguous.

Administrative data on SSDI applications come from the Disability Research File (DRF). The DRF reports characteristics of the applicant and details of the application. For this study, the sample is restricted to workers who filed for SSDI benefits in 1992 to 2000, who reported HIV as the primary or secondary disability, and who were ages 25 to 54 at the time of application. The DRF is linked to the Summary Earnings Record, which reports an applicant's annual earnings from 1980 to 1999, and to the Numident, which reports an applicant's date of birth and, if applicable, date of death. These data are used to measure pre-application earnings and mortality outcomes, respectively.

The empirical analysis yields several findings. First, HAART had an immediate and persistent effect on program entry. By 1997, HAART reasonably decreased HIV-related applications by 35.2 percent and new awards by 36.7 percent. Second, HAART substantially decreased mortality among existing beneficiaries, but did not substantially increase program exit for work. For example, among new beneficiaries in 1995, HAART decreased mortality in 1997 by 13.7 percentage points, but increased the share of beneficiaries with earnings above the substantial gainful amount by just 2.6 percentage points.

The effects of HAART are also examined across categories of socioeconomic status, measured by pre-application earnings. As shown, the effects of HAART on SSDI outcomes

were greater among workers of higher socioeconomic status. One interpretation is that the demand for benefits among workers of higher socioeconomic status is primarily due to health, whereas the demand for benefits among workers of lower socioeconomic status is due to non-health factors.[6] An alternative interpretation is that workers of higher socioeconomic status were in poorer health at the time of application and that, according to medical research, HAART was more effective at advanced stages of HIV/AIDS.

The empirical analysis also estimates the effect of HAART on SSDI expenditures. To derive these estimates, the analysis approximates both actual expenditures and predicted expenditures had HAART not been introduced. These estimates suggest that, by calendar year 1999, HAART had actually increased expenditures by $43.6 million. The increase in expenditures reflects that, in the short run, the increase in expenditures due to decreased mortality exceeded the decline in expenditures due to decreased program entry.

The results from this study contribute to a broader literature on health and SSDI outcomes. According to this literature, SSDI outcomes are associated with numerous measures of health, including self-reported global health (i.e. good, fair, etc.), health conditions (e.g. musculoskeletal, cardiovascular, etc.), and work limitations.[7] However, these associations likely overstate the causal effects of health, as workers may exaggerate the severity of their disabilities to qualify for benefits.[8] In contrast to related studies, this study relies on plausibly exogenous

[6] Autor and Duggan (2006) question whether the SSDI program serves as employability insurance, rather than disability insurance.
[7] Studies in this literature include Bound (1989), Meyer and Mok (2013), Nagi (1969), and Singleton (2014).
[8] Similarly, the association between self-reported health and labor market outcomes likely overstates the causal effects of health, since workers may justify poor labor market outcomes by claiming poor health (Bound 1991). This has been referred to as justification bias in the literature on health and labor supply (Currie and Madrian 1999).

variation in health due to a medical innovation. Thus, the results from this study likely reflect health's causal effects.

The results suggest that improving population health may be effective at reducing the size of the SSDI program. Policies to improve health include expanding access to public health insurance and incentivizing medical innovation, particularly for health conditions associated with work-limiting disabilities. As this study shows, such policies may be more effective at reducing program entry among existing workers, rather than increasing program exit among existing beneficiaries. In fact, improving population health may actually increase decrease program exits through death. To address this issue, benefit eligibility could be reevaluated as health improves.

II. Background

A. SSDI Program

Workers who become disabled and unable to work may qualify for disability benefits through the SSDI program. To qualify, an applicant must have worked at least five of the last ten years and must be unable to engage in substantial gainful activity.[9] In 1995, substantial gainful activity was defined as the ability to earn $500 per month. If these criteria are satisfied, benefits are automatically awarded if an applicant's disability is listed on Social Security's Listing of Impairments. The listing enumerates medical conditions that are both medically identifiable and deemed limiting of substantial gainful activity. If an applicant's disability is not on the listing, benefits are awarded using a vocational grid, which translates an applicant's characteristics – such as age, education, and vocational skills – into an award outcome. The

[9] A worker must also be younger than the normal retirement age, which ranges from 65 to 67 depending on one's year of birth, and the disability must be expected to last at least six months or result in death.

likelihood of award increases with age and decreases with education and skills. Applicants who are denied benefits may appeal the decision at multiple levels, up to the Federal Court.

The baseline monthly benefit – referred to as the Primary Insurance Amount (PIA) – is a progressive function of an applicant's past earnings. To calculate the PIA, past annual earnings are adjusted to current dollars using an average wage index. Earnings are then averaged across years – excluding some of the lowest earning years – and divided by 12. This calculation yields the average index monthly earnings (AIME). The AIME is then converted to the PIA using a progressive formula. In 2010, the PIA equals 90 percent of the AIME up to $761, yielding a PIA of $685. The marginal rate drops to 32 percent from $761 to $4,586 and to 15 percent from $761 onwards. In addition to the PIA, a disabled worker is eligible for Medicare coverage after two years of benefit receipt, and the spouse and children of a disabled worker may be eligible for benefits as dependents.

Once entitled, few disabled worker beneficiaries exit the SSDI program through increased earnings or improved health. In 2010, benefits were terminated for 640 thousand disabled workers, representing 7.8 percent of all disabled worker beneficiaries that year (SSA 2010).[10] Of these exits, 52.3 percent were transfers to the retirement benefits program, and 35.4 percent were due to death. Exits through increased earnings and improved health were just 6.4 percent and 3.1 percent, respectively.

B. Health and SSDI Outcomes

This study examines health as a determinant of SSDI application and receipt. The link between health and SSDI outcomes reflects multiple channels. First, poor health increases the likelihood of benefit award, thereby increasing the generosity of disability benefits. Second,

[10] These figures come from the Annual Statistical Report on the Social Security Disability Insurance Program, 2010.

poor health decreases productivity in the labor market, thereby decreasing the opportunity cost of benefit receipt. Both mechanisms increase the relative generosity of SSDI benefits and, as a result, the propensity to apply for and receive benefits.

The predictions regarding health and SSDI outcomes are supported by empirical research. First, SSDI applicants appear to be in poorer health than non-applicants. Using self-reported data, Bound (1989) finds that applicants are more likely to report work limitations and previously diagnosed health conditions compared to non-applicants. And, using longitudinal data, Singleton (2014) finds that disability onset increases the likelihood of SSDI application.

Second, applicants who are awarded benefits appear to be in poorer health than applicants who are denied. Nagi (1969) conducts clinical evaluations, independent of the Social Security Administration, and finds that functional health is poorer among accepted applicants. Using longitudinal data, Meyer and Mok (2013) and Singleton (2014) find that disability onset is associated with an increase in SSDI receipt. And, using administrative data matched to mortality records, Singleton (2012) finds that accepted applicants have higher rates of mortality compared to rejected applicants. These findings suggest that the SSDI program is somewhat effective at screening applicants based on health.

Although poor health is associated with SSDI outcomes, these associations may be biased measures of health's causal effects. The biases are similar to those discussed in the literature on health and labor market outcomes (Bound 1991; Currie and Madrian 1999). On one hand, the associations between SSDI outcomes and subjective measures of health – such as global health and disability status – likely overstate the effects health, as workers may exaggerate the severity of their disabilities to qualify for benefits. On the other hand, the associations between SSDI outcomes and objective measures of health – such as diagnosed health conditions and subsequent

mortality – likely understate the effects of health, since not all health measures affect work capacity.

C. SSDI and HIV/AIDS

To examine the effect of health on SSDI outcomes, this study focuses on the introduction of HAART in late 1995 and early 1996. HAART is a combination of antiretroviral drugs to treat HIV. In 1981, when HIV was first reported in the US, HIV was essentially untreatable, and AIDS was quickly fatal. By 1996, HIV/AIDS became the eighth leading cause of death (CDC National Vital Statistics 1998). Health outcomes drastically improved, however, with the introduction of HAART. As studies show, HAART decreased mortality by 70 percent (Evans and Duggan 2008) and improved functional health and work capacity (Goldman and Bao 2004). This study examines how improvements in health, identified from the introduction of HAART, affected the SSDI program.

Mentioned above, an applicant can qualify for benefits by meeting or exceeding the requirements outlined in Social Security's Listing of Impairments. The listing for HIV/AIDS, last updated in 1993, requires an applicant to be medically diagnosed with HIV or AIDS and to exhibit at least one opportunistic infection such as shingles, pneumonia, and certain skin cancers (Institute of Medicine 2010). An applicant who does not meet the listing may still qualify for benefits through the vocational grid. Importantly, the eligibility standards for HIV/AIDS did not change once HAART was introduced.

III. Data

A. Disability Research File

Administrative data on SSDI applications come from Disability Research File (DRF). All applications for SSDI benefits are recorded in the DRF once the case is adjudicated. The file includes characteristics of the applicant, including age, sex, and educational attainment. The file also includes information about the disability application, including the date of file, the primary and secondary disabilities, and the award outcome.

The DRF has been merged to two additional data files used in the analysis. The first is the Summary Earnings Record, which reports earnings annually from 1980 to 1999. The data are compiled from W-2 forms filed with the Internal Revenue Service. Earnings are reported up to the Social Security taxable maximum, beyond which payroll taxes are not levied. In 1994, the taxable maximum was $60,600. The second data file is the Numident, which contains an applicant's date of birth and, if applicable, date of death. Dates of death are compiled primarily from vital statistics of the Center for Disease Control and Prevention.

For this study, several restrictions are imposed on the DRF. First, the sample is restricted to applications filed in 1992 to 2000. These years adequately span the introduction of HAART, which occurred in late 1995 and early 1996. Second, the sample is limited to applications by disabled workers, thus excluding applications by disabled spouses and widows. Third, the sample is restricted to applicants who report HIV/AIDS as the primary or secondary disability. This addresses the concern that workers continue to apply for SSDI benefits, but report HIV/AIDS as a secondary disability, rather than a primary disability, once HAART becomes available. Finally, the sample is restricted to applicants who are aged 25 to 54 at the time of application. This limits the analysis to applicants of working age who have some work history. The remaining sample contains approximately 250 thousand applications.

B. Sample Summary

Summary statistics of HIV-related applicants are reported in the first column of **Table 1**. To characterize applicants just before HAART was introduced, the sample is limited to applicants in 1994. Listed first are demographic characteristics, including age, sex, and race. For comparison, similar characteristics for the general population were tabulated using the 1994 March Supplement of the Current Population Survey.[11] In comparison to the population, HIV-related applicants are slightly younger (36.9 versus 38.2), are more likely to be male (88.3 percent versus 49.4 percent), and less likely to be white (79.8 percent versus 92.7). Applicants also have lower earnings prior to application ($14.7 thousand versus $22.1 thousand).[12]

To examine educational attainment, 18.0 percent of applicants in 1994 must be omitted due to missing values. Summary statistics of the remaining sample are reported in column two of **Table 1**. The distribution of educational attainment is shown in the final three columns of **Table 1**, which report summary statistics across three categories of education. The categories are less than a high school diploma, a high school diploma only, and a college degree. According to the sample counts in the final three columns, applicants appear to be less educated than the general population. In particular, applicants are more likely to have less than a high school diploma (21.6 percent versus 13.1 percent), more likely to have a high school diploma only (65.3 percent versus 33.9 percent), and substantially less likely to have a college degree (12.9 percent versus 33.9 percent).

Table 1 also reports information about the socioeconomic status and health of HIV-related applicants. As shown in the first column, 67.4 percent of SSDI applicants applied concurrently for disability benefits through the Supplemental Security Income (SSI) program. A

[11] Statistics are tabulated using sampling weights.
[12] Pre-application earnings are calculated as the average of three years of annual earnings prior to the calendar year of application.

concurrent application is an indicator of low socioeconomic status, since the medical eligibility standards of both programs are the same, but the SSI program requires beneficiaries to have low income and assets. Nearly all applications reported HIV as the primary disability (92.1 percent) and reported HIV-related symptoms at the time of application (83.9 percent, respectively). The benefit award rate was 70.5 percent at the initial determination and 78.5 percent after the appeals process. And in regards to subsequent mortality, 24.0 percent of applicants were deceased within one calendar year of application, and 40.9 percent were deceased within two calendar years.

Summary statistics by educational attainment are reported in the last three columns of **Table 1**. As shown, higher educational attainment is associated poorer health at the time of application. In comparison to applications with no high school diploma, applicants with a college degree were more likely to report HIV-related symptoms (92.2 percent versus 74.1 percent) and more likely to be deceased within two calendar years of application (50.3 percent versus 31.1 percent). Poor health is also evident by higher award rates at the initial level (85.8 percent versus 56.7 percent) and after the appeals process (91.0 percent versus 68.1 percent).

The negative association between education and health – which is evident among all SSDI applicants, not just those related to HIV (Singleton 2014) – suggests that more educated workers apply for benefits at later stages of disease. One possibility is that, despite poorer health, the gains from employment are greater for more educated workers. This is evident by average annual earnings reported in **Table 1**: applicants with a college degree earned $26.4 thousand prior to application, whereas applicants with less than a high school diploma earned just $8.1 thousand. Another possibility is that benefits are relatively less generous for more educated workers. Educated workers face a lower likelihood of award, particularly when the

award decision is based on the vocational grid, and receive benefits that are relatively less generous, due to a combination of higher earnings and a progressive benefit formula.

IV. Program Entry

The empirical objective is to examine how HAART affected SSDI outcomes. The analysis first examines the effect of HAART on program entry, measured by both applications and new awards attributable to HIV/AIDS. Changes in applications are a better indicator of benefit demand, since the application decision rests solely with workers. The award decision, however, is ultimately determined by the Social Security Administration.

A. Applications

The effect of HAART on HIV-related applications is examined graphically in **Figure 2**. Using data from the DRF, the figure plots the number of HIV-related applications annually from 1992 to 2000. As shown, applications decreased steadily during the early 1990s, but decreased sharply in 1996 and 1997, just after the introduction of HAART. Applications continued to decline after 1997, but at a much lower rate. The figure suggests that HAART had an immediate and persistent effect on HIV-related applications.

To quantify the effect, it is necessary to predict how applications would have evolved in the absence of HAART. One method of prediction is to extrapolate the trend before 1995 to after, corresponding to periods before and after HAART. For example, from 1993 to 1995, applications decreased an average of 2,186 per year, reaching 31,264 in 1995. If this trend would have continued, applications would have decreased to 29,078 and 26,892 in 1996 and 1997, respectively. However, the actual number of applications was 26,609 and 17,435 in 1996 and 1997, respectively. If the difference between the actual and predicted numbers is attributable

to HAART, then the therapy reasonably decreased HIV-related applications in 1997 by 9,457, or 35.2 percent.

One concern with this estimate is that the sharp decline in applications may be due to systematic factors that affected all applications, not just those related to HIV/AIDS. If so, the estimate would overstate the causal effect of HAART. To address this concern, **Figure 2** plots the number of all SSDI applications annually from 1992 to 2000. As shown, the number of applications trended downward from 1994 to 1998, but did not decrease sharply after 1995. This suggests that systemic factors cannot account for the decline in HIV-related applications after 1995.

An important consideration is whether the effect of HAART on applications varies across types of workers. For two reasons, the effect should be greater among workers of higher socioeconomic status. First, according to medical research, HAART was most effective at more advanced stages of HIV/AIDS. This means that the effect of HAART on health should be greatest among applicants of higher socioeconomic status, who appear to be in the poorer health at the time of application (**Table 1**). Second, the gains from employment are greater among applicants of higher socioeconomic status, evident by higher pre-application earnings (**Table 2**). This means that, as health improves, workers of higher socioeconomic status would be less likely to apply for SSDI benefits.

To test this prediction, **Table 2** reports the number of applications by categories of socioeconomic status and health. For each category, the table reports the number of applications in 1993 and 1995 and the average annual decline between these two years. To predict the number of applications in 1997, twice the average decline between 1993 and 1995 is added to the

number of applications in 1995. The difference between the actual and predicted number of applications in 1997 is taken as the causal effect of HAART.

As expected, the effect of HAART on applications was greater among workers of higher socioeconomic status. This is most evident across categories of pre-application earnings. Among the highest earnings category – $20 thousand or more – HAART decreased applications by approximately 59.7 percent. Among the lowest earnings category – less than $10 thousand – HAART decreased applications by just 20.8 percent. Another indicator of socioeconomic status is a concurrent application for SSI benefits. As shown, HAART decreased applications for SSDI benefits singly by 40.7 percent, but decreased concurrent applications by just 27.9 percent.

The decline in applications was also greater among categories of poorer health. Poor health is measured by whether the applicant reported HIV as the primary disability and by whether the applicant exhibited HIV-related symptoms at the time of application. While the results by health are consistent with the predictions above, as poor health is associated with higher socioeconomic status (**Table 1**), the results may also reflect the direct of HAART on health, independent of socioeconomic status.

B. Awards

The effect of HAART on benefit awards is estimated using the same methodology above. To estimate the number of awards each year, the number of HIV-related applications plotted in **Figure 2** is factored by the annual award rate for HIV-related applications plotted in **Figure 3**. As **Figure 3** shows, the award rate for HIV-related applications decreased gradually from 1992 to 2000. Based on these figures, the number of awards in 1993 and 1995 was 27,867 and 21,353,

respectively.[13] Thus, new awards decreased by 3,257 per year before HAART was introduced. If this trend had continued in the absence of HAART, the number of new awards in 1996 and 1997 would have been 18,096 and 14,839, respectively. However, the actual number of awards in 1996 and 1997 was 26,630 and 9,397, respectively. Thus, HAART reasonably decreased the number of HIV-related awards in 1997 by 5,442, or 36.7 percent.

C. Award Rate

According to the analysis above, the introduction HAART had an immediate effect on HIV-related applications and awards. To attribute these changes to improvements in health, it is necessary to rule out alternative mechanisms. One alternative mechanism is that the Social Security Administration tightened eligibility standards after HAART was introduced, and tightened standards independently decreased both applications and awards. Although the statutory standards of eligibility did not change, as described above, the standards may have been applied more stringently nonetheless.

One measure of stringency is the rate of benefit award. As shown in **Figure 3**, the rate of award decreased from 1992 to 2000. While this decrease may reflect increased stringency, it may also reflect a change in the composition of applicants due to improvements in health. Indeed, as **Table 2** shows, HAART decreased applications among workers who were more likely to be awarded benefits. To measure a systemic change in stringency, while simultaneously controlling for the composition of applications, the following model is estimated:

$$Y_{it} = \alpha + \beta Year_{it} + \gamma HAART_{it} + \delta X_{it} + \varepsilon_{it}.$$

[13] These estimates are lower than the estimate presented in the introduction of 33 thousand new beneficiaries in 1994. The estimates here are limited to ages 25 to 54 and the award rate does not include appeals beyond the administrative law judge.

The outcome Y_{it} represents the award outcome, equaling one if benefits are awarded and zero otherwise. The variable $Year$ is the calendar year, which controls for a linear trend in the award rate. The variable $HAART$ indicates periods after HAART was introduced, equaling one for years after 1995 and zero otherwise. The vector X contains characteristics of the applicant, including age, sex, race, state-fixed effects, and pre-application earnings.

The coefficient of interest is γ, which represents the differential change in the award rate after HAART relative to the pre-existing trend. To measure the change in the award rate from 1995 to 1997 relative to the pre-existing trend from 1993 to 1995 – consistent with **Tables 2 and 3** – the sample is restricted to years 1993, 1995, and 1997. Without demographic controls, the estimate of γ reflects both tightened eligibility standards and changes in the composition of applications. The estimate, reported in the in the first column of **Table 3**, is -4.5 percentage points and statistically significant. With demographic controls, the estimate of γ reflects tightened eligibility standards, controlling for changes in the composition of applications. In this case, the estimate, reported in the second column of **Table 3**, is -0.22 percentage points and statistically insignificant. Together, the results suggest that the differential decline in the award rate after HAART was introduced, of 4.5 percentage points, is due largely to a change in the composition of applicants, not tightened eligibility standards.

V. Program Exit

The introduction of HAART may have affected program exit among existing beneficiaries. On one hand, improvements in health could increase program exit by increasing the capacity and propensity to work. On the other hand, improvements in health could decrease program exit through death. Thus, the net effect of HAART on program exit is ambiguous.

The analysis focuses on disabled workers who were awarded benefits just before HAART was introduced. **Table 4** reports summary statistics of new HIV-related beneficiaries by year of award. This allows for a comparison of new beneficiaries in 1994 to all applicants, regardless of award outcome, reported in **Table 1**. Compared to all applicants, new beneficiaries were more likely to report HIV-related symptoms at the time of application (96.6 percent versus 83.9 percent) and had greater earnings prior to application ($17.1 thousand versus $14.7 thousand). These results are consistent with previous findings that accepted applicants are in poorer health – and had greater attachment to the labor market – compared to rejected applicants (Singleton 2012). New beneficiaries are also more likely to be older (37.1 years versus 36.8 years), male (90.5 percent versus 87.6 percent), and white (58.2 percent versus 51.6 percent).

A. Mortality

Mortality outcomes of HIV-related beneficiaries are reported in **Table 5**. Statistics are reported separately by year of award, from 1992 to 1995, and by years since award, from zero to four. Years since award correspond to calendar years, with year zero as the year of award. Each statistic represents the cumulative share of beneficiaries who were deceased at the end each year, and the shaded region indicates years 1995 and earlier, before HAART was introduced.

The 1995 cohort is considered the last cohort to have been awarded benefits before HAART. As shown, mortality was initially high in years one and two, but decreased substantially thereafter. For example, 40.4 percent of beneficiaries died during years zero and one, but only 11.1 percent of beneficiaries died in years three and four. The simultaneous introduction of HAART and decrease in the marginal rate of mortality suggests that HAART decreased program exits through death.

To quantify this effect, it is necessary to predict how mortality would have changed in the absence of HAART. One method is to use mortality outcomes of earlier award cohorts, which were exposed to HAART at later years since award. For example, the 1994 cohort can be used as a comparison group for the 1995 cohort. In year zero, neither cohort was exposed to HAART; but, in year one, the 1995 cohort was exposed to HAART, while the 1994 cohort was not. Thus, the difference in mortality between cohorts, but within the same year since award, may be interpreted as the causal effect of HAART.

For the estimator to be unbiased, it must be assumed that the two cohorts would have had similar rates of mortality in the absence of HAART. This assumption is reasonably valid in regards to the cohorts in 1994 and 1995. Both cohorts have similar observable characteristics, including age, race, and pre-application earnings (**Table 4**), and both cohorts had similar rates of mortality in year zero, before HAART was introduced (**Table 5**). Thus, subsequent differences in mortality are likely due to HAART.

As shown, mortality in year one reached 40.4 percent among the 1995 cohort and 47.9 percent among the 1994 cohort. Thus, HAART reasonably decreased year-one mortality among the 1995 cohort by 7.5 percentage points. In subsequent years, the difference in mortality increases, despite the fact that the 1994 cohort was exposed to HAART in year two since award. In years two through four, the difference in mortality reaches 13.7 percent, 13.9 percent, and 13.1 percent, respectively.

Using the same methodology, **Table 5** reveals two additional findings. First, the effect of HAART on mortality appears larger after many years of treatment. For example, to identify the effect of HAART after three years of treatment, the 1992 cohort can be used as the comparison group for the 1995 cohort. By year three since award, the 1995 cohort had three years of

exposure, while the 1992 cohort had none. As shown, the difference in mortality reached 20.5 percentage points.

However, in this case, mortality of the 1992 cohort likely understates mortality of 1995 cohort had HAART not been introduced – a violation of the identification assumption described above. One reason is that, according to **Table 4**, the health of new beneficiaries became progressively worse from 1992 to 1995, evident by the share of beneficiaries reporting HIV-related symptoms. Another reason is that, according to **Table 5**, year-zero mortality was lower among earlier cohorts. If mortality of the 1992 cohort indeed understates mortality of 1995 cohort, then the differences in mortality between the two cohorts likely understate the causal effects of HAART.

A second finding is that the effect of HAART appears smaller among earlier award cohorts, which were exposed to HAART multiple years after benefit award. For example, when HAART is introduced in year two since award, the effect in year three is just -0.1 percentage points. This estimate is derived using the 1994 cohort as the treatment group and the 1993 cohort as the comparison group. Additionally, when HAART is introduced in year three since award, the effect in year four is -3.1 percentage points. This estimate is derived using the 1993 as the treatment group and the 1992 cohort as the comparison group.

B. Substantial Gainful Activity

While declines in mortality should decrease program exits, improvements in work capacity should increase exits. Unfortunately, the DRF does not report terminations of SSDI benefits due to improved health or increased employment. As an alternative, program exit is measured by the share of beneficiaries engaged in substantial gainful activity. Gainful activity is defined by earnings, so engaging in substantial gainful activity can measured using the Summary

Earnings Record. Because earnings are reported annually, but gainful activity is defined monthly, the latter is measured on an annualized basis. For example, the substantial gainful amount in 1995 was $500 per month, so the annualized measure is $6,000 that year.

Summary statistics of substantial gainful activity are reported in the right panel of **Table 5**. The columns correspond to award cohorts, and the rows correspond to years since award. Each statistic represents the share of beneficiaries engaged in gainful activity during a calendar year, not adjusted for mortality. Gainful activity is highest in year zero, which may reflect earnings before benefit award. Gainful activity is considerably lower in period one, which corresponds to the first full calendar year after benefit award.

Among the 1995 cohort, 3.6 percent of beneficiaries were engaged in substantial gainful activity in year one. This figure increases slightly in subsequent years, reaching 4.6 percent, 5.8 percent, and 5.3 percent in years two, three, and four, respectively. While the increase in substantial gainful activity may reflect improvements in health due to HAART, it may also reflect that health may improve after a disability award, independent of the introduction of HAART.

To identify the effect of HAART, the analysis again uses earlier cohorts as comparison groups for later cohorts. Using this methodology, the data suggest that HAART may have increased gainful activity among existing beneficiaries, but the magnitude of the effect is relatively small. For example, in year one, the difference in gainful activity between the 1994 and 1995 cohorts was just 1.0 percentage point. In year two and three, the difference increased slightly to 2.6 and 3.0 percentage points, respectively. Thus, the data do not suggest that HAART substantially increased program exit for work.

C. Effects by Pre-Application Earnings

As with program entry, the effects of HAART on program exit should be greater among workers of higher socioeconomic status. To examine this prediction, **Table 6** reports summary statistics on mortality and gainful activity for three categories of pre-application earnings. Panel A corresponds to earnings less than $10 thousand; Panel B corresponds to earnings from $10 thousand to $20 thousand; Panel C corresponds to earnings greater than $20 thousand. Each panel is constructed similarly to **Table 5**.

In general, the effect of HAART on mortality appears greater among workers with higher pre-application earnings. The immediate effect can be measured by comparing the 1994 and 1995 cohorts in year one. As shown, the difference in mortality is 5.9, 7.4, and 9.5 percentage points in panels A, B, and C, respectively. The long-run effect can be measured by comparing the 1992 and 1995 cohorts in year four. In this case, the difference in mortality is 17.3, 24.1, and 26.8 percentage points, respectively.[14]

The effect of HAART on gainful activity also appears greater among workers with higher pre-application earnings. Again, the long-run effect can be measured as the difference in gainful activity between the 1992 and 1995 cohorts in year four. As shown, this difference is 2.3, 4.5, and 5.1 percentage points in panels A, B, and C, respectively. Taken together, the results suggest that the effects of health on program exit are greatest among workers of higher socioeconomic status.

VI. Expenditures

[14] As previously noted, year-zero mortality in **Table 5** increased from earlier to later cohorts. As **Table 6** shows, this increase occurs predominately in panels A and B, corresponding to categories of low pre-application earnings. This means that differences in mortality in these panels likely understate the causal effects of HAART.

The effect of HAART on SSDI receipt also affects program expenditures. To estimate this effect, Panel A of **Table 7** reports actual expenditures by award cohort and year of award. The calculations assume that beneficiaries receive the PIA every month, beginning with the month of benefit award. If a beneficiary dies, the monthly benefit equals zero, beginning with the month of death.

Panel B reports predicted expenditures after 1995 had HAART not been introduced. These predictions are based on three observations of actual expenditures in panel A. First, from the 1992 to 1995 cohort, year-zero expenditures decreased an average of eight percent. This trend is extrapolated to cohorts 1996 through 1999. Second, from year zero to one, expenditures of the 1994 cohort increased 30.1 percent. This increase is used to predict year-one expenditures for cohorts 1995 and later. Finally, after year one, expenditures of the 1992 and 1993 cohorts decreased annually by approximately 36 percent. This decrease is used to predict expenditures in year two and later, from calendar years 1996 through 1999.

The effect of HAART on expenditures is calculated as the difference between actual expenditures (panel A) and predicted expenditures (panel B). The differences, reported in Panel C, reveal two general findings. First, HAART had a positive effect on expenditures among earlier award cohorts, from 1992 to 1995. This reflects increased expenditures due to fewer program exits through death. Second, HAART had a negative effect on program expenditures among later award cohorts, starting with the cohort in 1996. This decrease reflects fewer applications and awards related to HIV. To calculate the net effect by 1999, the figures are summed across all cohorts and years. Based on this calculation, HAART increased program expenditures by $43.6 million.

One important limitation of these estimates is that they do not account for program exit through improved health and work capacity. If benefits had been terminated, then expenditures in panel A would be overstated, and the estimates in panel C serve as upper bounds to the true effects of HAART. However, the bounds in panel C may be close to HAART's true effect, since the effects of HAART on substantial gainful activity were limited (**Table 5**).

VII. Conclusion

This study examines the effect of health on SSDI outcomes. To identify health's causal effect, the analysis relies on an antiretroviral therapy introduced in late 1995 and early 1996 to treat the human immunodeficiency virus. As research shows, the therapy immediately decreased HIV-related mortality and increased the capacity and propensity to work. This study shows that the new therapy substantially decreased HIV-applications and awards, but did not substantially increase program exit for work among existing beneficiaries. In fact, the therapy effectively increased benefit receipt by decreasing program exits through death, thereby increasing HIV-related expenditures by 1999 by $43.6 million.

This study contributes to the literature on health and SSDI outcomes. Although several studies report that SSDI outcomes are associated with poor health, these associations may be biased measures of health's causal effect. In contrast to related studies, this study adopts a production function approach to identification, providing new insights into the causal effects of health on SSDI outcomes.

The results suggest that improving population health may be effective at reducing the size of the SSDI program. One policy option is to increase access to public health insurance and health care, independent of employment status or SSDI receipt. By increasing health insurance,

workers may be less inclined to apply for SSDI to qualify for Medicare coverage (Gruber and Kubik 2002). Moreover, access to health care may improve population health and work productivity, thereby decreasing the propensity to apply for and receive SSDI benefits.

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Table 1

Summary Statistics of SSDI Applicants related to HIV: Application Year 1994

		Education			
	All	All	Less than High School Diploma	High School Diploma	College Degree
A. SSDI Applicants					
Age (years)	36.9	36.8	36.7	36.4	39.2
Male	88.3	87.6	83.8	87.3	95.2
Race: Black	34.0	36.4	45.9	36.8	18.3
Race: Other	13.9	12.0	18.8	10.3	9.3
Pre-application earnings ($1000)	14.7	14.3	8.1	13.9	26.4
Concurrent SSI	67.4	70.8	85.0	71.5	43.7
Primary HIV	92.1	91.4	89.2	91.7	93.4
Symptomatic HIV	83.9	82.5	74.1	83.4	92.2
Primary Symptomatic HIV	78.7	76.9	68.0	77.8	87.1
Award - initial	70.5	69.4	56.7	70.5	85.8
OHA appeal	12.3	12.6	17.0	12.4	6.4
Award - final	78.5	78.4	68.1	79.3	91.0
Death in one year	24.0	22.8	16.7	23.0	31.5
Death in two years	40.9	39.4	31.1	39.9	50.3
Observations	33225	27255	5895	17848	3512

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who apply for benefit in 1994, who are ages 25 to 54, and who report HIV as the primary or secondary. Pre-application earnings are calculated as the average annual earnings during the three calendar years prior to the calendar year of application. All figures are in percentage points unless otherwise noted.

Table 2

Change in HIV-related SSDI Applications: Years 1993, 1995, and 1997

				1997			
	1993	1995	Predicted Annual Change	Predicted	Actual	Difference	Percent Difference
				(a)	(b)	(b)-(a)	[(b)-(a)]/(a)
All	35636	31264	-2186	26892	17435	-9457	-0.352
Pre-application earnings ($1000)							
$0 to $10	17191	15097	-1047	13003	10304	-2699	-0.208
$10 to $20	9157	7861	-648	6565	4179	-2386	-0.363
Greater than $20	9288	8306	-491	7324	2952	-4372	-0.597
Concurrent SSI	24108	21358	-1375	18608	12957	-5651	-0.304
SSDI singly	11528	9906	-811	8284	4478	-3806	-0.459
Primary HIV	32811	28861	-1975	24911	15587	-9324	-0.374
Secondary HIV	2825	2403	-211	1981	1848	-133	-0.067
Symptomatic	30429	26154	-2138	21879	13693	-8186	-0.374
Asymptomatic	5207	5110	-49	5013	3742	-1271	-0.254
Primary Symptomatic HIV	28621	24503	-2059	20385	12456	-7929	-0.389
Primary Asymptomatic HIV	7015	6761	-127	6507	4979	-1528	-0.235

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who are ages 25 to 54 and who report HIV as the primary or secondary. Pre-application earnings are calculated as the average annual earnings during the three calendar years prior to the calendar year of application.

Table 3
Linear Probability Model of SSDI Award

Variable	(1)	(2)
HAART	-4.5	-0.22
	(0.65)*	(0.52)
Year	-5.0	-3.2
	(0.17)*	(0.14)*
Age 35 to 44		0.61
		(0.27)*
Age 45 to 54		1.5
		(0.38)*
Male		2.5
		(0.38)*
Black		-3.9
		(0.30)*
Other		-10.2
		(0.38)*
Earnings $10 to $20 thousand		10.5
		(0.31)*
Earnings greater than $20 thousand		14.3
		(0.33)*
Primary HIV		-19.1
		(0.45)*
Symptomatic HIV		55.3
		(0.36)*
Death in one year		4.7
		(0.44)*
Death in two years		16.6
		(0.39)*
Observations	86013	86013

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who are ages 25 to 54 and who report HIV as the primary or secondary. The data are also restricted to cases that were adjudicated in 1993, 1995, and 1997. Pre-application earnings are calculated as the average annual earnings during the three calendar years prior to the calendar year of application. State fixed-effects are included in the second model. Estimates are in percentage points. * indicates significance at the 5 percent level.

Table 4

Summary Statistics of Primary HIV SSDI Beneficiaries

Year of Award	1995	1994	1993	1992
Age (years)	37.5	37.1	36.7	36.4
Male	89.1	90.5	90.7	91.5
Race: Black	31.1	29.4	29.2	27.6
Race: Other	12.5	12.4	12.4	12.1
Pre-application earnings ($1000)	17.3	17.1	16.2	16.0
Concurrent SSI	63.7	64.0	65.8	65.2
Primary HIV	91.1	91.7	92.3	91.8
Symptomatic HIV	97.0	96.6	95.8	94.0
Observations	22249	23360	26855	30427

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who are ages 25 to 54, who report HIV as the primary or secondary, and who are awarded benefits. Pre-application earnings are calculated as the average annual earnings during the three calendar years prior to the calendar year of application. All figures are in percentage points unless otherwise noted.

Table 5

Mortality and Earnings of new SSDI Beneficiaries Related to HIV by Year of and since Award

	Deceased				Substantial Gainful Activity			
Year of Award	1995	1994	1993	1992	1995	1994	1993	1992
Year since Award								
0	20.6	19.8	16.3	17.1	25.4	25.7	23.8	21.7
1	40.4	47.9	43.2	42.8	3.6	2.6	2.6	2.3
2	47.2	60.9	61.0	61.2	4.6	2.0	1.9	1.6
3	51.5	65.4	68.9	72.0	5.8	2.8	1.7	1.5
4	55.0	68.1	71.6	76.8	5.3	3.2	2.1	1.5

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who are ages 25 to 54, who report HIV as the primary disability, and who are awarded benefits. Substantial gainful activity, measured on an annualized basis , is an indicator of program exit through work. All figures are in percentage points. The shaded region corresponds to calendar years 1995 and earlier, before HAART was introduced.

Table 6

Mortality and Earnings of new SSDI Beneficiaries Related to HIV by Year of and since Award

	Deceased				Substantial Gainful Activity			
Year of Award	1995	1994	1993	1992	1995	1994	1993	1992
A. Pre-Applications Earnings: $0 to $10 thousand								
Year since Award								
0	17.4	15.6	12.7	12.3	6.8	6.0	5.2	4.8
1	36.4	42.3	35.4	34.3	2.1	1.4	1.6	1.3
2	43.6	55.6	53.1	52.3	3.6	1.7	1.7	1.5
3	48.3	60.4	61.4	63.9	4.7	2.7	1.7	1.7
4	52.4	63.3	64.7	69.7	4.0	3.2	2.3	1.7
B. Pre-Applications Earnings: $10 to $20 thousand								
Year since Award								
0	20.8	20.5	16.0	17.7	25.2	25.8	24.0	2.2
1	41.0	48.4	44.6	44.1	3.4	2.7	2.7	2.4
2	47.7	61.8	63.6	63.6	5.3	2.4	2.1	1.9
3	51.8	66.9	71.8	74.8	6.7	3.2	2.1	1.7
4	55.0	69.7	74.3	79.1	6.1	3.6	2.4	1.6
C. Pre-Applications Earnings: Greater than $20 thousand								
Year since Award								
0	24.1	24.1	22.1	23.5	46.2	47.9	48.4	45.1
1	44.3	53.8	52.5	53.5	5.4	3.8	3.9	3.6
2	50.9	66.1	69.4	71.5	5.3	2.0	1.8	1.6
3	54.8	69.8	76.3	80.9	6.4	2.4	1.4	1.0
4	57.9	72.1	78.4	84.7	6.0	3.0	1.5	0.9

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who are ages 25 to 54, who report HIV as the primary disability, and who are awarded benefits. Substantial gainful activity, measured on an annualized basis , is an indicator of program exit through work. Pre-application earnings are calculated as the average annual earnings during the three calendar years prior to the calendar year of application. All figures are in percentage points. The shaded region corresponds to calendar years 1995 and earlier, before HAART was introduced.

Table 7

Actual and Predicted SSDI Expenditures related to HIV (in millions)

Year of Award	1992	1993	1994	1995	1996	1997	1998	1999
A. Actual Expenditures								
Year since award								
0	96.1	89.6	79.2	75.6	54.3	28.4	21.1	19.7
1	138.0	124.0	103.0	100.0	83.0	45.4	36.5	
2	88.9	78.0	64.9	77.8	72.2	40.3		
3	56.9	52.6	50.3	67.6	64.8			
4	40.6	42.6	43.5	60.5				
5	33.6	37.7	38.9					
6	29.8	34.3						
7	27.2							
B. Predicted Expenditures								
Year since award								
0	96.1	89.6	79.2	75.6	69.6	64.0	58.9	54.2
1	138.0	124.0	103.0	98.3	90.4	83.2	76.5	
2	88.9	78.0	65.9	62.9	57.9	53.2		
3	56.9	49.9	42.2	40.3	37.0			
4	36.4	31.9	27.0	25.8				
5	23.3	20.4	17.3					
6	14.9	13.1						
7	9.5							
C. Actual Minus Predicted Expenditures								
Year since award								
0	0.0	0.0	0.0	0.0	-15.3	-35.6	-37.8	-34.5
1	0.0	0.0	0.0	1.7	-7.4	-37.8	-40.0	
2	0.0	0.0	-1.0	14.9	14.3	-12.9		
3	0.0	2.7	8.1	27.3	27.8			
4	4.2	10.7	16.5	34.7				
5	10.3	17.3	21.6					
6	14.9	21.2						
7	17.7							

Data on HIV-related applications come from Social Security's Disability Research File. The data are restricted to applicants who are ages 25 to 54, who report HIV as the primary disability, and who are awarded benefits. Actual expenditures are calculated from the monthly Primary Insurance Amount and account for the month of award and exit through death. Predicted expenditures are calculated based on assumptions described in the text. Expenditures are expressed in millions of dollars in 1994. The shaded region corresponds to calendar years 1995 and earlier, before HAART was introduced.

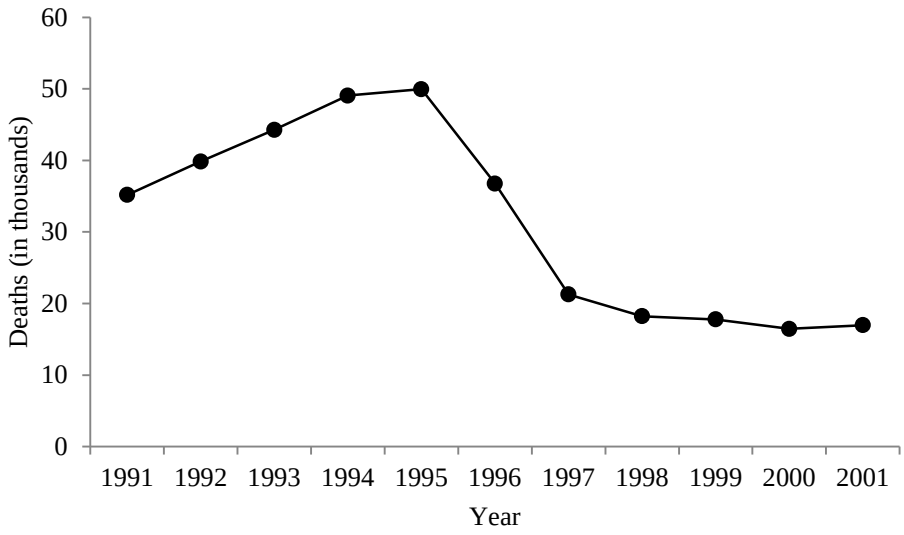

Figure 1: Deaths related to HIV/AIDS

The data come from the HIV Surveillance Report (CDC 2001).

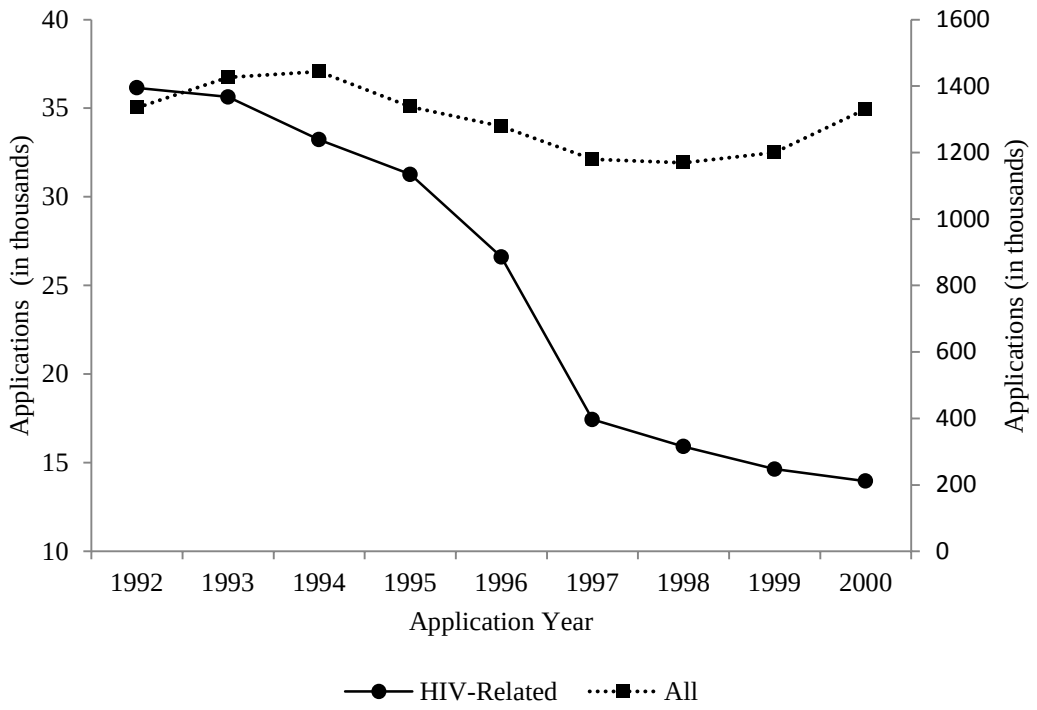

Figure 2: Applications for SSDI Disabled Worker Benefits

Data on HIV-related applications come from the 831 File. The file is restricted to applicants aged 25 to 54. Data on all SSDI applications come from the Social Security Administration (accessed at www.ssa.gov/oact/STATS/table6c7.html on April 14, 2015).

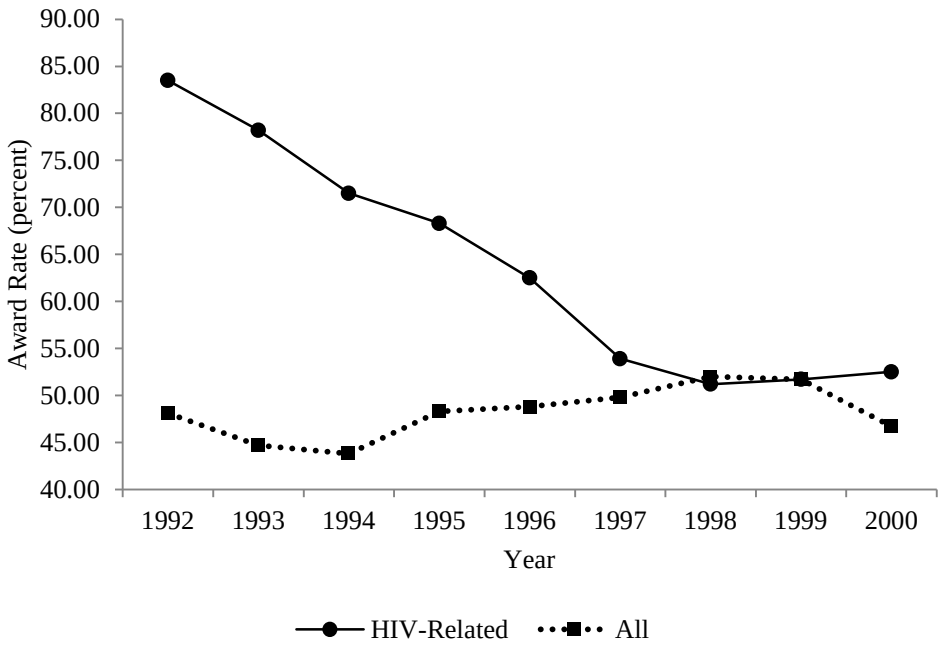

Figure 3: HIV-related Award Rates

Data on HIV-related applications come from the 831 File. The file is restricted to applicants aged 25 to 54. The award rates reflect the decision of the Disability Determination Services and, thus, do not account for appeals. Data on all SSDI applications come from the Social Security Administration (accessed at www.ssa.gov/oact/STATS/table6c7.html on April 14, 2015).