An Antidote for Despair: The Effect of Highly Active Antiretroviral Therapy (HAART) on Suicide Rates*

Hasan Shahid†

March 28, 2024

Abstract

The introduction of Highly Active Antiretroviral Therapy (HAART) in 1995, transformed the prognosis of an HIV infection from a death sentence to a manageable chronic health condition. Using a difference-in-differences strategy, this paper exploits spatial variation in HIV/AIDS incidence at the time HAART treatment was introduced and finds that, in addition to reducing HIV/AIDS deaths, the introduction of HAART led to a disproportionate decrease in suicide rates for groups most affected by the virus. Estimates suggest that HAART saved approximately 756 men aged 25 to 44 from suicide each year following its introduction.

JEL codes: D63, I12, J15, N32
Key Words: HIV/AIDS, Suicide, Mental Health, Infectious Disease

*I thank Thomas A. Mroz, Lauren Hoehn-Velasco, Keith Teltser, Kirsty A. Clark, Jesús Villero, Christopher S. Carpenter, Marcus Dillender, Daniel Lee, Jose Manuel Fernandez and seminar and conference participants at Georgia State University, American Society of Health Economics 2022 conference, the Committee on the Status of LGBTQ+ Individuals in the Economics Profession (CSQIEP) virtual seminar series, Association for Public Policy and Management (APPAM) 2022 meeting, Southern Economic Association (SEA) 2022 meeting, and American Social Science Association 2023 meeting for useful feedback.
†Vanderbilt University, Department of Economics. Email: hasan.shahid@vanderbilt.edu

1 Introduction

The HIV/AIDS crisis represented a specific set of mental health challenges for at-risk communities in the US: the risk of dying from a highly infectious disease, increased pressure to come out, and grieving the loss of friends and family members. Prior to the introduction of effective combination drug therapies, testing positive for HIV/AIDS was a death sentence. In 1995, the US Food and Drug Administration (FDA) approved the use of Saquinavir in combination with other nucleoside analog medications. This combination proved to be highly effective and marked a new era in combination drug therapy treatments that became known as Highly Active Antiretroviral Therapy (HAART). HAART led to substantial reductions in HIV-related morbidity and mortality and resulted in significant increases in life expectancies of HIV-positive individuals.

Using publicly available mortality data from the US Vital Statistics, this paper finds that the introduction of HAART, not only reduced HIV/AIDS mortality but also reduced suicide rates for men aged 25 to 44 (NCHS, 1990-2002). There are several ways the introduction of HAART can affect suicide rates for at-risk groups. First, HAART could reduce suicide rates by improving mental health outcomes for HIV positive individuals. There is a significant body of research that highlights the negative mental health effects of testing positive for HIV (Carrico 2010; Kalichman et al. 2000; Schlebusch and Govender 2015; Pelton et al. 2021). Suicide ideation and self-harm are significantly more common among those who test positive for HIV relative to other groups. Given the improved prognosis for people living with HIV infections after the introduction of HAART, it is reasonable to expect lower levels of suicide risk among HIV positive individuals post-HAART. Secondly, HAART reduced the consequences of testing positive among those who fear infection but are not yet infected with HIV. There was an increase in HIV testing rates after the introduction of

HAART, indicating a potential mental health toll associated with the anticipation of a positive HIV diagnosis in the absence of treatment (Kellerman et al., 2002). Although HAART is not a cure for the infection, the treatment may ameliorate heightened fears of death among populations at increased risk of contracting infection, thus improving their mental health outcomes.[1] Third, improved physical and mental health outcomes in the community may have spillover effects on those who are HIV negative. Gay men routinely mourned the deaths of their friends and fellow community members during the height of the epidemic and the introduction of HAART would have reduced these instances of grief.[2]

Despite the clear mechanisms through which the introduction of HAART can impact the mental health outcomes of at-risk individuals, to the best of my knowledge, no study estimates the effects of HAART on suicide rates in the United States. By exploiting spatial variation in HIV/AIDS prevalence before HAART was introduced, this paper presents plausibly causal estimates, comparing suicide rates in areas with varying levels of HIV/AIDS incidence both before and after the introduction of HAART.

I utilize a difference-in-differences event study design to estimate the effect on the group that was most affected by the HIV/AIDS crisis (men aged 25 to 44) across the distribution of pre-HAART HIV/AIDS death rate. I use HIV/AIDS death rate as a proxy for HIV/AIDS incidence due to the superior quality of mortality data relative to other sources. I find that counties with higher preexisting HIV/AIDS death rates experience a disproportionate decrease in suicides for men aged 25 to 44 at the time HAART treatment was introduced. My estimates suggest that a standard deviation higher preexisting HIV/AIDS death rate is associates with a 0.9

[1] Medical innovations reduces the negative utility associated with contracting an illness even for those who do not fall sick. Lakdawalla et al. (2017) refers to this as the insurance value of medical innovation.

[2] In his 1995 book, Odets highlights the emotional and psychological impact of AIDS on the lives of HIV-negative gay men.

per 100,000 population decrease in suicide rates for men aged 25 to 44. Back of the envelope calculations reveal that HAART saved approximately 756 men aged 25-44 from suicide each year following its introduction.

I then conduct several robustness tests to show that the documented effects are driven by the introduction of HAART. I expand my analysis to groups that are less affected by the HIV/AIDS crisis and therefore less affected by the introduction of a treatment: women aged 25 to 44, men over 65, and men under 19. Since the vast majority of HIV infections in this period are a result of Male-to-Male sexual intercourse, these groups had significantly lower rates of HIV infection and are less likely to be affected by the introduction of a treatment.[3] I find that the introduction of HAART had little or no effect on suicide rates for these groups. Then, I employ a triple-difference strategy, where I difference out effects on suicide rates for these groups and find similar estimates, which lends credence to my findings. Subsequently, I explore the modes of suicide driving my estimates. Given that gay men had significantly higher rates of HIV/AIDS, it is reasonable to assume that HAART would most likely affect suicide rates for these men. The literature finds that homosexual men are half as likely to use firearms as a mode of suicide relative to heterosexual men (Clark et al., 2020b). Although I do not observe sexual orientation in the mortality data, I do observe the mode of suicide and find that my estimates are driven almost entirely by non-firearm suicides. This provides further evidence that my effects are likely driven by gay men who are more likely to contract HIV.

Additionally, I examine the welfare implications of my research findings, demonstrating that suicides were not simply a substitute for HIV/AIDS deaths within the population driving my results. I highlight that preventing suicide by improvements in mental health had non trivial implications for the welfare of the affected population.

[3] By 1987, men who have sex with men accounted for over 72 percent of all AIDS cases (CDC, 1995).

Given that welfare effects are measured in terms of years of life saved via preventing suicide, they likely underestimate the mental health benefits of HAART. Suicide is an extreme mental health outcome which is highly correlated with other mental health outcomes. Due to data limitations, I am unable to measure the effect of HAART on other mental health outcomes but decreases in suicide rates are likely correlated with improvements in other mental health outcomes.[4]

My findings contribute to a growing literature exploring the specific mental health challenges experienced by the LGBTQ community and HIV-positive individuals. Sexual minorities experience elevated levels of suicide risk (Björkenstam et al., 2016; Cochran and Mays, 2015; Hottes et al., 2016; Raifman et al., 2017; Clark et al., 2020b). Testing positive for HIV is also associated with heightened suicidal ideation and mortality (Carrico, 2010; Kalichman et al., 2000; Schlebusch and Govender, 2015; Pelton et al., 2021).

The effect of HAART on HIV-associated morbidity and mortality is well documented (Egger et al. 2002; Keiser et al. 2004). Previous studies have also estimated the effects of HAART on health disparities, labor supply, risky sex, and health-related quality of life indicators (Hamilton et al. 2021; Chan et al. 2016; Pelton et al. 2016; Lakdawalla et al. 2006; Liu et al. 2006). Recent work also explores the effect of federal public health funds for HIV/AIDS-related mortality (Dillender, 2023). More relevant to this paper, using data from a longitudinal study conducted in Australia, Judd et al. (2000) finds that the introduction of HAART was accompanied by a fall in depressive symptoms amongst HIV positive individuals. Similarly, Keiser et al. (2010) makes use of a cohort of HIV positive individuals who are part of a longitudinal study conducted in Switzerland and finds that individuals who are part of

[4] In Appendix B, I use data from the Behavioral Risk Factor Surveillance System (BRFSS) to provide suggestive evidence that the introduction of HAART improved self-reported mental health among at-risk population. Additionally, poor mental health may affect mortality in ways other than through suicide. To explore this mechanism more closely, I explore the effects of HAART on other deaths of despair in Appendix F.

the study experience a greater fall in suicides after the introduction HAART than the general population. Although the study finds compelling evidence of differential trends in suicides for HIV positive individuals relative to the general population before and after the introduction of HAART, it only observes a subset of HIV positive individuals and does not make causal claims. Since HIV positive individuals are only observed in the study conditional on enrollment and participation, suicide rates among this population may not be representative of suicide rates among the general HIV positive population. Findings from this study are also based on a total of 150 suicides. My design makes use of the distribution of HIV/AIDS deaths across the United States and exploits the universe of suicides in many U.S. counties to estimate the causal effect of HAART on suicide rates. Overall, this study builds upon and extends the findings of Keiser et al. (2010), indicating that the trends observed in the subset of HIV positive individuals in Switzerland is evident on a larger scale in the Unites States. There is also a growing literature using more recent data from developing countries that explores the effect of access to HIV/AIDS treatment on labor market outcomes, mental health, and human capital accumulation (Baranov and Kohler, 2018; Baranov et al., 2015). To the best of my knowledge, no current study estimates the effect of the introduction of HAART on suicide rates for at-risk populations in the United States.

This study has several limitations. First, I do not observe HIV/AIDS status, sexual orientation, or the cause of suicide in the mortality data. Although I conduct several robustness tests to show that the measured effects are a result of falling suicide rates among populations most impacted by the HIV/AIDS crisis, there is no way to completely rule out other mechanisms. The 90s saw several significant cultural and political changes which may influence my results. For example, several studies document improved attitudes towards same-sex couples around 1992-1993 following presidential debates on whether gay people should serve in the U.S. military

(Fernández et al., 2021; Twenge et al., 2015). Although my main specification is an event study design and I do not observe a discontinuity in suicide rates in high HIV/AIDS counties relative to low HIV/AIDS counties around the 1992-1993 debate, it is possible that my estimates are confounded by a delayed response of the improvements in attitudes towards same-sex couples in the early 90s. Second, the HIV/AIDS crisis represented a unique shock, distinct from other health crises. HIV/AIDS is a sexually transmitted infection, primarily affecting sexual minority men and drug users. Unlike many other chronic health conditions, this epidemic disproportionately impacted young men. This implies that while these findings are informative, caution should be exercised when generalizing these results to treatments for other diseases.

Nonetheless, this study has important implications for measuring the effects of the HIV/AIDS epidemic and HAART treatment. With over 1 million people living with HIV in the US and over 40 million worldwide, understanding the mental health challenges of those living with HIV and those at risk of contracting the virus is important. It is estimated that a total of 700,000 people have died of HIV/AIDS in the United States.[5] This study implies that HIV/AIDS affects mortality in ways other than just HIV/AIDS mortality. Measures of total HIV/AIDS deaths may undercount the effect of the HIV/AIDS crisis.

The findings in this study warn us about the threat of chronic medical issues on mental health outcomes and the benefits of coming up with treatments more generally. By only focusing on the direct impacts of treatment, we miss meaningful aspects of the benefits of innovations in medical treatments.

[5] Estimate obtained from KKF: https://www.kff.org/hivaids/fact-sheet/the-hivaids-epidemic-in-the-united-states-the-basics/ last accessed August 24th, 2022

2 Background

In 1981, a mysterious new disease emerged that seemed to affect gay men in New York and California. Similar reports of gay men suffering from a previously unknown disease emerged in other parts of the country, and by the end of the year, the New York Times published an article titled "Rare Cancer Seen in 41 Homosexuals."[6] The number of new cases grew rapidly among gay men and the disease was termed the "gay plague." Although HIV/AIDS also affects heterosexual men and women, the high prevalence of the virus among gay men resulted in many associating the virus with the gay community.

In the fall of 1982, the CDC defined the disease as Acquired Immune Deficiency Syndrome (AIDS) for the first time (AIDS is the final and most severe stage of the infection). It wasn't until 1983 that scientists identified the virus that caused the development of AIDS, Human Immunodeficiency Virus (HIV). Little was known about the virus in its early years and the care of HIV/AIDS patients was largely palliative. Scientists struggled to make progress in combating the new virus and HIV/AIDS-related deaths continued to rise. Early estimates of total HIV/AIDS cases and deaths are unreliable because misreporting was common, but by 1987, an estimated 40,849 people had died from the virus.[7] Figure 1 depicts the recorded rise in cumulative HIV/AIDS deaths from 1981 to 2002.

HIV is transmitted through contact with bodily fluids of an HIV-positive individual with a detectable viral load. The most common forms of transmission are through sexual intercourse and the sharing of drug injection equipment. By 1987,

[6] The New York Times, July 3rd, 1981: https://www.nytimes.com/1981/07/03/us/rare-cancer-seen-in-41-homosexuals.html

[7] Estimates obtained from HIV/AIDS: Snapshots of an epidemic: https://www.amfar.org/thirty-years-of-hiv/aids-snapshots-of-an-epidemic/

men who have sex with men accounted for over 72 percent of all AIDS cases.[8,9] Without treatment, HIV usually progresses to AIDS (the final stage of the virus) in 5 to 10 years, and the life expectancy of an untreated AIDS patient is approximately 2 years (Poorolajal et al., 2016). Before the introduction of combination drug therapies, testing positive for the virus was a death sentence.

In 1987, the US Food and Drug Administration (FDA) approved Zidovudine (AZT) as the first medicine to treat HIV/AIDS. Although AZT experienced some success in increasing white blood cell counts among HIV/AIDS patients, the side effects of the medication proved unbearable for patients, and it experienced only moderate success in reducing the progression of the virus. HIV/AIDS deaths continued to rise through the 1980s and early 1990s.

HIV/AIDS patients and activists grew weary and impatient about the lack of advances made to come up with an effective treatment. Many organized in protest of the government's perceived inaction in combating this crisis.[10,11] In response to growing pressures to address the crisis, in 1990, Congress passed the Ryan White CARE ACT. The Ryan White program remains the largest federally funded program in the United States aimed at improving access to healthcare for low-income, uninsured, and underinsured people living with HIV. The Act has been reauthorized in 1996, 2000, 2006, and 2009.

In 1995, the FDA approved Saquinavir, the first protease inhibitor. This ushered in a new era of combination drug therapies which became known as the "AIDS Cock-

[8]Statistics obtained from November 24, 1995, CDC MMWR weekly report accessed at: https://www.cdc.gov/mmwr/preview/mmwrhtml/00039622.htm

[9]There is some evidence that the proportion of new HIV/AIDS cases represented by men who have sex with men decreased over time and the proportion represented by drug users increased. However, even at the time HAART became available, men who have sex with men made up over 57 percent of HIV/AIDS infections.

[10]Organizations such as ACT UP mobilized the gay community and held protests bringing attention to the government's slow response to the crisis.

[11]The crisis became a hotly contested political debate. In the early years, President Reagan refused to address the crisis altogether. In the 1992 presidential election, gay-related issues were discussed in great detail.

tail" and later, as Highly Active Antiretroviral Therapy (HAART). HAART was a game changer in this epidemic and led to a substantial reduction in HIV-associated mortality. Figure 2 shows the rapid fall in HIV/AIDS death rates after the introduction of HAART. From 1995 to 1997, men's HIV/AIDS death rate fell by over 60%. Although HIV/AIDS continues to be a major health problem in the US, especially amongst Black and Latinx men, the introduction of HAART meant that testing positive for HIV was no longer a death sentence.

3 Data

3.1 Suicide & HIV/AIDS-Related Mortality Data

I use publicly available data from the 1990-2002 US Vital Statistics National Center for Health Statistics Multiple Cause of Death Files in order to calculate Suicide and HIV/AIDS-related mortality rates (NCHS, 1990-2002). The mortality data includes all deaths that occurred in the United States and is abstracted from death certificates filed in the vital statistics departments of each state and the District of Colombia.

A large portion of the analysis in this article is based on county, sex, and age group-specific mortality rates. For the years 1989 onwards, county codes are only provided for counties with a population above 100,000. Therefore, smaller counties are dropped from my data set. To conduct my analysis, I have constructed a panel consisting of 390 counties for which mortality rates are available for all years.[12] Given the high concentration of HIV/AIDS in certain high HIV/AIDS cities, using county level data over state-level data allows me to exploit a wider breadth of variation in pre-HAART

[12] Although I do not see a large number of smaller counties, I still observe over 60% of deaths since most Americans live in larger counties. In Figure A1, I present the geographical distribution of my treatment variable. My sample contains most large metropolitan areas. To further explore the selection of counties in my sample, I present summary statistics of counties in and outside my sample in Table A2. Counties in my sample are significantly larger, more densely populated, and have a smaller Evangelical populations compared to counties outside my sample.

HIV/AIDS death rates.[13] To discern suicide and HIV/AIDS-related mortality, I use the International Classification of Disease (ICD) Code provided under the primary cause of death. Records from 1990-1998 are based on ICD-9 codes, whereas records from 1999 onwards use ICD-10 codes. Appendix Table A1 provides which ICD codes are associated with suicide and AIDS-related mortality. Although physicians became aware of a disease that was later classified as HIV back in 1981, HIV did not join the list of communicable diseases, and therefore is not visible in the mortality data until 1987. Although there are no reliable estimates of HIV/AIDS-related mortality rates before 1987, this does not affect my analysis. I only use HIV/AIDS deaths before the introduction of combination drug therapy in 1995 as a proxy for HIV incidence.

I calculate the number of suicides and HIV/AIDS-related deaths per 100,000 population. Sex and age group-specific suicide deaths and population levels are used to calculate suicide rates for men aged 25-44. I chose this group for my main analysis because this group was most affected by the HIV/AIDS crisis. For example, from 1993 to 1995, HIV/AIDS was the leading cause of death for men aged 25 to 44 in the United States. Since HIV/AIDS death rates are only used as a measure of pre-HAART HIV incidence in a county and I exploit differences in HIV incidence across demographic groups as a robustness check, I calculate overall county HIV/AIDS mortality per 100,000 population instead of sex and age-specific rates.

Figure 2 shows national HIV/AIDS-related death rates in the mortality data from 1990 to 2002. There is a steep rise in HIV-related mortality peaking in 1995. In 1995, the FDA approved the use of Saquinavir to be used in combination with other nucleoside analogue medications. This combination proved to be highly effective and marked a new era in combination drug therapy treatments that scientists began to call highly active antiretroviral therapy (HAART). HAART became widely available

[13] In Appendix E, I reestimate my main model at the state-level. Although I still find that the introduction of HAART led to statistically significant reductions in suicide rates for men aged 25 to 44, these estimates are significantly less compelling compared to my main specification.

in 1996 and there was a significant fall in HIV/AIDS-related deaths thereafter.

There are important variations in HIV/AIDS-related death rates by sex and age group. As depicted in Figure 2, men were significantly more likely to contract and die from HIV compared to women. Men between the ages of 25 and 44 were most likely to contract the disease followed by men aged 45 to 64. HIV/AIDS death rates were significantly lower for young (under 24) and older men (over 65).

I also obtain census estimates of county population and demographics using a data set constructed by the Survey of Epidemiology and End Results (SEER, 2020).

3.2 Summary Statistics

For my main analysis, I use a continuous treatment measure of the 1994 HIV/AIDS death rate as an indicator of HIV incidence in a county before the introduction of HAART. My analysis is based on comparing changes in suicide rates over time between high and low HIV counties. High and low HIV counties have some different observable characteristics. Table 3 provides summary statistics by pre-HAART HIV/AIDS death rates. Here, I divide counties across quartiles of pre-HAART HIV/AIDS death rates. Counties with higher pre-HAART HIV/AIDS death rates experience higher rates of unemployment, are racially more diverse, and have higher population densities than other counties.[14]

4 Methodology

The CDC multiple causes of death data does not provide information about an individual's HIV/AIDS status unless the individual dies from the HIV infection. I observe county, gender, and age identifiers for all deaths. There are large geographic, age,

[14] I use county unemployment data from the Bureau of Labor Statistics (BLS, 1990-2002). I calculate population density using population and land area data obtained from the 2000 census. I obtain county-level religious adherence data for the Church and Church Membership study conducted by the Glenmary Research Center (Grammich et al., 2018).

and gender variations in HIV/AIDS death rates. I exploit geographic variation in county pre-HAART HIV/AIDS incidence to estimate the effect of HAART on suicide rates. There are several ways to measure pre-HAART HIV/AIDS incidence. One might gauge HIV prevalence by positive HIV tests, AIDS statistics (the final and most severe stage of HIV infection), and HIV/AIDS deaths. Reliable testing data is unavailable for this period and differences in testing availability across counties would result in testing data being plagued with selection issues. Although AIDS data is available through the AIDS public information data set, the data set only records AIDS cases in cities with populations that exceed 500,000 people, according to the latest available official U.S. Bureau of Census estimates. HIV/AIDS death data is available through the US vital statistics. Although county codes are only provided for counties with populations above 100,000, this is the same data-set I use to measure my outcome variable and therefore, I do not drop any additional counties when using HIV/AIDS death rates as my treatment variable.

For my main analysis, I use the HIV/AIDS death rate in 1994 as a measure of pre-HAART HIV/AIDS incidence.[15] This is an imperfect measure of HIV/AIDS incidence because it reflects some combination of incidence, access and quality of medical care, and correct identification of cause of death. It may also underestimate HIV/AIDS incidence for younger groups who are at the earlier phases of their HIV/AIDS infection. Despite these problems, it is the best measure available during this period. I also conduct several robustness checks where I explicitly deal with some of these issues.

[15] In Appendix C, I repeat the analysis by changing the HIV/AIDS death rate measure to the AIDS case rate in 1994 as per the AIDS public information data set and find similar effects.

4.1 Event Study

I choose an event study design to estimate the effects of HAART on suicide rates for several reasons. First, the event study shows time-varying treatment effects, where suicide rates may change in response to the introduction of combination drug therapy over time. Suicide may be linked to the affected population's expectations and belief's about the effectiveness of the therapy and these are expected to change over time. Second, examining the period leading up to the introduction of combination drug therapy tests whether suicide rates were on a pre-existing trend before the introduction of the treatment.

I restrict my sample to men aged 25 to 44 because this group this group is the most likely to be affected by HIV/AIDS and therefore, most likely to be affected by the introduction of a treatment. Formally, I estimate the following equation:

$$\text{Suicide Rate}_{ct} = \alpha + \sum_{\substack{m \neq 1994 \\ m=1990}}^{2002} \beta_m \left(\text{Pre-HIV/AIDS deathrate}_c \times 1[t=m]\right) + a_c + \mu_{st} + \epsilon_{ct} \tag{1}$$

where Suicide Rate_{ct} measures the number of suicides per 100,000 population in county c at year t. Pre-HIV/AIDS deathrate_c is the number of HIV/AIDS deaths per 100,000 population in 1994 and serves as a measure of the level of HIV incidence before the introduction of combination drug therapy. For ease of interpretation, I use the standardized form of the HIV/AIDS death rate. $1[t=m]$ is an indicator variable that equals 1 when the observations time period is m years relative to 1995.[16]

[16] I use 1995 as my first post-HAART year and 1994 as my reference year because Saquinavir was first made available on the market in 1995, and through 1995 newspapers such as the New York Times and San Francisco Chronicle published articles highlighting the promise of combination drug therapies and results from clinical trials (David Perlman, June 22, 1995; Sullivan, Nov 21, 1995; Altman, Feb 02, 1995). Over the next couple of years, the medical community made several changes in drug formulation and other combinations of drug therapies were introduced, but Saquinivir was the first of its kind.

I control for time fixed effects (η_t) and the interaction of state and time fixed effects (μ_{st}).[17] I use data for the years 1990-2002 in my analysis because this allows me to observe 5 years before the introduction HAART, and 8 years after.[18] I restrict my sample to men aged 25-44 because this group is the most likely to be affected by HIV/AIDS and therefore, most likely to be affected by the introduction of a treatment.

4.2 Specifications without Time Variations in Treatment Effect

To summarize my findings, I also consider a standard difference-in-differences specification where I focus on the impact of the introduction of combination drug therapy in a grouped post period. Formally, I estimate the following equation:

$$\text{Suicide Rate}_{ct} = \alpha + \beta \left(\text{Pre-HIV/AIDS deathrate}_c \times \text{Post}_t\right) + a_c + \mu_{st} + \epsilon_{ct} \quad (2)$$

where Post_t is a dummy variable that is equal to one after the introduction of combination drug therapy. This is a restricted version of Equation 1. All other features of this equation are the same as that of Equation 1. Grouping pre and post-periods provides a convenient way of presenting results in table form.

[17] In my preferred specification, I opt to exclude any time varying control variables because recent evidence suggests that assuming parallel trends conditional on the inclusion of covariates might cause problems with the suggested estimation procedure (Sant'Anna and Zhao, 2020). Additionally, since I include state-time fixed effects in my main specification, I am exploiting within state variation to conduct my analysis. Although this method accounts for changes in state policy which may be important, my estimates may be different when I consider across state variation. Therefore, In Figure A2, I show that my estimates are robust to the inclusion of time varying county level controls including county unemployment rate, percentage of population that is white, percentage of population that is evangelical protestant, and percentage of population that adheres to a religion. I also show that estimates are robust to the removal of the state-year fixed effects term.

[18] Given that my analysis does not rely on staggered treatment timing, I am less concerned about recent developments in the difference-in-differences literature which find issues with two way fixed effects models. Nonetheless, I show that my estimates are robust to the use of the recently developed imputation estimator by Borusyak et al. (2021) in Appendix D.2.

5 Results

Figure 3 depicts estimates from Equation 2 for men aged 25 to 44. I find little evidence of effects being driven by pre-trends.[19] The figure implies that the introduction of HAART is associated with a small immediate fall in suicide rate and this effect grows over time. This may be a result of increasing trust in the efficacy of HAART treatment and increasing access to life-saving medications.[20] To summarize these estimates into a single coefficient, I present estimates for the standard difference in differences specification (Equation 2) in Table 4. These estimates suggest that there is approximately a 1 per 100,000 population decrease in suicide rates for men aged 25-44 in counties that have a 1 standard deviation higher pre-HAART HIV/AIDS death rate.

A 1 per 100,000 population reduction in suicide rates represents approximately 4% change since the average suicide rate for the population of interest is 24 per 100,000 population. Some back of the envelope calculations would reveal that HAART saves approximately 756 men aged 25 to 44 from suicide each year following its introduction.[21]

The majority of the analysis conducted in this paper relies on age-based rates.

[19] This is in contrast to Fernández et al. (2021) who finds suggestive evidence that improvements in attitudes towards same-sex relationships in 1992-1993 resulted in a fall in suicide rates in states with higher rates of AIDS relative to states with lower rates of AIDS. To explore this channel more closely, I reestimate Equation 1 for the years 1988-1994 while changing the treatment year to 1992. I present estimates in Figure A3. Although I find no evidence that improved attitudes following the 1992 presidential debates decreased suicide rates based on my preferred specification, these estimates should still be interpreted with caution. Disentangling the effect of HAART and improved attitudes towards same-sex relationships following the 1992 presidential debates is challenging because of the small period of time between the two events. Although the estimates provided in this study yield compelling evidence that HAART decreased rates of suicide among at risk populations, I am unable to completely rule out whether effect are contaminated by improvements in attitudes towards same-sex relationships.

[20] This is in line with other studies which find falling suicide rates amongst HIV-positive individuals over time even after the introduction of HAART (Ruffieux et al., 2019).

[21] HIV/AIDS death rate was 26 per 100,000 in 1994. That's 1.8 in standard deviation terms (1 standard deviation of 1994 HIV/AIDS death rate is approximately 14). Therefore, suicide rates should decrease by 1.8 per 100,000 and the population of men aged 25 to 44 is approximately 42 million.

This approach results in inconsistent cohorts over time, as individuals age into and out of my main analysis group throughout the study period. Therefore, to ensure that the effects observed in this study are not a result of the changing composition of my main group of analysis, I reestimate Equation 2 using suicide rates for men born 1951 to 1970 (men aged 25-44 at the time HAART was introduced) and present estimates in Table A3. I find that estimates remain largely similar.[22]

To further contextualize the magnitude of these results, I compare effects across the distribution of pre-HAART HIV/AIDS incidence. I divide counties into deciles of pre-HAART HIV incidence and re-estimate Equation 1 where Pre-HIV/AIDS deathrate$_c$ is now a dummy variable equal to 1 when looking at the highest decile of pre-HAART HIV/AIDS death rate and is equal to zero when looking at the lowest three deciles. Here, I am trying to consider the most extreme case so I drop the deciles in between. Estimates are presented in Figure 4. Here, I see a 5 per 100,000 reduction in suicide rates in the top decile of HIV/AIDS death rate when compared to the bottom 3 deciles for men aged 25-44. This represents an approximate decrease in 25-44-year-old men's suicide rate by 20%.[23]

Due to the large magnitude of estimates, I must convince the reader that these effects are reasonable. Since this is the first study of its kind, it's difficult to make direct comparisons to other studies. Keiser et al. (2010) estimates suicide rates among a subset of HIV-positive men and women in Switzerland before and after the introduction of HAART. They find that among HIV-positive men, suicide rates fell from 447.4 per 100,000 person-years to 90.1 person-years after the introduction of HAART.[24] Although I do not observe HIV status in my suicide data, on aver-

[22] Although cohort level analysis would deal with this selection, it is also based on comparing suicide rates among older and younger people within the same-cohort. This can be somewhat problematic if the probability of dying by suicide varies across ages differently in high HIV/AIDS counties relative to low HIV/AIDS counties.

[23] In Appendix D.3, I repeat this analysis for several deciles of pre-HAART HIV/AIDS death rates and show that effects are largest in the top deciles adding further credibility to my findings.

[24] Keiser et al. (2010) and others have documented that HIV positive men experience significantly

age there were approximately 20 HIV-positive individuals in 1994 for every reported HIV/AIDS death.[25] Therefore, I can infer that a 1 standard deviation increase in 1994 HIV/AIDS death rate is associated with a 280 increase in the HIV positive population (defined as HIV-positive individuals per 100,000 population).[26] If I assume that this HIV positivity rate remained constant before and after the introduction of HAART, estimates from Keiser et al. (2010) would suggest that the overall suicide rate for men would decrease by 1 per 100,000 driven entirely by a fall in suicide rates among HIV positive individuals.[27] Although I cannot discern whether the effects are driven by a reduction in suicide rates among HIV-positive individuals or through other mechanisms (such as reduced consequences of infection for uninfected people or reductions in grief experienced by young gay men), finding similar estimates to those in the Switzerland study suggests that the effects may largely be a result of falling suicide rates among HIV positive individuals.[28] Nonetheless, these estimates should still be interpreted with caution since the mortality data does not provide HIV/AIDS status or any information regarding the cause of suicide.

It may also be important to consider the role of selection when interpreting these results. HIV positive individuals have higher rates of suicide compared to the general population. Since HAART increased survival among HIV positive populations, there is a greater pool of people with a high probability of suicide in the post period.[29]

higher rates of suicide compared to the general population especially prior to the introduction of HAART. Pre-HAART studies of suicide rates among HIV positive men estimate rates of suicide ranging from 7 to 36 times that of the general population (Coté et al., 1992; Marzuk et al., 1988; Kizer et al., 1988).

[25] 20 HIV-positive individuals for each death might be a conservative estimate. In 1994, there were a total of 41,930 HIV-related deaths in the US and an estimated 950,000 people living with HIV according to the Kaiser Family Foundation (KFF, 2006).

[26] 1 standard deviation increase in HIV/AIDS deaths is equal to 14

[27] Pre-HAART: $(14 \times 20) * \frac{447.4}{100{,}000} = 1.25$
Post-HAART: $(14 \times 20) * \frac{90.1}{100{,}000} = 0.25$
Change: $1.25 - 0.25 = 1$

[28] In Appendix G, I explicitly attempt to disentangle effects on Gay Men and Drug Users. I find that effects on

[29] This is more true in areas of high rates of HIV/AIDS and the fixed effects in my model are unable to capture this selection.

I find that HAART reduces suicide rates in counties with high rates of HIV/AIDS. This implies that my estimates are biased downwards and likely underestimate the true effect of HAART on rates of suicide.

6 Robustness Tests

This study depicts falling suicide rates among men aged 25 to 44 in high HIV/AIDS counties relative to low HIV counties. Back-of-the-envelope calculations reveal that the estimates suggested in this paper are reasonable when comparing them to a longitudinal study of HIV-positive individuals in Switzerland. Despite these findings, this study has several limitations.

I exploit geographic variations in HIV/AIDS incidence to conduct my analysis but as depicted in Table 3, high HIV/AIDS counties are different from low HIV/AIDS counties. The effects mentioned above could be the result of different trends between counties with different characteristics.[30] I also do not observe actual HIV/AIDS status or sexual orientation in the mortality data. I have argued that HAART would have significantly larger effects on HIV-positive individuals and gay men but I am unable to observe if these groups are driving the observed results. The 90s are also a period of falling urban violence and crime (Levitt, 2004). Since much of this decline occurred in high HIV/AIDS areas and has larger effects on men aged 25 to 44, relative to other groups, it is possible that the same factors that are driving these changes are affecting my results. Below, I conduct several robustness tests, which provide some evidence that the estimates are driven because of the introduction of HAART.

[30] To ensure that my effects are not driven solely by differing trends in suicide rates in densely and sparsely populated counties, I alter the functional form to account for differential trends in more densely populated counties in Appendix subsection D.4. I find similar effects lending further credibility to main finding.

6.1 Effects on Other Groups and Triple Difference Specification

A potential threat to identification in this model is that differential rates of suicide following 1995 may be a result of geographic changes in mental health that are unrelated to the introduction of HAART. Therefore, I also estimate Equation 1 and Equation 2 for women aged 25-44, men over 65, and men under 20. Since the vast majority of HIV/AIDS infections in this period are a result of Male-to-Male sexual intercourse, these groups have significantly lower rates of HIV/AIDS and should be significantly less affected by the introduction of HAART. Estimates are presented in the first row of Figure 5 and Table 5. These coefficients are negative but statistically insignificant. This may represent some spillover effects. Although these groups had significantly lower rates of HIV/AIDS, they were still affected by the virus. Rates of HIV infection were low but they were not zero. Members of these groups may also have friends and family members who are HIV positive, and therefore it is reasonable to find some negative effects on suicidality following the introduction of HAART.

In addition to testing for spillovers, this group can also serve as a control group in a triple difference specification. Although, mechanisms that influence suicide rates across groups may be different, a triple difference specification allows me to include county-year fixed effects and provides some evidence that effects are not driven by county specific trends which are unrelated to the introduction of HAART.

To verify my main findings, I employ a triple-difference strategy where I difference out effects on suicide rates for groups less affected by HIV/AIDS. Formally, I estimate the following equation:

$$\text{Suicide Rate}_{jct} = \alpha + \sum_{\substack{m \neq 1994 \\ m=1990}}^{2002} \beta_m \left(\text{Pre-HIV/AIDS deathrate}_c \times 1[t=m] \times \text{Men 25-44}_j\right) + \theta_{ct} + \iota_{jc} + \delta_{sjt} + \epsilon_{ctj} \tag{3}$$

where $SuicideRate_{jct}$ measures suicide rates for men aged 25-44, women aged 25-44, men over 65, and men under 20.[31] Men 25-44$_j$ is a dummy variable that measures whether the observation represents suicide rates for men aged 25 to 44. In my triple-difference analysis, I seperately compare effects on men aged 25 to 44 to women aged 25 to 44, men over 65 and men under 19. Pre-HIV/AIDS deathrate$_c$ and $1[t = m]$ are the same as equation 1. Estimates are weighted by group-specific populations and standard errors are clustered at the county level.

I also consider the triple-difference specification because it allows me to control for the interaction of time and county fixed effects (θ_{ct}), and sex and county fixed effects (ι_{jc}). I also control for the interaction of state, sex, and time-fixed effects (δ_{sjt}). This controls for any state-level changes in policy during the period of analysis that may have affected men aged 25 to 44 differently from other groups.

In order to summarize my findings, I consider a standard triple-difference specification where I focus on the impact of the introduction of combination drug therapy on 25 to 44-year-old men's suicide rate relative to suicide rates of other groups in a grouped post period. Formally, I estimate the following equation:

$$\begin{aligned}\text{Suicide Rate}_{jct} = \alpha + \beta\ (\text{Pre-HIV/AIDS deathrate}_c \times \text{Post}_t \times \text{Men 25-44}_j) \quad &+ \theta_{ct} \\ &+ \iota_{jc} + \kappa_{jt} + \delta_{sjt} + \epsilon_{ctj}\end{aligned} \tag{4}$$

where Post_t is a dummy variable that is equal to one after the introduction of HAART. This is a restricted version of Equation 3 and all other features of this equation are the same as that of Equation 3.

[31]Given the differences in suicide rates across demographic groups, I also consider percentage changes of the outcome variable. In Appendix Figure A7, I change my outcome variable to represent the inverse hyperbolic sine of suicide rates and find similar effects.

Estimates for Equation 3 and Equation 4 are provided in the second row of Figure 5 and Table 6. Estimates for the triple difference specification are qualitatively similar to the difference in differences specification lending further credibility to my main finding.

6.2 Firearm and Non-Firearm Suicides

If my estimates are a result of the introduction of HAART, I expect my results to be driven by individuals who are more likely to be affected by the treatment. Gay and bisexual men were significantly more likely to contract HIV, and therefore more likely to be affected by the introduction of a treatment. Although I do not observe sexual orientation in the suicide data, I do observe the method of suicide. There are significant differences in the methods of suicide employed by sexual minority and heterosexual men. Clark et al. (2020a) finds that sexual minority men are significantly less likely to be gun owners compared to heterosexual men. Clark et al. (2020b) finds that firearms are half as likely to be used in suicide for sexual minority men compared to heterosexual men. In my main specification, I collapsed all the different methods of suicide into a single suicide rate. To explore whether my results are driven by effects on sexual minority men, I now categorize suicides into either firearm or non-firearm suicides and calculate rates for each category. The breakdown of ICD codes into firearm and non-firearm suicides is provided in Appendix Table A1.

Figure 6 depicts my event study representing the effect of HAART on firearm and non-firearm suicides. I find that my effects are driven almost entirely by non-firearm suicides. This provides further evidence that my estimates are driven by effects on sexual minority men who are more likely to contract HIV. Since my results are largely driven by non-firearm suicides, this also provides some evidence that my estimates are not a result of changes in gun access.[32]

[32] In Appendix D.1, I explicitly explore how trends in violence might affect the results by comparing

7 Welfare Implications

Accurately measuring the welfare implications of HAART through its effects on suicide is challenging due to data limitations. Simply multiplying the measured effect with the statistical value of life would result in an incomplete and potentially misleading estimation of the overall welfare impact. This is because the population contributing to this effect differs from the general population. HIV-positive individuals generally have a lower life expectancy compared to the general population. Consequently, preventing the death of an HIV-positive individual would result in a lower number of years of life saved in comparison to preventing the death of someone from the general population. In addition to HIV status, the number of life years saved is influenced by the age of the individual, the stage of infection, and other underlying health factors. If the men who were previously dying by suicide were in the late stages of their infection, the number of years of life saved by preventing suicide would be small. Since HAART is an intervention that improves both physical and mental health, this would imply that the welfare benefits of HAART in terms of years of life saved of those individuals who are no longer dying by suicide are driven by preventing HIV/AIDS deaths rather than mental health improvements.

To categorize the individuals driving these results, three groups can be considered: individuals who are HIV negative, individuals in the early phase of HIV infection, and individuals in the later phase of HIV (AIDS). I assume the average individual driving my results is 35 years old.[33] Studies find that without treatment, a person who is exposed to HIV has 5 to 10 years before their infection progresses to AIDS, after which the individual has a life expectancy of 2 years (Poorolajal et al., 2016). Therefore, I assume that the number of life years lost due to poor mental health for a person

trends in homicides and suicides.

[33]This is the average of ages 25, 35, and 45, weighted by coefficients presented in Table 7. Men's life expectancy is 1998 is 72 years.

in the early phases of an HIV infection is 9.5 years whereas the years of life lost for a person in the late phase of an HIV infection is 2 years. Since HAART improves physical health in addition to mental health, I obtain life expectancies of HIV positive individuals in the years following HAART from Harrison et al. (2010) to determine the total years of life saved by preventing an HIV related suicide.[34] According to Harrison et al. (2010), as of 1998, HIV-positive men had a life expectancy of approximately 15.9 years, while men in the late stages of their infection had a life expectancy of approximately 12.1 years. These findings provide important information for estimating the welfare implications of preventing an HIV-related suicide in terms of years of life saved, categorized by HIV status and progression. Based on these statistics, I present estimates of the average years of life saved for a person in each of these three groups through improvements in mental health and physical health in Table 1.[35] I also adjust these years by Quality of Life and present Quality Adjusted Life Years (QALYs) saved. These adjustments are important to consider for this population because, not only do HIV positive individuals experience lower life expectancies, they also experience lower quality of life.[36]

It is reasonable to assume that my effects are being driven by some combination of these three groups. As mentioned earlier, HAART may affect the mental health

[34] It is important to note that estimates obtained from Harrison et al. (2010) are based on national statistics of death rates and may be different from the life expectancies of individuals driving my results. This includes those individuals who take-up HAART as well as those who do not. Since the effects measured in this paper are likely driven by groups of individuals who change their suicide behaviours, they may have better access to treatment and estimates from Harrison et al. (2010) should be considered a lower bound.

[35] "Mental Health" represents how many additional years a person may have lived had they not died by suicide but there was still no treatment for HIV. "Physical Health" represents the additional number of years a person would live due to the improved life expectancy of an HIV positive individual following HAART.

[36] I assume HIV negative individuals have a QALY of 1 per year. I assume individuals with an untreated HIV infection have a QALY of 0.6 per year and individuals with treated HIV infections have a QALY of 0.9 per year. These figures were obtained from Colombo et al. (2013). To isolate mental health benefits, I assume that individuals do not have access to treatment and for physical health benefits, I assume individuals have access to treatment. Although the literature also identifies changes in quality of life through different stages of an HIV infection, for simplicity, I assume that all treated and untreated individuals have the same QALY per year.

	Mental Health		Physical Health	
Status	Years	QALYs	Years	QALYs
HIV -	37	37	0	0
HIV +: early stages	9.5	5.8	6.4	5.8
HIV +: late stages (AIDS)	2	1.2	10.1	9.1

Table 1. Years of life safe saved through improved mental health and physical health for those that died by suicide based on HIV status and progression.

of HIV positive individuals by improving the prognosis of infection but may also improve outcomes for HIV negative individuals through reducing the consequences of contracting HIV, and seeing fewer friends and family members dying from the virus. Although there is a limited literature which explores HIV/AIDS progression and suicide prior to the introduction of HAART, there is some evidence that suicide risk may be highest directly following the diagnosis of an infection or late stages of the virus when an individual might experience pain and disability (Siegel and Meyer, 1999). More recent literature offers examples of both heightened suicide risk directly following the diagnosis of an HIV infection as well as heightened suicide risk following the progression of the virus (Pelton et al., 2021).[37]

While the stage of the virus is not observed in the dataset, the ages of individuals driving the observed effects on suicide as well as the ages of those dying from HIV/AIDS are available. In the primary analysis, the effects of HAART on suicide rates are measured using a broad age group consisting of men aged 25 to 44. While this grouping offers certain benefits, it may also be beneficial to consider effects by narrower age groups to discern who is driving these results.[38] Therefore, I reestimate Equation 2 for men in their 20s, 30s and 40s.[39] My estimates are significantly larger

[37] For many individuals, the time of diagnosis and the progression of the virus to AIDS may have coincided. For example, from 1994-1999, 41% of new HIV diagnosis represented cases of AIDS.

[38] Looking at a broader group allows me to estimate effects on mortality rates more precisely. Estimating rates for smaller populations are more noisy.

[39] Although I restrict my treatment group to men aged 25 to 44 in my primary specification, men who are slightly younger and slightly older may also experience similar effects since they have similar rates of HIV/AIDS.

for men in their 20s and 30s compared to men in their 40s. In Figure 7, I break down pre-HAART HIV/AIDS death rates by age groups. Although the effects in this study are driven by men in their 20s, and 30s, I find higher HIV/AIDS death rates for older cohorts. Although it is possible that the kinds of people who are dying by suicide are different from those that are dying by HIV/AIDS, this provides some suggestive evidence that there is a non-trivial difference in the age of suicide and the age of HIV/AIDS death and that a significant portion of the welfare benefits from preventing an HIV related suicide are a result of improvements in mental health.

Estimates from my main specification suggest that HAART saved approximately 756 men aged 25 to 44 from suicide each year. Assuming an average value of statistical life year (VSLY) of $302,000, I present welfare implications of HAART due to a fall in suicides for several reasonable combinations of the previously mentioned groups based on both years of life saved as well as quality adjusted years of life saved in Table 2.[40]

	USD Millions			
	Mental Health		Physical Health	
Scenario	Years	QALYs	Years	QALYs
10% HIV-, 45% HIV+ early, 45% HIV+ late	2,026	1,564	1,695	1,531
5% HIV-, 30% HIV+ early, 65% HIV+ late	1,370	998	1,937	1,747
5% HIV-, 65% HIV+ early, 30% HIV+ late	1,969	1,365	1,642	1,484

Table 2. Value of statistical life years (VSLYs) saved due to HAART through a fall in suicides for different combinations of HIV status and disease progressions.

The estimates suggest that the introduction of HAART resulted in significant annual savings in VSLY terms through its effect on suicides even after adjusting for quality of life.[41] A significant portion of welfare savings was driven by improvements in mental health through preventing suicide. This implies that suicides were not just

[40] There is significant variation in estimates of the value of a statistical life year (VSLY). A VSLY of $302,000 is obtained from Aldy and Viscusi (2008)

[41] It is important to note that this figure only represents benefits through effects on suicide. There were significantly larger benefits through falling HIV/AIDS death rates.

an alternative to an HIV/AIDS death and had non trivial implications for the welfare of the affected population. It is also important to note that the estimates presented in this study are a lower bound of the benefits of HAART through improvements in mental health more generally because they only measure welfare implication by preventing suicides. Suicide is an extreme mental health outcomes which is highly correlated with other mental health outcomes and decreases in suicide rates are likely correlated with improvements in other mental health outcomes.[42]

8 Conclusion

This study highlights the substantial fall in suicide rates among HIV-affected populations following the introduction of HAART. I find a 1-point decrease in suicide rates for men aged 25 to 44 in counties that have a 1 standard deviation higher pre-HAART HIV/AIDS death rate. The estimates suggest that the introduction of HAART saved approximately 756 men aged 25 to 44 from suicide each year. I find that suicide rates for other groups such as women aged 25-44, men over 65, and men under 20, are largely unaffected by the introduction of HAART.

This study has several limitations. I do not observe HIV/AIDS status, sexual orientation, or the cause of suicide in the mortality data. Despite conducting several robustness tests to demonstrate that the observed effects stem from declining suicide rates in populations most affected by HIV/AIDS, I am unable to completely disentangle the effects of HAART from other changes which occurred over the 90s. This study finds extremely large effects. To argue that these estimates are reasonable, I extrapolate from a similar study in Switzerland and compare estimates. The Swiss study finds large reductions in suicide rates among HIV-positive populations

[42] In Appendix B, I use data from The Behavioral Risk Factor Surveillance System to explore trends in poor mental health days for the affected population. I find suggestive evidence that HAART improved non-extreme mental health outcomes for at-risk groups.

after the introduction of HAART (Keiser et al., 2010). Although I do not observe HIV status in my suicide data, I approximate HIV-positive populations using my HIV/AIDS death data. I use these approximations and the estimates in the Swiss study to predict the fall in suicide rates. These predictions are very similar to my estimated effects and lend credibility to my findings. Although I am unable to discern the exact mechanisms driving my result, finding similar estimates to the Swiss study provides some evidence that results are largely driven by changing patterns of suicide amongst HIV-positive individuals after the introduction of HAART.

This study has important implications for understanding the effects of the HIV/AIDS crisis and the introduction of HAART treatment. By simply measuring HIV/AIDS mortality as deaths that were the direct result of HIV/AIDS progression, we are underestimating the total number of HIV/AIDS deaths. We must account for suicides among populations affected by the virus to get a more accurate figure. It also implies that if we only focus on the direct benefits of HIV treatment, we miss meaningful parts of the benefits of innovations in medical treatments. This has implications for the cost-benefit analyses of HIV treatments but may also affect how we estimate the effects of other treatments for medical conditions. This study warns us about the potential threat of chronic health conditions on mental health outcomes more generally. Although HIV/AIDS was a specific type of virus that affected a particularly vulnerable community, poorer mental health outcomes are observed in patients with other chronic health conditions as well. Understanding the physical and mental health challenges of those with chronic illnesses is integral to their care.

9 Figures

Figure 1 : Cumulative HIV/AIDS deaths overtime

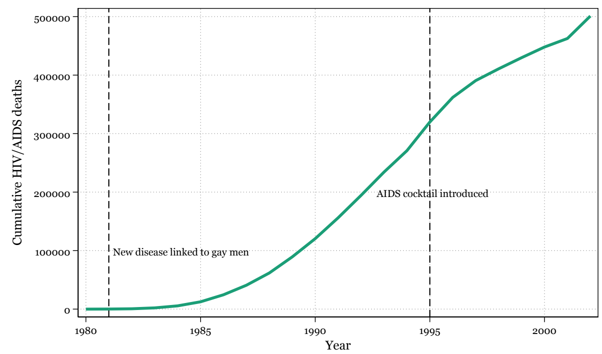


Figure 1. Source: amfAR: The Foundation for AIDS Research (https://www.amfar.org/thirty- years-of-hiv/aids-snapshots-of-an-epidemic).
Notes: Cumulative HIV/AIDS deaths over time.

Figure 2: HIV/AIDS Death Rates Over Time

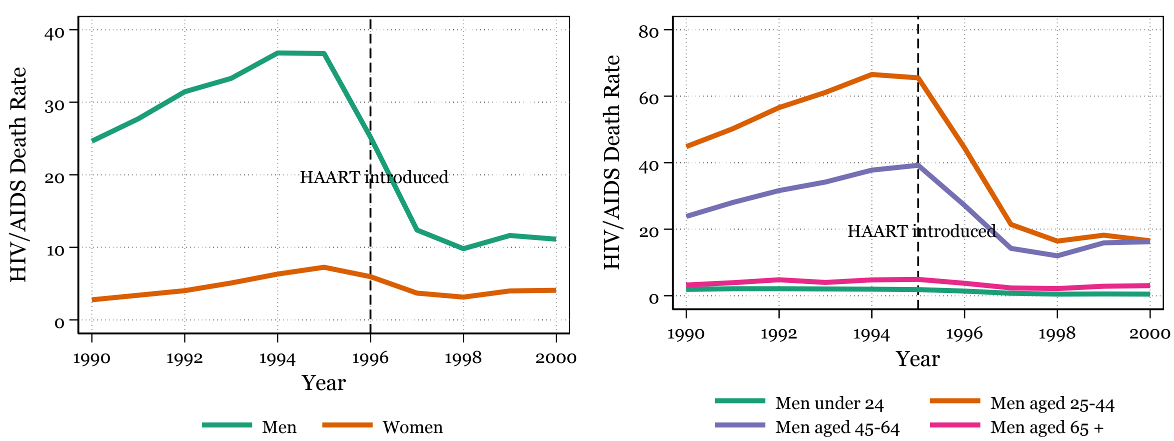


Figure 2. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: HIV/AIDS death rates are calculated per 100,000 group population.

Figure 3 : Estimates from Equation 1 for Men Aged 25 to 44.

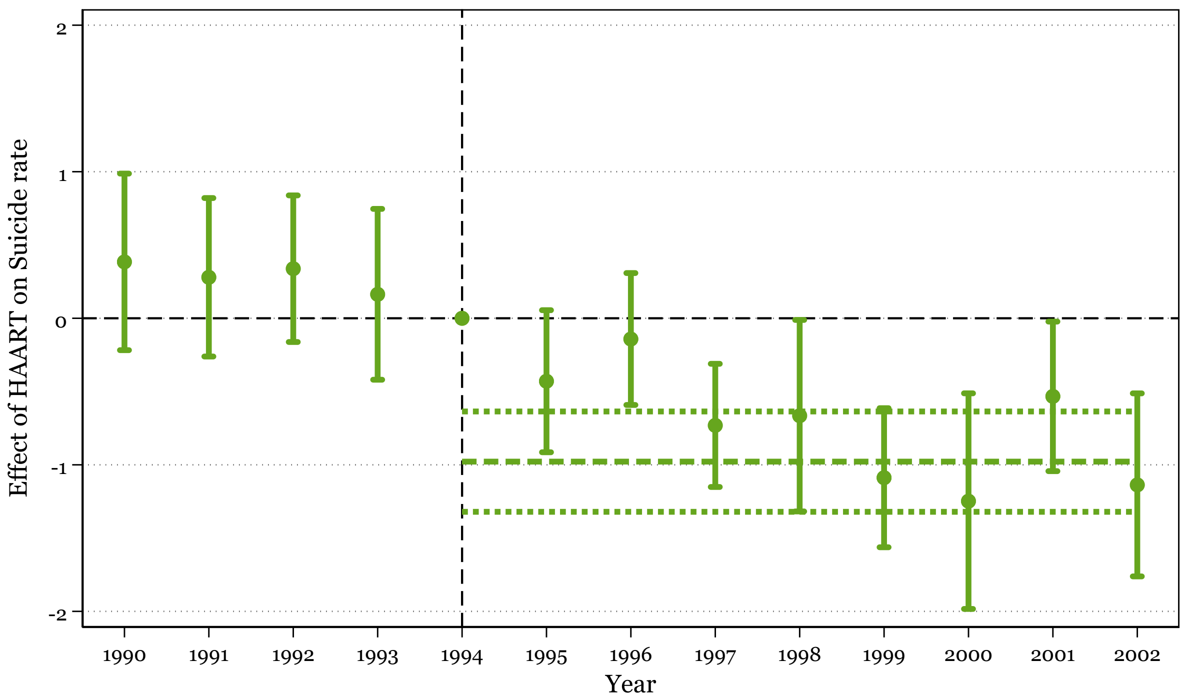


Figure 3. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Figure presents difference-in-differences estimates from Equation 1 for men aged 25 to 44. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure 4 : Effects across distribution

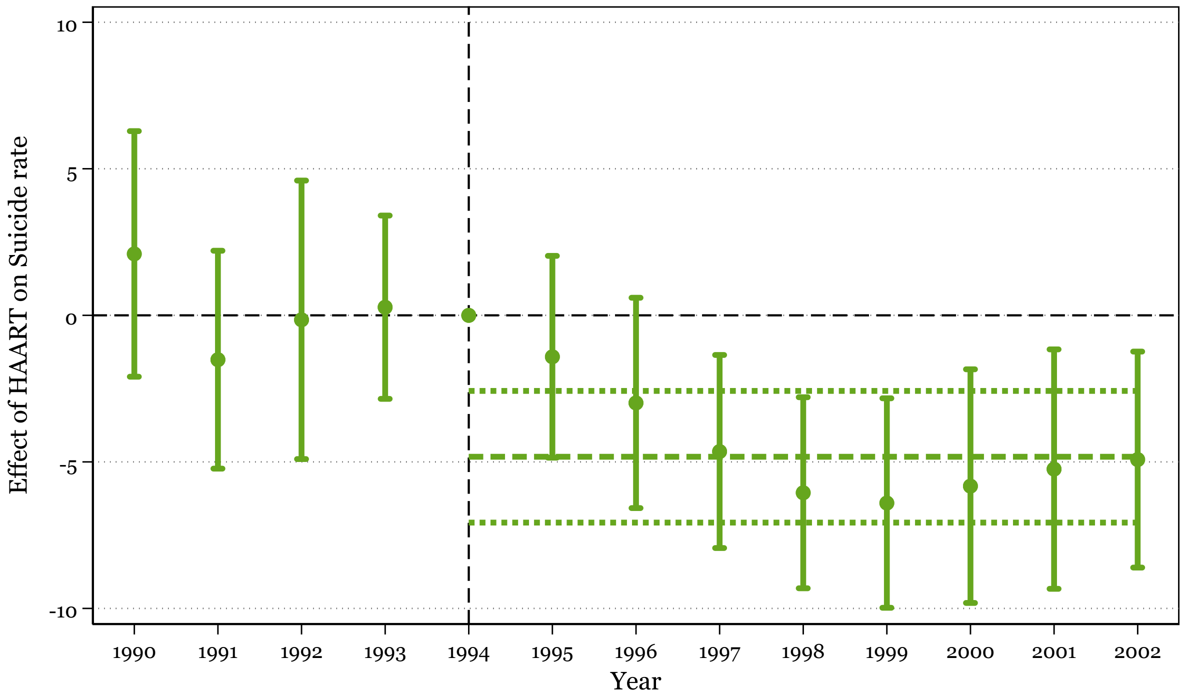


Figure 4. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: This figure presents estimates from Equation 1 where, HIV/AIDS deathrate$_c$ is now a dummy variable that is equal to 1, when looking at the top decile of pre-HAART HIV/AIDS death rates and zero when looking at the bottom 3 for men aged 25 to 44. I control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure 5 : Estimates from Equation 1 & Equation 3

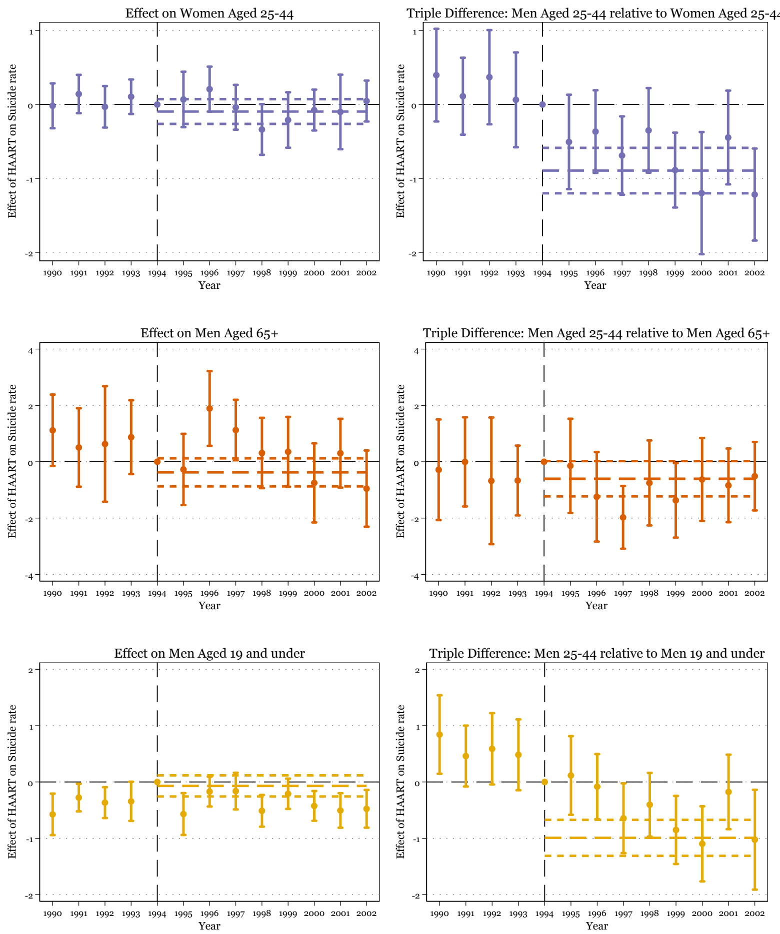


Figure 5. Source: CDC Multiple Cause of Death Data NCHS (1990-2002)
Notes: The first figure in each row presents difference-in-differences estimates from Equation 1 for women aged 25 to 44, men aged 65 plus, and men 19 and under. The second figure of each row presents triple-difference estimates from Equation 3 for men aged 25 to 44 relative to women aged 25-44, men aged 65 plus, and men aged 19 and under. The first figure in each row controls for county fixed effects and state and time fixed effects. The second figure in each row controls for the interaction sex and county fixed effects, county and time fixed effects and state, sex and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure 6: Firearm and non-Firearm Suicides

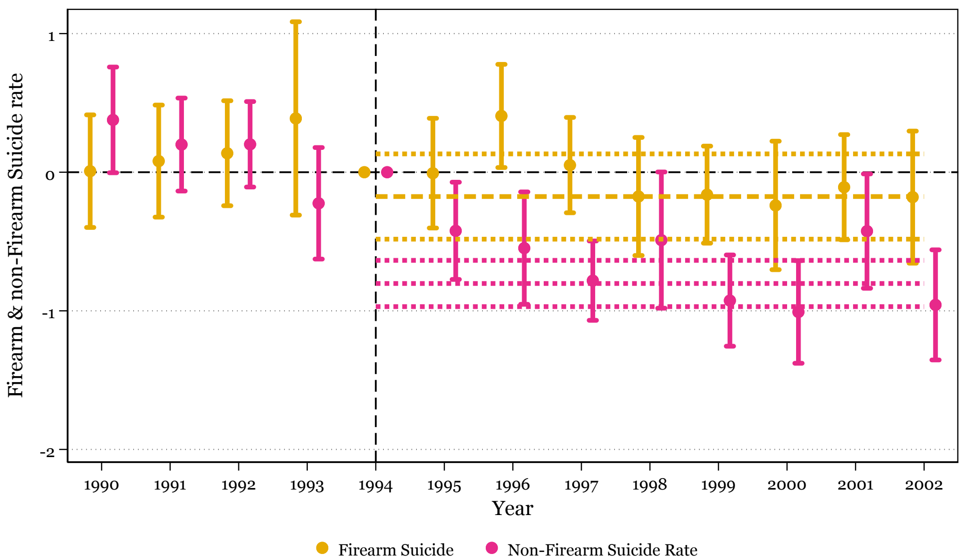


Figure 6. Source: CDC Multiple Cause of Death Data NCHS (1990-2002)
Notes: In this figure, I change the outcome variable to represent firearm or non-firearm suicide rates instead of the overall suicide rate. The figure presents difference-in-differences estimates from Equation 1 for men aged 25 to 44. I control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure 7: HIV/AIDS Death Rates by Age

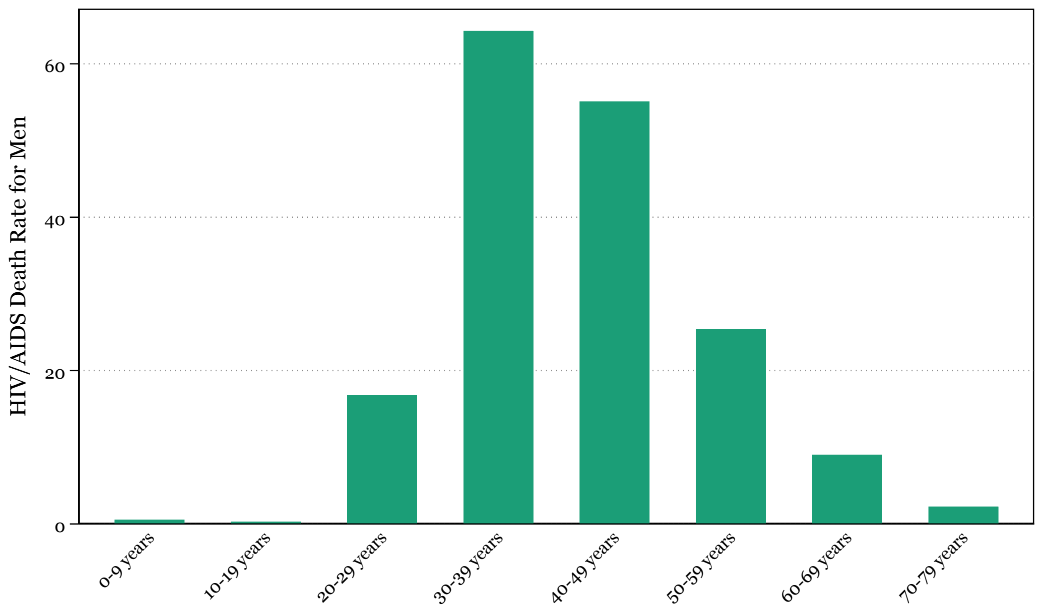


Figure 7. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: The figure presents pre-HAART (1990-1994) HIV/AIDS-related death rates for men in different age groups.

10 Tables

Table 3: Summary Statistics

	4th Quartile	3rd Quartile	2nd Quartile	1st Quartile
Male Suicide Rate	20.39	18.48	19.03	17.77
	(7.42)	(7.97)	(8.58)	(8.57)
Female Suicide Rate	5.17	4.72	4.57	3.94
	(2.68)	(2.74)	(3.04)	(3.40)
Male HIV Death Rate	43.70	15.77	8.50	4.47
	(55.49)	(15.95)	(9.81)	(6.04)
Female HIV Death Rate	5.07	1.81	0.78	0.41
	(10.25)	(2.87)	(1.56)	(1.10)
1994 HIV Death Rate	28.85	11.06	5.34	2.40
	(20.02)	(2.26)	(0.96)	(0.85)
Male Fire Arm Suicide Rate	12.26	11.19	12.07	11.06
	(5.78)	(6.06)	(6.74)	(6.25)
Female Fire Arm Suicide Rate	1.94	1.67	1.57	1.33
	(1.66)	(1.77)	(1.82)	(1.92)
Male Non Fire Arm Suicide Rate	8.12	7.29	6.96	6.71
	(4.43)	(4.19)	(4.62)	(5.12)
Female Non Fire Arm Suicide Rate	3.23	3.06	3.00	2.61
	(1.87)	(2.08)	(2.41)	(2.65)
Unemployment Rate	6.82	6.25	6.26	6.53
	(1.98)	(2.33)	(2.55)	(3.35)
Population Density	2,484.85	1,305.59	704.97	519.17
	(2,849.46)	(1,160.48)	(613.32)	(539.54)
Percentage Pop Male	48.68	48.71	48.81	49.12
	(1.13)	(1.13)	(0.96)	(1.21)
Percentage Pop White	74.42	84.81	89.78	93.77
	(12.56)	(7.89)	(6.35)	(5.41)
Percentage Pop aged b/w 0 and 24	35.95	35.68	36.12	37.45
	(3.28)	(3.63)	(3.58)	(4.72)
Percentage Pop aged b/w 25 and 44	33.95	32.90	32.91	32.36
	(2.43)	(2.38)	(2.88)	(3.12)
Proportion Evangelical Protestant	0.11	0.11	0.12	0.10
	(0.10)	(0.11)	(0.09)	(0.07)
Proportion Adherants to a Religion	0.57	0.59	0.56	0.62
	(0.11)	(0.15)	(0.15)	(0.16)
Observations	1980	2040	1960	1820

mean coefficients; sd in parentheses
4th Quartile: counties in top 25 percentile of HIV/AIDS death rates in 1994
3rd Quartile: counties in 50th-75th percentile of HIV/AIDS death rates in 1994
2rd Quartile: counties in 25th-50th percentile of HIV/AIDS death rates in 1994
1st Quartile: counties in bottom 25 percentile HIV/AIDS death rates in 1994

Table 3. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents summary statistics for counties across the distribution of 1994 HIV/AIDS death rates for the years before the introduction of HAART (1990-1994).

Table 4: Difference in Differences: Men aged 25 to 44.

	Men 25-44	
	(1)	(2)
Post=1 × Stdz 1994 HIV death rate	-1.03379***	-0.97821***
	(0.147)	(0.174)
Observations	5070	4979
County FE	Yes	Yes
Time FE	Yes	No
State X Time FE	No	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation 2 for men aged 25 to 44. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Estimates include controls for county unemployment, percentage of population that is white, percentage of population that is evangelical protestant, percentage of population that adheres to a religion.

Table 5: Difference in Differences: Women aged 25-44, Men aged 65+ and Men under 19.

	Women 25-44		Men 65+		Men Under 19	
	(1)	(2)	(3)	(4)	(5)	(6)
Post=1 × Stdz 1994 HIV death rate	-0.07506	-0.09490	-0.16355	-0.07436	-0.06766	-0.06984
	(0.079)	(0.085)	(0.323)	(0.246)	(0.084)	(0.095)
Observations	5070	4979	5070	4979	5067	4976
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	No	Yes	No
State X Time FE	No	Yes	No	Yes	No	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation 2 for women aged 25-44, men over 65 and men under 19. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

Table 6: Triple Difference: Men aged 25-44 relative to women aged 25-44, Men aged 65+, Men under 19.

	Relative to: Women 25-44		Relative to: Men over 65		Relative to: Men under 19	
	(1)	(2)	(3)	(4)	(5)	(6)
Post=1 × Men 25-44=1 × Stdz 1994 HIV death rate	-0.95622***	-0.89336***	-0.87495**	-0.92818***	-1.01339***	-0.97783***
	(0.130)	(0.156)	(0.358)	(0.349)	(0.147)	(0.156)
Observations	10140	9958	10140	9958	10134	9952
County X Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Time X Age/Sex FE	Yes	No	Yes	No	Yes	No
Age X County FE	Yes	Yes	Yes	Yes	Yes	Yes
Time X Age/Sex X State FE	No	Yes	No	Yes	No	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents triple-difference estimates from Equation 4 for men aged 25 to 44 relative to women aged 25 to 44, Men over 65, and Men under 19. Estimates control for the interaction of sex and county fixed effects, county and time fixed effects and state, sex and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

Table 7: Difference in Differences: Alternate age groups

	Men 20-29		Men 30-39		Men 40-49	
	(1)	(2)	(3)	(4)	(5)	(6)
Post=1 × Stdz 1994 HIV death rate	-0.85202***	-0.93916***	-1.17184***	-1.08579***	-0.86411***	-0.67275**
	(0.292)	(0.362)	(0.252)	(0.238)	(0.303)	(0.326)
Observations	5070	4979	5070	4979	5070	4979
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	No	Yes	No
State X Time FE	No	Yes	No	Yes	No	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation 2 for men aged 20-29, 30-39, and 40-49. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

References

Aldy, Joseph E and W Kip Viscusi, "Adjusting the value of a statistical life for age and cohort effects," *The Review of Economics and Statistics*, 2008, *90* (3), 573–581.

Altman, Lawrence K., "Combination of Drugs Appears To Slow AIDS Virus, Studies Say," Feb 02 Feb 02, 1995. Copyright - Copyright New York Times Company Feb 2, 1995; People - ALTMAN, LAWRENCE K; Last updated - 2017-11-15; CODEN - NYTIAO.

Baranov, Victoria and Hans-Peter Kohler, "The impact of AIDS treatment on savings and human capital investment in Malawi," *American Economic Journal: Applied Economics*, 2018, *10* (1), 266–306.

_ , Daniel Bennett, and Hans-Peter Kohler, "The indirect impact of antiretroviral therapy," 2012.

_ , _ , and _ , "The indirect impact of antiretroviral therapy: mortality risk, mental health, and HIV-negative labor supply," *Journal of health economics*, 2015, *44*, 195–211.

Björkenstam, Charlotte, Gunnar Andersson, Christina Dalman, Susan Cochran, and Kyriaki Kosidou, "Suicide in married couples in Sweden: Is the risk greater in same-sex couples?," *European journal of epidemiology*, 2016, *31* (7), 685–690.

BLS, "U.S. Bureau of Labor Statistics Unemployment Rate 1990-2002," *U.S. Bureau of Labor Statistics*, 1990-2002.

Borusyak, Kirill, Xavier Jaravel, and Jann Spiess, "Revisiting event study designs: Robust and efficient estimation," *arXiv preprint arXiv:2108.12419*, 2021.

Bozzette, Samuel A, Geoffrey Joyce, Daniel F McCaffrey, Arleen A Leibowitz, Sally C Morton, Sandra H Berry, Afshin Rastegar, David Timberlake, Martin F Shapiro, and Dana P Goldman, "Expenditures for the care of HIV-infected patients in the era of highly active antiretroviral therapy," *New England Journal of Medicine*, 2001, *344* (11), 817–823.

Carpenter, Christopher S, Samuel T Eppink, Gilbert Gonzales, and Tara McKay, "Effects of access to legal same-sex marriage on marriage and health," *Journal of Policy Analysis and Management*, 2021, *40* (2), 376–411.

Carrico, Adam W, "Elevated suicide rate among HIV-positive persons despite benefits of antiretroviral therapy: implications for a stress and coping model of suicide," 2010.

Case, Anne and Angus Deaton, *Deaths of Despair and the Future of Capitalism*, Princeton University Press, 2021.

CDC, "AIDS Public Information Data Set US serveilance data 1990-2002," *Centers for Disease Control and Prevention*, 1990-2002.

_ , "Centers for Disease Control and Prevention (CDC). Behavioral Risk Factor Surveillance System Survey Data. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention," 1990-2002.

_ , "First 500,000 AIDS Cases–United States, 1995," *MMWR. Morbidity and mortality weekly report*, 1995, *44* (46), 849–853.

Chaisemartin, Clément De and Xavier d'Haultfoeuille, "Difference-in-differences estimators of intertemporal treatment effects," Technical Report, National Bureau of Economic Research 2022.

— **and —**, "Two-way fixed effects and differences-in-differences with heterogeneous treatment effects: A survey," Technical Report, National Bureau of Economic Research 2022.

Chan, Tat Y, Barton H Hamilton, and Nicholas W Papageorge, "Health, risky behaviour and the value of medical innovation for infectious disease," *The Review of Economic Studies*, 2016, *83* (4), 1465–1510.

Clark, Kirsty A, John R Blosnich, Robert WS Coulter, Patricia Bamwine, Robert M Bossarte, and Susan D Cochran, "Sexual orientation differences in gun ownership and beliefs about gun safety policy, General Social Survey 2010–2016," *Violence and gender*, 2020, *7* (1), 6–10.

—, Vickie M Mays, Onyebuchi A Arah, Leeka I Kheifets, and Susan D Cochran, "Sexual orientation differences in lethal methods used in suicide: findings from the National Violent Death Reporting System," *Archives of suicide research*, 2020, pp. 1–17.

Cochran, Susan D and Vickie M Mays, "Mortality risks among persons reporting same-sex sexual partners: Evidence from the 2008 General Social Survey—National Death Index Data Set," *American journal of public health*, 2015, *105* (2), 358–364.

Colombo, Giorgio L, Sergio Di Matteo, Andrea Antinori, Massimo Medaglia, Silvia Murachelli, and Giuliano Rizzardini, "Economic evaluation of initial antiretroviral therapy for HIV-infected patients: an update of Italian guidelines," *ClinicoEconomics and Outcomes Research*, 2013, pp. 489–496.

Coté, Timothy R, Robert J Biggar, and Andrew L Dannenberg, "Risk of suicide among persons with AIDS: a national assessment," *Jama*, 1992, *268* (15), 2066–2068.

Dillender, Marcus, "Evidence and lessons on the health impacts of public health funding from the fight against HIV/AIDS," *American Economic Review*, 2023, *113* (7), 1825–1887.

Egger, Matthias, Margaret May, Geneviève Chêne, Andrew N Phillips, Bruno Ledergerber, François Dabis, Dominique Costagliola, Antonella D'Arminio Monforte, Frank De Wolf, Peter Reiss et al., "Prognosis of HIV-1-infected patients starting highly active antiretroviral therapy: a collaborative analysis of prospective studies," *The Lancet*, 2002, *360* (9327), 119–129.

Fernández, Raquel, Sahar Parsa, and Martina Viarengo, "Coming out in America: Thirty years of cultural change."," *Unpublished paper*, 2021.

Grammich, Clifford, K Hadaway, Richard Houseal, DE Jones, Alexei Krindatch, Richie Stanley, and RH Taylor, "Longitudinal Religious Congregations and Membership File, 1980–2010 (County-Level)," 2018.

Hamilton, Barton, Andrés Hincapié, Emma C Kalish, and Nicholas W Papageorge, "Innovation and Health Disparities During an Epidemic: The Case of HIV," Technical Report, National Bureau of Economic Research 2021.

Harrison, Kathleen McDavid, Ruiguang Song, and Xinjian Zhang, "Life expectancy after HIV diagnosis based on national HIV surveillance data from 25 states, United States," *JAIDS Journal of Acquired Immune Deficiency Syndromes*, 2010, *53* (1), 124–130.

Hottes, Travis Salway, Laura Bogaert, Anne E Rhodes, David J Brennan, and Dionne Gesink, "Lifetime prevalence of suicide attempts among sexual minority adults by study sampling strategies: A systematic review and meta-analysis," *American journal of public health*, 2016, *106* (5), e1–e12.

Judd, Fiona K, Alex M Cockram, Angela Komiti, Anne M Mijch, Jennifer Hoy, and Richard Bell, "Depressive symptoms reduced in individuals with HIV/AIDS treated with highly active antiretroviral therapy: a longitudinal study," *Australian & New Zealand Journal of Psychiatry*, 2000, *34* (6), 1015–1021.

Kalichman, Seth C, Timothy Heckman, Arlene Kochman, Kathleen Sikkema, and Jo Bergholte, "Depression and thoughts of suicide among middle-aged and older persons living with HIV-AIDS," *Psychiatric Services*, 2000, *51* (7), 903–907.

Keiser, Olivia, Adrian Spoerri, Martin WG Brinkhof, Barbara Hasse, Angèle Gayet-Ageron, Frédéric Tissot, Anna Christen, Manuel Battegay, Patrick Schmid, Enos Bernasconi et al., "Suicide in HIV-infected individuals and the general population in Switzerland, 1988–2008," *American Journal of Psychiatry*, 2010, *167* (2), 143–150.

_, Patrick Taffé, Marcel Zwahlen, Manuel Battegay, Enos Bernasconi, Rainer Weber, Martin Rickenbach, Swiss HIV Cohort Study et al., "All cause mortality in the Swiss HIV Cohort Study from 1990 to 2001 in comparison with the Swiss population," *Aids*, 2004, *18* (13), 1835–1843.

Kellerman, Scott E, J Stan Lehman, Amy Lansky, Mark R Stevens, Frederick M Hecht, Andrew B Bindman, and Pascale M Wortley, "HIV testing within at-risk populations in the United States and the reasons for seeking or avoiding HIV testing," *JAIDS-HAGERSTOWN MD-*, 2002, *31* (2), 202–210.

KFF, "AIDS at 25: An Overview of Major Trends in the U.S. Epidemic," *Kaiser Family Foundation*, 2006.

Kizer, Kenneth W, Martin Green, Carin I Perkins, Gwendolyn Doebbert, and Michael J Hughes, "AIDS and suicide in California," *Jama*, 1988, *260* (13), 1881–1881.

Kumar, Santosh, Mengyao Jin, Anusha Ande, Namita Sinha, Peter S Silverstein, and Anil Kumar, "Alcohol consumption effect on antiretroviral therapy and HIV-1 pathogenesis: role of cytochrome P450 isozymes," *Expert opinion on drug metabolism & toxicology*, 2012, *8* (11), 1363–1375.

Lakdawalla, Darius, Anup Malani, and Julian Reif, "The insurance value of medical innovation," *Journal of public economics*, 2017, *145*, 94–102.

_ , Neeraj Sood, and Dana Goldman, "HIV breakthroughs and risky sexual behavior," *The Quarterly Journal of Economics*, 2006, *121* (3), 1063–1102.

Levine, Robert S, Nathaniel C Briggs, Barbara S Kilbourne, William D King, Yvonne Fry-Johnson, Peter T Baltrus, Baqar A Husaini, and George S Rust, "Black–white mortality from HIV in the United States before and after introduction of highly active antiretroviral therapy in 1996," *American journal of public health*, 2007, *97* (10), 1884–1892.

Levitt, Steven D, "Understanding why crime fell in the 1990s: Four factors that explain the decline and six that do not," *Journal of Economic perspectives*, 2004, *18* (1), 163–190.

Liu, Chenglong, Kathleen Weber, Esther Robison, Zheng Hu, Lisa P Jacobson, and Stephen J Gange, "Assessing the effect of HAART on change in quality of life among HIV-infected women," *AIDS research and therapy*, 2006, *3* (1), 1–11.

Marzuk, Peter M, Helen Tierney, Kenneth Tardiff, Elliot M Gross, Edward B Morgan, Ming-Ann Hsu, and J John Mann, "Increased risk of suicide in persons with AIDS," *Jama*, 1988, *259* (9), 1333–1337.

Meyer, Breed D, "Natural and quasi-experiments in economics," *Journal of business & economic statistics*, 1995, *13* (2), 151–161.

NCHS, "Multiple Cause of Death Data 1968-1995," *National Bureau of Economic Research*, 1990-2002.

Odets, Walts, *In the shadow of the epidemic: Being HIV-Negative in the Age of AIDS*, Due University Press, 1995.

Papageorge, Nicholas W, "Why medical innovation is valuable: Health, human capital, and the labor market," *Quantitative Economics*, 2016, *7* (3), 671–725.

Pelton, Matt, Matt Ciarletta, Holly Wisnousky, Nicholas Lazzara, Monica Manglani, Djibril M Ba, Vernon M Chinchillli, Ping Du, Anna E Ssentongo, and Paddy Ssentongo, "Rates and risk factors for suicidal ideation, suicide attempts and suicide deaths in persons with HIV: a systematic review and meta-analysis," *General psychiatry*, 2021, *34* (2).

Perlman, Chronicle Science Editor David, "Promising AIDS Drug Available By Lottery2,000 patients to get free trial treatment," *THE SAN FRANCISCO CHRONICLE*, June 22, 1995, p. A2.

Poorolajal, Jalal, Elham Hooshmand, Hossein Mahjub, Nader Esmailnasab, and Ensiyeh Jenabi, "Survival rate of AIDS disease and mortality in HIV-infected patients: a meta-analysis," *Public health*, 2016, *139*, 3–12.

Raifman, Julia, Ellen Moscoe, S Bryn Austin, and Margaret McConnell, "Difference-in-differences analysis of the association between state same-sex marriage policies and adolescent suicide attempts," *JAMA pediatrics*, 2017, *171* (4), 350–356.

Ruffieux, Yann, Liis Lemsalu, Karoline Aebi-Popp, Alexandra Calmy, Matthias Cavassini, Christoph A Fux, Huldrych F Günthard, Catia Marzolini, Alexandra Scherrer, Pietro Vernazza et al., "Mortality from suicide among people living with HIV and the general Swiss population: 1988-2017," *Journal of the International AIDS Society*, 2019, *22* (8), e25339.

Ruggles, Steven, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek, "IPUMS USA: version 10.0 2000 Census," *Minneapolis, Mn: Ipums*, 2023, *10*, D010.

Sant'Anna, Pedro HC and Jun Zhao, "Doubly robust difference-in-differences estimators," *Journal of Econometrics*, 2020, *219* (1), 101–122.

Schlebusch, L and RD Govender, "Elevated risk of suicidal ideation in HIV-positive persons," *Depression research and treatment*, 2015, *2015.*

SEER, National Cancer Institute, "U.S. Population Data, 1969-2019," Technical Report, Surveillance, Epidemiology, and End Results Program. 2020.

Siegel, Karolynn and Ilan H Meyer, "Hope and resilience in suicide ideation and behavior of gay and bisexual men following notification of HIV infection," *AIDS Education and Prevention*, 1999, *11*, 53–64.

Smith, David M and Gary J Gates, "Gay and Lesbian Families in the United States: Same-Sex Unmarried Partner Households. A Preliminary Analysis of 2000 United States Census Data.," 2001.

Sullivan, Andrew, "Fighting The Death Sentence," Nov 21 Nov 21, 1995. Copyright - Copyright New York Times Company Nov 21, 1995; Last updated - 2017-11-15; CODEN - NYTIAO.

Twenge, Jean M, Ryne A Sherman, and Brooke E Wells, "Changes in American adults' sexual behavior and attitudes, 1972–2012," *Archives of sexual behavior*, 2015, *44*, 2273–2285.

Zalla, Lauren C, Stephen R Cole, Joseph J Eron, Adaora A Adimora, Anissa I Vines, Keri N Althoff, Michael J Silverberg, Michael A Horberg, Vincent C Marconi, Sally B Coburn et al., "Association of Race and Ethnicity with Initial Prescription of Antiretroviral Therapy among People with HIV in the US," *JAMA*, 2023, *329* (1), 52–62.

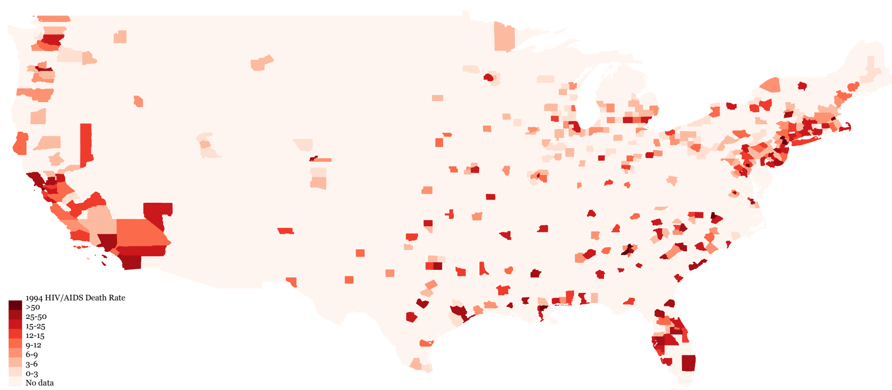
A Appendix: Additional Tables and Figures

Table A1: ICD Codes by Cause of Death.

Cause of Death	ICD 9 Code (1990 - 1998)	ICD 10 Code (1999 - 2002)
Suicide	E950-E959	U03, X60-X84, Y87.0
HIV/AIDS death	042	B20-B24
Firearm Suicide	E955	X72, X73, X74
Non Firearm Suicide	E950-E954, E956-E959	U03, X60-X71, X76-X84, Y87.0

Appendix Table A1. ICD codes by cause of death

Figure A1 : Map of County Level Pooled HIV/AIDS Death Rate



Appendix Figure A1. Source: NCHS (1990-2002).
Notes: The figure represents a map of the U.S. depicting county level rates of 1994 HIV/AIDS Deaths per 100,000 population.

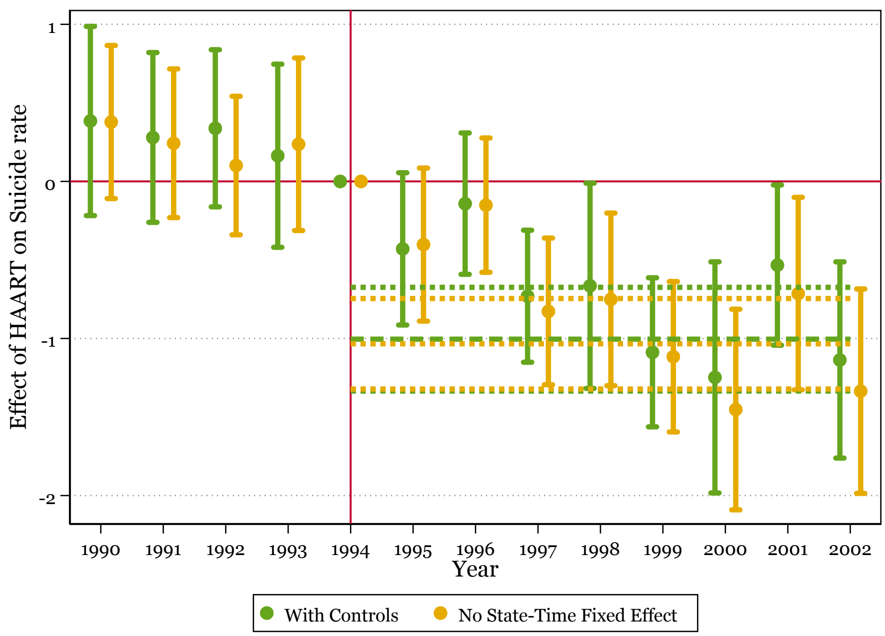
Table A2: Summary Statistics of counties in and outside sample.

	Counties in Sample	Other Counties
Unemployment Rate	6.53	7.17
	(2.37)	(3.04)
Population Density	1,412.99	559.81
	(1,631.10)	(2,804.12)
Percentage Pop Male	48.76	48.92
	(1.12)	(1.53)
Percentage Pop White	82.16	85.58
	(12.24)	(17.28)
Percentage Pop aged b/w 0 and 24	36.07	36.25
	(3.65)	(4.36)
Percentage Pop aged b/w 25 and 44	33.29	30.54
	(2.66)	(3.23)
Proportion Evangelical Protestant	0.11	0.21
	(0.10)	(0.17)
Proportion Adherants to a Religion	0.58	0.60
	(0.14)	(0.19)
Population	422,026.8	33,498.96
	(625,432.6)	(97,669.53)
Observations	1950	13685

mean coefficients; sd in parentheses

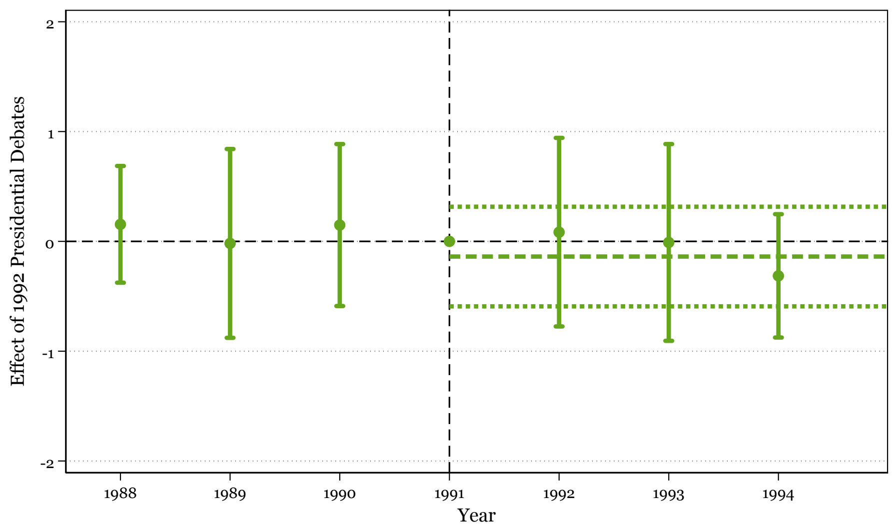
Appendix Table A2. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents summary statistics for counties that are in my sample of analysis and counties which are not for the years before the introduction of HAART (1990-1994).

Figure A2: Including Time Varying Control Variables and Removing State-Year Fixed Effects.



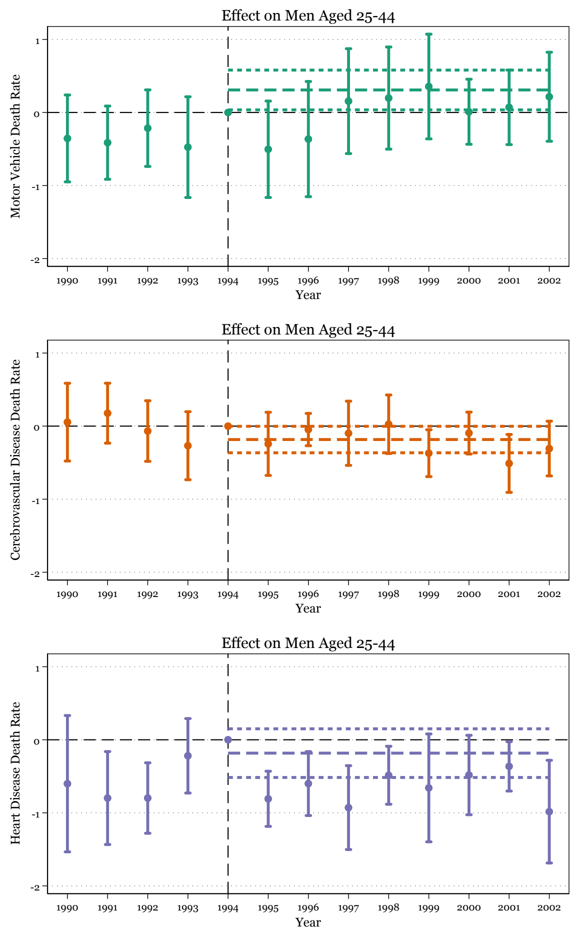
Appendix Figure A2. Source: NCHS (1990-2002).
Notes: The figure presents difference in differences estimates from Equation 1 for men aged 25 to 44 while including time-varying control variables and removing state-year fixed effects. In green, I present estimates while including controls for county unemployment, percentage of population that is white, percentage of population that is evangelical protestant, percentage of population that adheres to a religion. I control for county fixed effects and state and time fixed effects. In yellow, I present estimates where I control for county fixed effects and year fixed effects instead of state and year fixed effects. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect. All estimates are weighted by group county level population and standard errors are clustered at the county level.

Figure A3 :Including Time Varying Control Variables and Removing State-Year Fixed Effects.



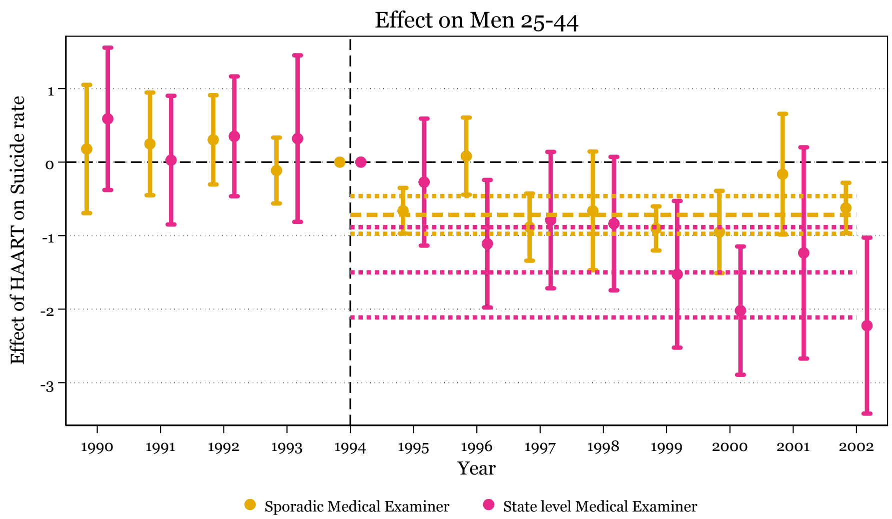
Appendix Figure A3. Source: NCHS (1990-2002).
Notes: The figure presents difference in differences estimates from Equation 1 for men aged 25 to 44 for the year 1988-1994 while changing the treatment year to 1992. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure A4: Falsification Tests



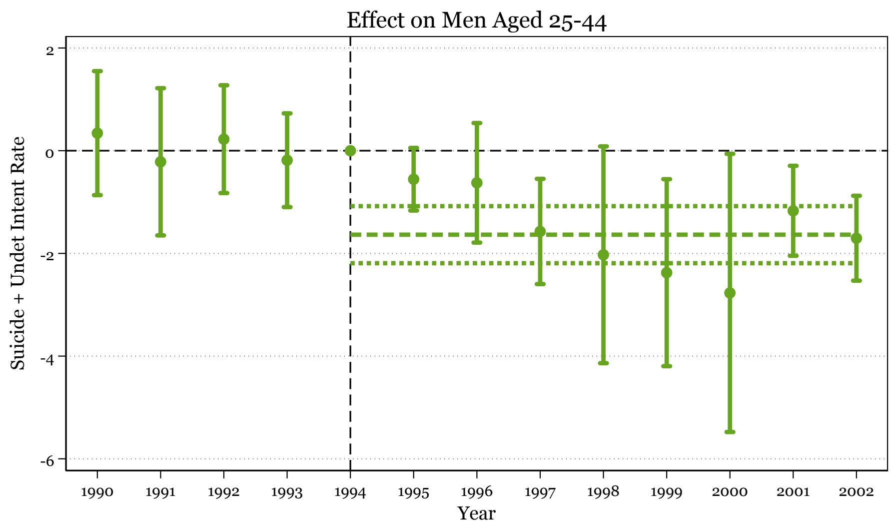
Appendix Figure A4. In these figures, I change the outcome variable represent death rates from motor vehicle accidents, cerebrovascular diseases, and heart diseases. I present Difference in Differences Estimates from Equation 1 for men aged 25-44. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure A5: Coroners and Medical Examiners



Appendix Figure A5. In these figures, I reesimate Equation 1 and Equation 3 for states with sporadic county medical examiner systems (AL, CA, CO, GA, HI, IL, MN, MO, NY, OH, PA, TX, WA, and WI) while controling for medical examiner system status and other states. I present Equation 1 for men aged 25 to 44. I control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

Figure A6: Misclassified Suicide Deaths



Appendix Figure A6. The figure presents difference in difference estimates from Equation 1 for men aged 25 to 44 where the suicide rate is calculated using both suicides and misclassified deaths. I control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

Table A3: Effects on Men Aged 25-44 at the time HAART was introduced (Born 1951-1970).

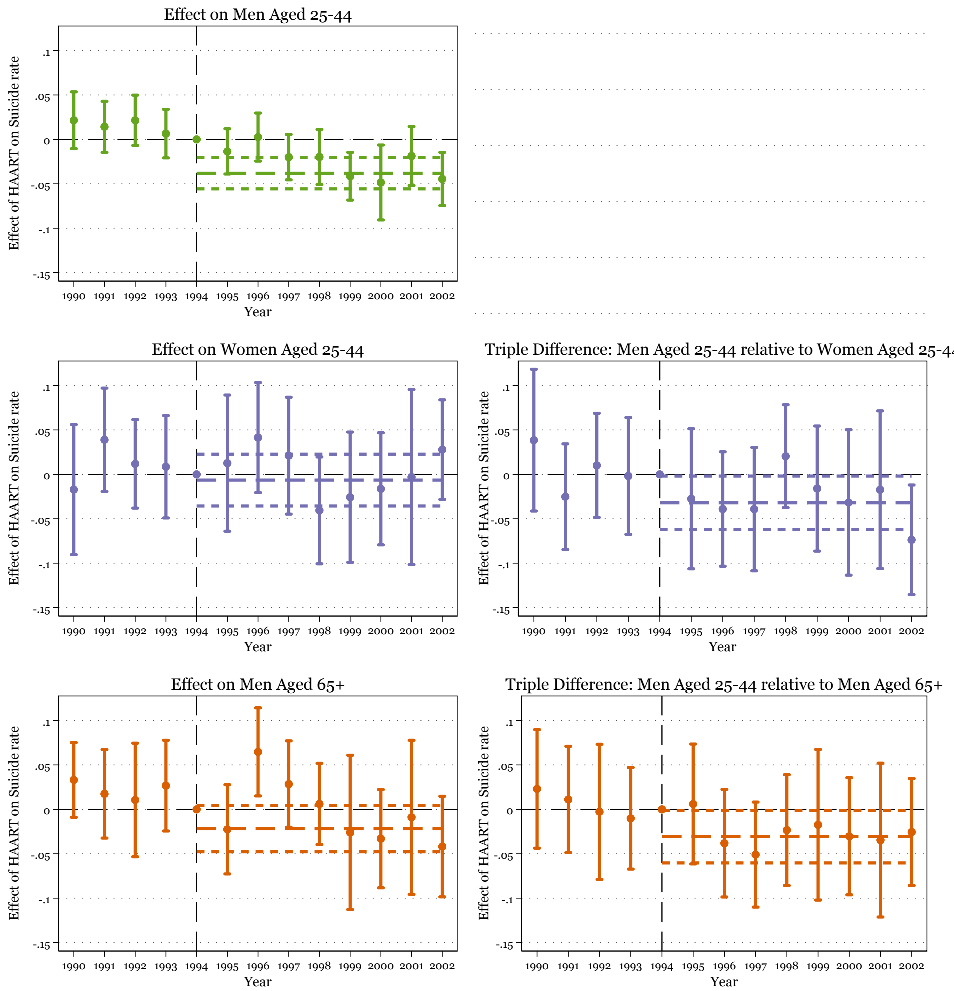
	Men Aged 25-44 in 1995	
	(1)	(2)
post=1 × Stdz 1994 HIV death rate	-0.77197***	-0.81982***
	(0.163)	(0.170)
Observations	5070	4979
County FE	Yes	Yes
Time FE	Yes	No
State X Time FE	No	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A3. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation 9 for men aged 25-44 at the time HAART treatment was introduced. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

Figure A7: Inverse Hyperbolic Sin Transformation



Appendix Figure A7. Figures on the left depict estimates for Equation 1 for men aged 25 to 44, women aged 25 to 44 and men over 65 after changing the dependant variable to represent the inverse hyperbolic sine transformation of suicide rates. I control for county fixed effects and state and time fixed effects. The figure on the right presents Triple Difference Estimates from Equation 3 with women aged 25 to 44 and men over 65 as control groups. I control for the interaction of time and county fixed effects, sex and county fixed effects, and state, sex and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimates and confidence intervals from specifications without time variations in treatment effect.

B Poor Mental Health Days

Thus far, this paper focuses on the effect of HAART on suicide rates. Suicides represent an extreme outcome resulting from poor mental health; however, poor mental health is often accompanied by several nonextreme outcomes. Mental health also plays an integral role in overall well-being, therefore it may also be important to consider mental health in and of itself. Due to the dearth of mental health data, this study is unable to estimate the causal effects of HAART on non-suicide mental health outcomes. Instead, I use data from the Behavioral Risk Factor Surveillance System (BRFSS) and provide suggestive evidence that the introduction of HAART reduced the average number of poor mental health days for certain at-risk groups.

The BRFSS is a national telephone survey that collects data from U.S. residents regarding their health-related risk behaviors, chronic health conditions, and use of preventive services. The BRFSS is considered to be representative at the state level but, since this paper exploits county-level variations in pre-HAART HIV/AIDS death rates, I conduct analysis at the county level and caution that this should only be considered suggestive evidence. The BRFSS only provides county codes for counties with over 50 respondents. Due to the smaller sample size, I only consider a discrete variable indicating HIV/AIDS intensity instead of the continuous variable used in my main analysis. Counties that are in the top 10 percentile of pre-HAART HIV/AIDS death rates as per the mortality data are classified as high HIV counties whereas all other counties are classified as low HIV counties.

Similar to my main sample, the BRFSS does not provide information about sexual orientation or the HIV/AIDS status of respondents surveyed. I follow Carpenter et al. (2021) and exploit a key feature of the BRFSS to obtain a sample of the population that has a higher proportion of gay respondents. The BRFSS asks the respondent to report the number of adult males and adult females in the household. By creating a sample that includes only households consisting of exactly two adult males, Carpenter et al. (2021) argues that we can construct a sample with a greater proportion of gay respondents. Since 2014, some states have added questions about sexual orientation to their survey. Carpenter et al. (2021) uses this data and shows that when we restrict the sample to respondents who are over 25 and reside in households consisting of exactly two adult males, the sample consists of 26.1% respondents who identify as gay relative to only 1.8% of respondents who identify as gay overall.

The BRFSS also provides information about self-reported mental health from 1993 onwards. The BRFSS asks the following question: "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" To study the effect of HAART on self-reported mental health, I look at responses to this questions among respondents aged 25 to 44 living in households comprised of exactly two same-sex adult males in high HIV/AIDS counties (top 10 percentile). I expect this group to be at a higher risk of contracting HIV, and therefore more likely to be affected by the introduction of HAART. I compare trends for this group to trends of other groups. For some of the years in my sample, the BRFSS also provides information about the self-assessed risk of contracting HIV. Below, I provide information about the proportion of respondents reporting medium or high risk of contracting HIV by the group in question. Same-sex male households residing in high HIV counties report a higher self-assessed risk of contracting HIV. This gives further support to my assertion that this group is more affected by the introduction of HAART.

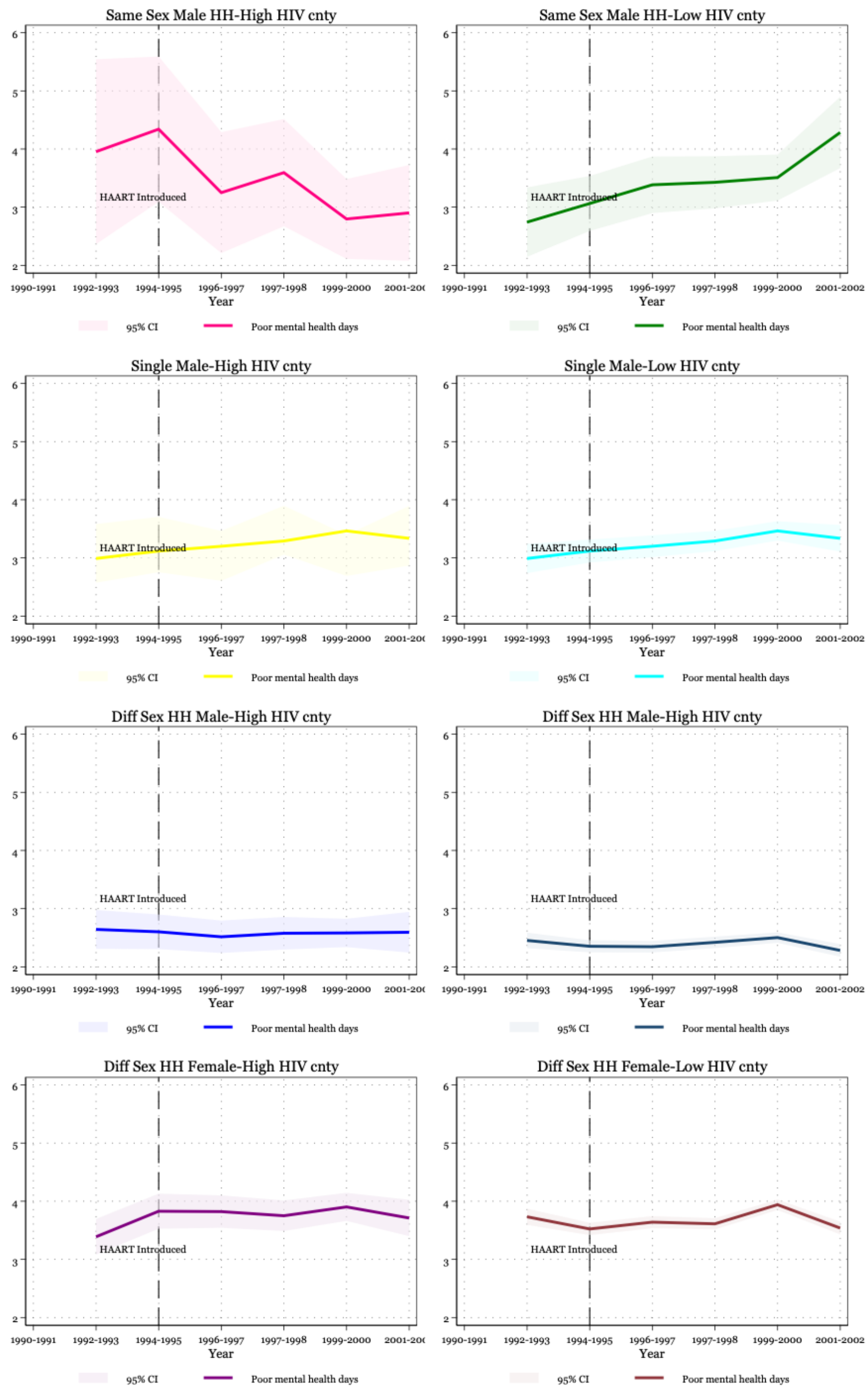
Group	High or Medium Risk of contracting HIV
Same-Sex Male HH in high HIV county	0.215
Same-Sex Male HH in low HIV county	0.148
Single Men in high HIV county	0.129
Single Men in low HIV county	0.106
Diff Sex HH Male in high HIV county	0.0850
Diff Sex HH Male in low HIV county	0.057
Diff Sex HH Women in high HIV county	0.074
Diff Sex HH Women in low HIV county	0.058

When I split my sample between the groups mentioned above and the years of the survey, the sample sizes become very small. To ensure that each group-year combination contains at least 50 respondents, I lump responses from every other year together.

I depict trends in the average number of poor mental health days for several groups in Figure B.1. I find that men aged 25 to 44 residing in households consisting of exactly two male adults in high HIV counties experience a steady decline in the average number of poor mental health days following the introduction of HAART. This is the only group that experiences such a reduction. No other group appears to experience a fall in the average number of days with poor mental health. This provides further evidence that these effects are a result of the introduction of HAART. Since frequent mental distress is an indicator of health-related quality of life and is characterized by 14 or more days of self-reported poor mental health in the past month, I construct an indicator variable that is equal to one when the reported number of days with poor mental health is equal to or greater than 14. Trends of this variable by group follow a similar pattern with respondents with over 14 days of poor mental health only decreasing for respondents living in exactly two male adult households in high HIV counties.

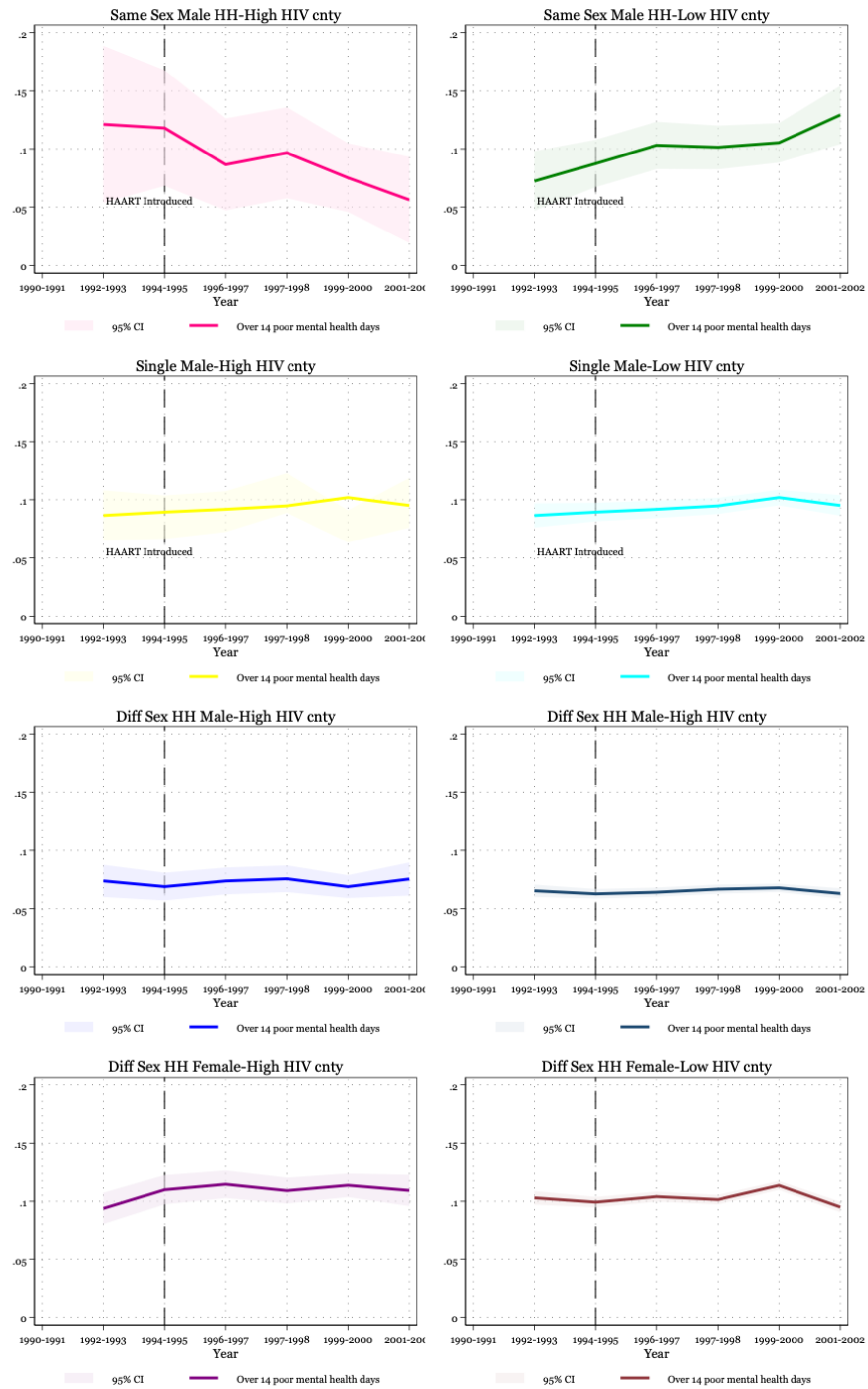
Although using BRFSS data for this kind of analysis can be problematic because of the small sample size, the trends provide some suggestive evidence that apart from the introduction of HAART reducing suicide rates, HAART also improved non-extreme mental health outcomes for at-risk groups.

Figure B.1 :Poor Mental Health Days in the last 30 days



Appendix Figure B.1. Source: BRFSS 1990-2002 CDC (1990-2002b)
Notes: Trends for the average number of poor mental health days in the past 30 days by group.

Figure B.2: Fourteen or More Poor Mental Health Days in the past 30 days



Appendix Figure B.2. Source: BRFSS 1990-2002 CDC (1990-2002b)
Notes: Trends for the proportion of respondents reporting over 14 days of poor mental health days in the past 30 days by group.

C AIDS Data

I obtain total annual city counts of AIDS cases from the AIDS Public Information Data set from the Department of Health and Human Services (CDC, 1990-2002a). The AIDS Public Information data set contains data through 2002 for each city that has a population of at least 500,000 people as per the 2000 census. AIDS represents the final and most severe stage of HIV infection. Before the introduction of combination drug therapy, a person diagnosed with AIDS had a life expectancy of 1-3 years.

Due to a large number of counties with missing AIDS case data, I do not use AIDS case rates as a measure for HIV/AIDS incidence in my main analysis. However, to verify my findings, I repeat my analysis by changing the HIV incidence measure to AIDS cases instead of HIV/AIDS deaths and find similar effects. As mentioned earlier, the AIDS Public Information Dataset only includes data from cities with populations over 500,000. Counties that lie outside large cities are therefore dropped. Table C.1 presents summary statistics.

Figure C.1 presents Difference in Difference estimates from Equation 1 where Pre-HIV Incidence$_c$ now represents 1994 AIDS case rate (total AIDS cases per 100,000 population). Although estimates are less precise, they are quantitatively similar to my main specification.

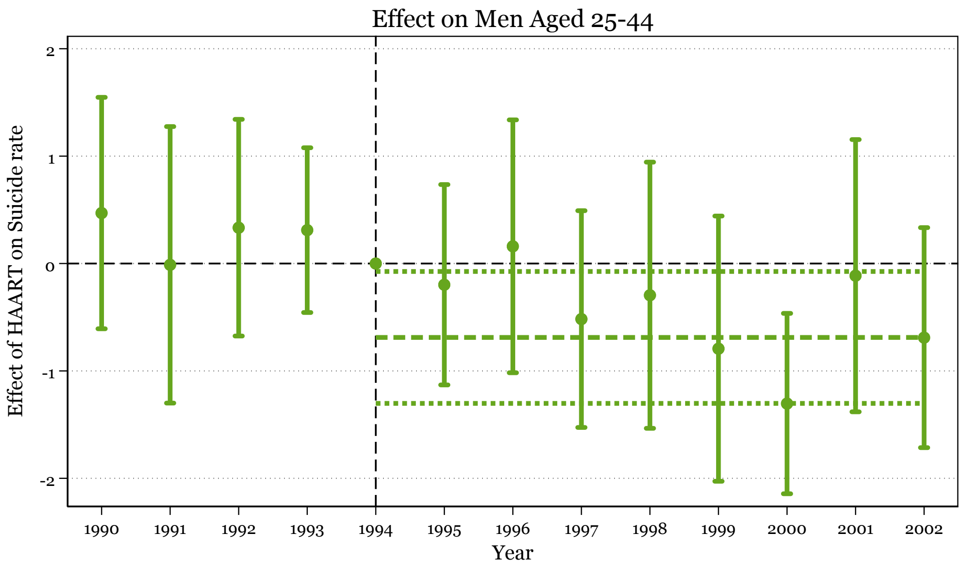
Table C.1: Summary Statistics with AIDS Data.

	4th Quartile	3rd Quartile	2nd Quartile	1st Quartile
Male Suicide Rate	16.13	18.09	16.41	19.18
	(6.26)	(7.71)	(7.19)	(7.66)
Female Suicide Rate	4.32	4.56	3.98	4.43
	(2.32)	(2.48)	(2.35)	(2.88)
1994 AIDS Case Rate	58.89	30.88	18.32	11.22
	(29.13)	(4.63)	(2.22)	(2.76)
Male HIV Death Rate	30.01	17.32	13.22	9.24
	(48.68)	(22.05)	(21.07)	(14.16)
Female HIV Death Rate	5.39	2.82	2.08	0.96
	(11.30)	(4.35)	(3.61)	(1.64)
1994 HIV Death Rate	28.72	17.19	13.28	8.37
	(26.14)	(8.33)	(10.24)	(5.39)
Male Fire Arm Suicide Rate	9.08	10.36	9.46	11.28
	(4.34)	(5.75)	(5.71)	(5.08)
Female Fire Arm Suicide Rate	1.46	1.54	1.28	1.42
	(1.31)	(1.50)	(1.40)	(1.46)
Male Non Fire Arm Suicide Rate	7.05	7.73	6.95	7.90
	(4.04)	(4.01)	(3.81)	(4.61)
Female Non Fire Arm Suicide Rate	2.86	3.02	2.70	3.01
	(1.68)	(1.76)	(1.76)	(2.15)
Unemployment Rate	5.58	5.30	5.12	5.45
	(1.97)	(1.75)	(2.25)	(2.86)
Population Density	2,695.05	1,646.44	1,886.24	1,210.94
	(3,037.16)	(1,744.34)	(1,911.38)	(1,128.67)
Percentage Pop Male	48.95	49.04	48.55	48.48
	(0.99)	(1.09)	(0.86)	(1.00)
Percentage Pop White	73.73	79.95	81.77	86.16
	(13.37)	(10.87)	(11.69)	(9.05)
Percentage Pop aged b/w 0 and 24	35.38	35.51	35.03	36.13
	(3.53)	(3.64)	(2.28)	(3.98)
Percentage Pop aged b/w 25 and 44	33.75	32.53	32.46	31.01
	(2.84)	(2.76)	(2.12)	(2.27)
Observations	3120	3016	2704	3276

mean coefficients; sd in parentheses
4th Quartile refers to counties in top 25 percentile of AIDS case rate in 1994
3rd Quartile refers to counties in 50th-75th percentile of AIDS case rate in 1994
2rd Quartile refers to counties in 25th-50th percentile of AIDS case rate in 1994
1st Quartile refers to counties in bottom 25 percentile AIDS case rate in 1994

Appendix Table C.1. Source: The AIDS Public Information data set CDC (1990-2002a)
Notes: Table presents summary statistics for counties across the distribution of 1994 AIDS case rate for the years before the introduction of HAART (1990-1994).

Figure C.1: Effects using AIDS rate data



Appendix Figure C.1. The figure present difference in differences estimates from Equation 1 for men aged 25 to 44. Now, Pre-HIV/AIDS deathrate$_c$ represents the standardized form of 1994 AIDS case rate. I control for time fixed effects, county fixed effects and state and time fixed effects. All estimates are weighted by county level population and standard errors are clustered at the county level. Horizontal dashed lines present estimate and confidence intervals from specifications without time variations in treatment effect.

D Additional Robustness Tests

D.1 Homicides

As mentioned earlier, the 90s was a period of falling urban violence and crime. Given the disproportionate impact of violence on young men in densley populated areas which tend to also be high HIV/AIDS areas, the results in this paper may be influenced by factors linked to trends in violence, independent of HAART. In this section, I compare trends and effects on homicides and suicides in order to convince the reader that the effects outlined in this paper are not driven by broader trends in violence.

The first panel in Figure D.1 depicts trends in homicide and suicide rates for men aged 25 to 44 living in the highest decile of 1994 HIV/AIDS death rate. Although I observe a fall in both suicide and homicide rates for this group, the fall in suicides occurs after the introduction of HAART in 1995 whereas homicides have been on a downwards trend since the early 90s. In the next panel of Figure D.1, I present trends in homicide rates for men aged 25-44 living in counties that are in the top decile of 1994 HIV/AIDS death rates and bottom 3 deciles. Similarly, the third panel of Figure D.1 depicts trends for women aged 25-44. Since the 90s fall in homicide rate is driven by areas of high HIV/AIDS, it is important to ensure that the effects highlighted in this paper are driven by the introduction of HAART and not broader trends in violence.

The first panel of Figure D.2 presents estimates from Equation 3 while changing the outcome variable to homicide rates. Given that the fall in homicides is driven by changes in high HIV/AIDS counties it is unsurprising that a negative effect is observed. Unlike the estimates for suicide rate, there are very strong pre-trends and there does not appear to be a discontinuity around the time of HAART introduction. This highlights the importance of using event study models which allow us to observe pre-existing trends. These effects are likely a result of falling homicide rates in more densely populated areas.

In order to account for this possibility, I reestimate the following equation:

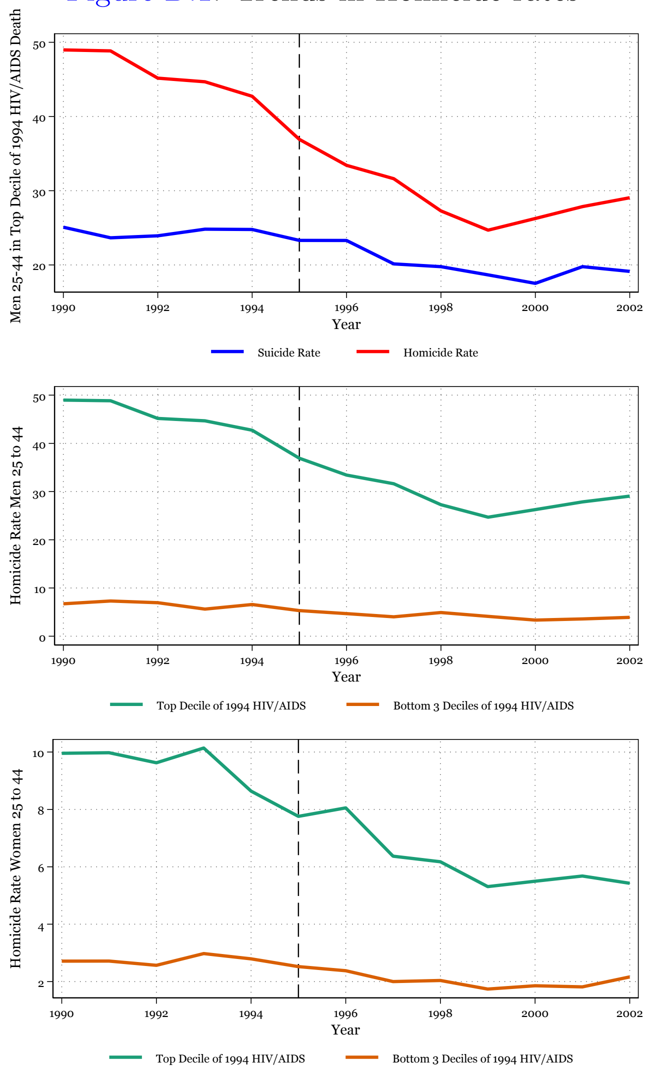
$$\begin{aligned}\text{Homicde Rate}_{jct} =& \alpha + \sum_{\substack{m \neq 1994 \\ m=1990}}^{2002} \beta_m \left(\text{Pre-HIV/AIDS deathrate}_c \times 1[t=m] \times \text{Men 25-44}_j\right) + \\ & \sum_{\substack{m \neq 1994 \\ m=1990}}^{2002} \theta_m \left(\text{PopDence}_c \times 1[t=m] \times \text{Men 25-44}_j\right) + \theta_{ct} + \iota_{jc} + \delta_{sjt} + \epsilon_{ctj}\end{aligned} \tag{5}$$

Equation 5 is similar to Equation 3 except it includes a term where I interact 1994 population density (PopDence_c) with the treatment variables. This should account for changing trends in homicides in more densely populated counties. Estimates for β_m are presented in the second panel of Figure D.2. I no longer observe pretrends and effects are much smaller and statistically not different from zero.

Since both men and women experience a fall in homicide rates in high HIV/AIDS counties relative to low HIV/AIDS counties and men have significantly higher rates of homicide, I consider percentage changes in addition to rates. I re-estimate Equation 3 while changing my outcome variable to now represent the inverse hyperbolic sine transformation of homicide rates. Estimates are presented in the third panel of Figure D.2. The estimates are now flipped. In percentage terms, effects of women's homicide rates outweigh effects of men's homicide rate. This is in contrast to my findings in Appendix Figure A7 where I change the outcome variable to the inverse hyperbolic sine of the suicide rate.

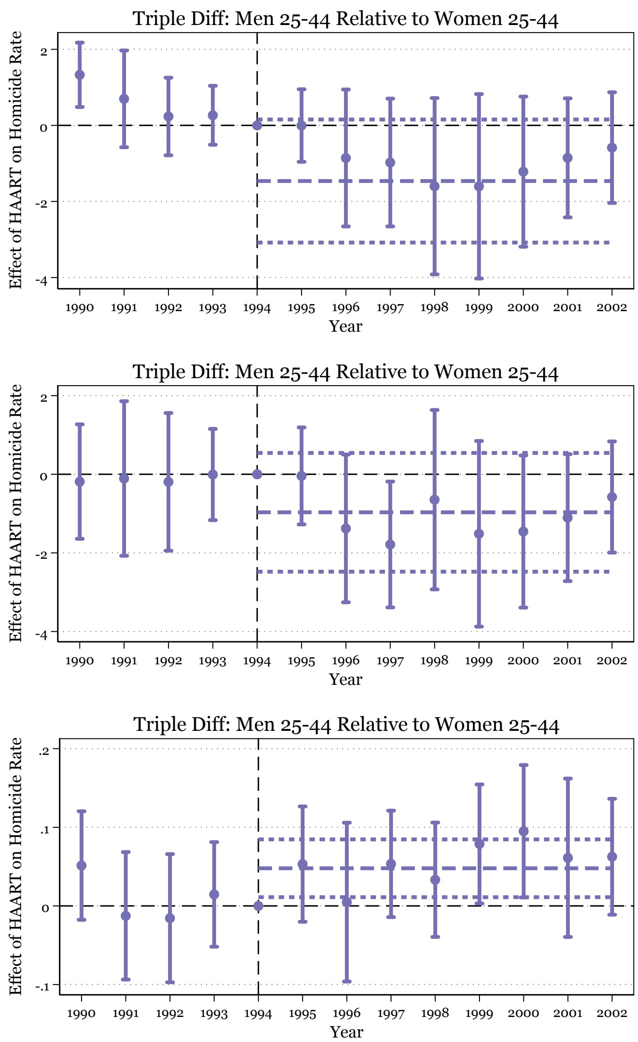
Taken together, I find that although homicides have been falling throughout my period of analysis, there does not appear to be a discontinuous change at the time HAART treatment was introduced. After accounting for changing trends by population density, effects appear statistically not different from zero. When I change the outcome variable to represent percentage changes rather than rates, it appears that trends in homicide over this period are larger for women compared to men. This implies that trends in homicide rates do not match the effects on suicide highlighted in this study. Although there is no way to rule out the possibility that my effects are contaminated by broader trends in violence, it is unlikely since I do not see similar effects on homicides.

Figure D.1: Trends in Homicide rates



Appendix Figure D.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: The above figures represent trends in homicide rates in 1990 to 2002. The first panel depicts homicide and suicide rates for men aged 25 to 44 living in high HIV/AIDS counties (counties in the top decile of per-HAART HIV/AIDS death rates). The second and third panel depict trends in homicide rates for men and women aged 25-44 living in high HIV/AIDS counties (counties in the top decile of per-HAART HIV/AIDS death rates) and low HIV/AIDS counties (counties in the bottom 3 decilesof per-HAART HIV/AIDS death rates)

Figure D.2: Effect on Homicide Rate



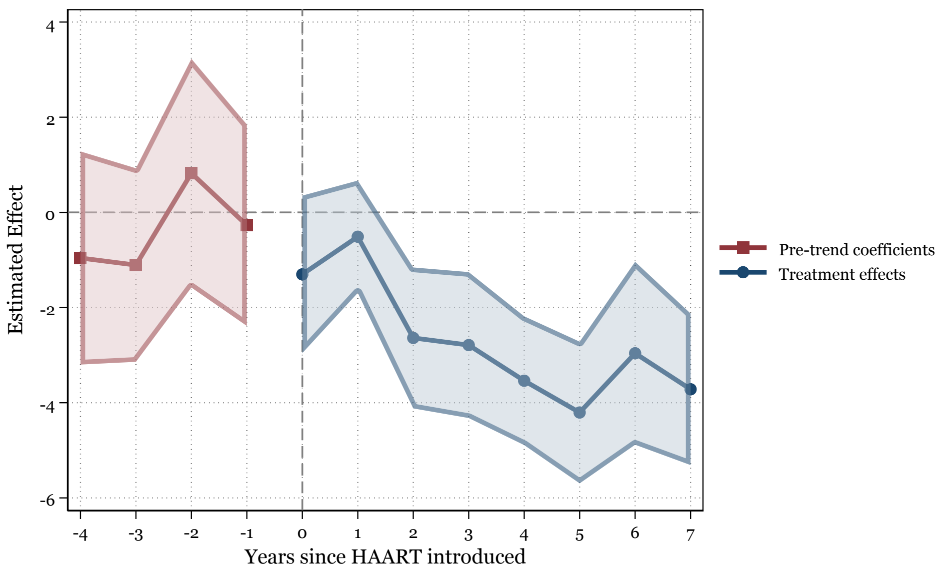
Appendix Figure D.2. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: The first panel depicts Equation 3 while changing the outcome variable to homicide rate. The second panel presents estimates from Equation 5. The third panel presents estimates from Equation 3 while changing the outcome variable to represent the inverse hyperbolic sine transformation of homicide rates. I control for the interaction of time and county fixed effects, sex and county fixed effects, sex and time fixed effects and state, sex and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level

D.2 Alternative Estimator

Although my estimation strategy does not rely on the staggered timing of treatment, recent studies show that heterogeneous treatment effects can bias even non-staggered treatments (De Chaisemartin and d'Haultfoeuille, 2022a). In order to account for these developments, I use the imputation estimator developed by Borusyak et al. (2021) and reestimate Equation 1 & Equation 3. Estimates are provided in Figure D.3. Note that I use a binary treatment variable and considering counties in the top 10 percentile of pre-HAART HIV/AIDS death rates as treated counties instead of the continuous treatment used in my main specification.[43]

[43] Current heterogeneity robust estimators with dynamic effects do not allow for continious and non-staggard treatment (De Chaisemartin and d'Haultfoeuille, 2022b).

Figure D.3: Alternative Estimator



Appendix Figure D.3. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: I present estimates for Equation 1 using the Borusyak et al. (2021) estimator for men aged 25-44. I control for county fixed effects and state-time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

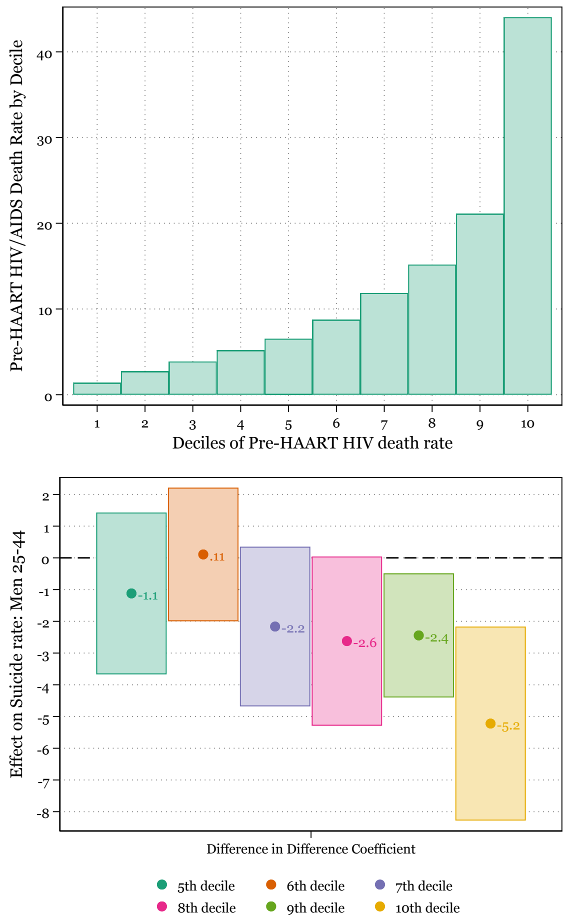
D.3 Exploiting Continuous Treatment

In order to verify that my results are driven by changes in pre-HAART HIV/AIDS incidence, I also exploit the continuous nature of the treatment measure used in this study. Meyer (1995) argues that "differences in the intensity of the treatment across different groups allow one to examine if the changes in outcomes differ across treatment levels in the expected direction." If my results are, in fact, driven by the introduction of HAART treatment, I expect the largest effects in counties with the highest pre-HAART HIV incidence and smaller effects in counties with lower rates of pre-HAART HIV.

The first panel in Figure D.4 shows mean pre-HAART HIV/AIDS death rates by deciles of pre-HAART HIV/AIDS death rate in a county. The pre-HAART HIV/AIDS death rate is under 10 per 100,000 population in the first 6 deciles and I expect the treatment to have little effect on these counties. Thereafter, I see exponential increases in HIV/AIDS death rates with larger jumps when I move from the 7th to the 8th, 8th to the 9th decile, and the largest jump, when moving from the 9th to 10th decile.

I modify my treatment variable from Equation 2 into a dummy variable which is equal to one when looking at different deciles of pre-HAART HIV/AIDS death rate and zero when looking at the lowest 2 deciles. The next panel of Figure D.4 represents the difference-in-differences estimates from Equation 2 for men aged 25 to 44. I observe larger negative coefficients at higher deciles of pre-HAART HIV/AIDS death rates. This verifies that changes in suicide rates differ across treatment levels in the expected direction. This provides further evidence that the results are driven by the introduction of HAART.

Figure D.4: Exploiting Continuous Treatment



Appendix Figure D.4. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: The first figure presents mean pre-HAART HIV death rate at 10 deciles of pre-HAART HIV/AIDS deathrate. In the next figure, Pre-HIV/AIDS deathrate$_c$ is a dummy variable that is equal to 1, when looking at a particular decile of pre-HAART HIV deaths and zero when looking at the bottom 2. The second figure presents difference-in-differences estimates from Equation 2 for men aged 25 to 44. I control for time fixed effects, county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

D.4 Altering the Functional Form

There are systematic differences between high and low HIV counties as depicted in Table 3. High HIV counties tend to be more urban and have higher population densities. To ensure that my effects are not driven solely by differing trends in sex-specific suicide rates for densely and sparsely populated counties, I alter the functional form in an attempt to disentangle these effects. I also allow for non-linear relationships between Pre-HAART HIV/AIDS incidence and population densities by including squared terms. More formally, I estimate the following equation:

$$\begin{aligned}
SuicideRate_{ct} =& \alpha + \beta_0 \text{ Pre-HIV/AIDS deathrate}_c \times \text{Post}_t + \beta_1 \text{PopDense}_c \times \text{Post}_t \\
& \beta_2 \text{PopDense}_c \times \text{Pre-HIV/AIDS deathrate}_c \times \text{Post}_t + \beta_4 \text{PopDense}_c^2 \times \text{Post}_t \\
& + a_c + \eta_t + \mu_{st} + \epsilon_{ct}
\end{aligned} \tag{6}$$

Here, PopDense_c represents the 1994 population density. I include the interaction of PopDense_c and Post_t, the interaction of the square of PopDense_c and Post_t, the interaction of PopDense_c, Pre-HAART HIV incidence, and Post_t as well as the interaction of the square of Pre-HAART HIV incidence and Post_t. All other features of this equation reflect Equation 2. These additional terms allow us to assess whether the effects are driven by differential trends in more densely populated areas or whether effects are driven by underlying HIV/AIDS incidence.

The results for Equation 6 are provided in Table D.1. Even after accounting for differential effects in more densely populated counties, I find that higher HIV counties experience a disproportionate fall in suicide rates for men aged 25 to 44. I also find no effects on women.

Although the only significant interaction term in my results table is the coefficient for Pre-HIV/AIDS $\text{deathrate}_c \times \text{Post}_t$, the partial effect of an increase in pre-HAART HIV before and after the introduction of HAART on suicide rates also depends on other terms. I estimate this partial effect using the following equation:

$$\frac{\partial \triangle \text{Suicide Rate}_{ct}}{\partial \text{Pre-HIV/AIDS deathrate}_c \triangle Post_t} = \beta_0 + \beta_2 \text{PopDense}_c + 2\beta_3 \text{Pre-HIV/AIDS deathrate}_c \tag{7}$$

Equation 7 measures the partial effect of HIV/AIDS death rate before and after the introduction of HAART on suicide rates. I insert coefficients from my results table and values from my dataset to estimate partial effects across the distribution of pre-HAART HIV/AIDS deaths and population densities. I present these effects across percentiles of pre-HAART HIV/AIDS deaths and population densities in Figure D.5. I insert pre-HAART HIV/AIDS death rate values from several points in the pre-HAART HIV /AIDS death rate distribution and estimate Equation 7 across the distribution of population densities. Here, I find some evidence that the effect of a 1 standard deviation increase in pre-HAART HIV/AIDS death rate is slightly smaller for counties with higher pre-HAART HIV/AIDS death rates.[44]

According to the figure, there is approximately a 1 per 100,000 person decrease in suicides in counties with a 1 standard deviation higher pre-HAART HIV/AIDS death rate for most of the distribution of pre-HAART HIV/AIDS incidence and population densities. This estimate is similar to our main specification providing some evidence that these effects are not being driven by differential trends in more densely populated counties.

[44] Note, the effect of a standard deviation increase in pre-HAART HIV/AIDS death rate implied in Figure D.5 is different from the overall effects depicted in Figure D.4.

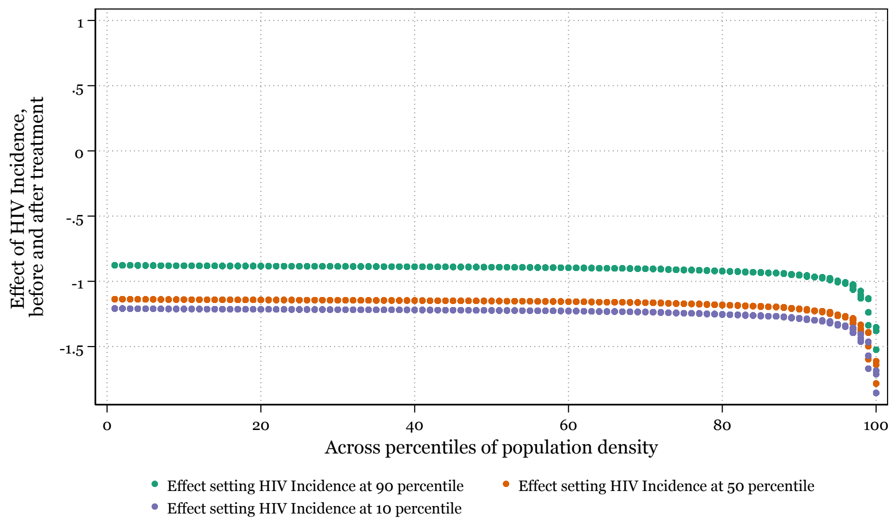
Table D.1: Alternative Functional Form

	Male (1)	Female (2)
Post=1 × 1994 Population Density	-0.0003318895	-0.0001578184
	(0.00026862)	(0.00015233)
Post=1 × Stdz 1994 HIV Death Rate	-1.0668610213***	-0.2008205097
	(0.33692078)	(0.18802535)
Post=1 × 1994 Population Density × Stdz 1994 HIV Death Rate	-0.0000417580	0.0000500640
	(0.00007580)	(0.00004775)
Post=1 × 1994 Population Density Squared	0.0000000149	-0.0000000015
	(0.00000003)	(0.00000002)
Post=1 × Stdz 1994 HIV Death Rate Squared	0.1049286842	-0.0196175580
	(0.09660417)	(0.06073718)
Observations	4979	4979
County FE	Yes	Yes
Time FE	Yes	Yes
State X Time FE	Yes	Yes

Standard errors in parentheses
Effect of HAART on Suicide Rates
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table D.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents alternative difference-in-differences estimates from Equation 6 for men and women aged 25 to 44. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level. Estimates include controls for county unemployment, percentage of population that is white, percentage of population that is evangelical protestant, percentage of population that adheres to a religion.

Figure D.5: Altering the Functional Form



Appendix Figure D.5. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: Estimates for Equation 7 using coefficients from Equation 6 and data from my dataset. I set pre-HAART HIV/AIDS death rate at the 10th, 50th and 90th percentile and estimate Equation 7 across the distribution of Population Densities. Estimates include controls for county unemployment, percentage of population that is white, percentage of population that is evangelical protestant, percentage of population that adheres to a religion. All estimates are weighted by group county level population and standard errors are clustered at the county level.

E State Level Analysis

The analysis conducted in this paper exploits county level variation in pre-HAART HIV/AIDS death rates. Conducting county-level analysis rather than state-level analysis has the benefit of exploiting a greater breadth of variation in pre-HAART HIV/AIDS death rates. However, due to confidentiality rules, I only observe county codes for counties with populations exceeding 100,000. Since I observe state codes for all deaths in the mortality data, I conduct my analysis at the state-level using all the data I have at hand.

First, I present a map of the U.S. depicting state level HIV/AIDS death rates prior to the introduction of HAART in Figure E.1. I also list counties in the top 10 percentile of HIV/AIDS death rates.

In order to conduct state-level analysis, I estimate the following equation:

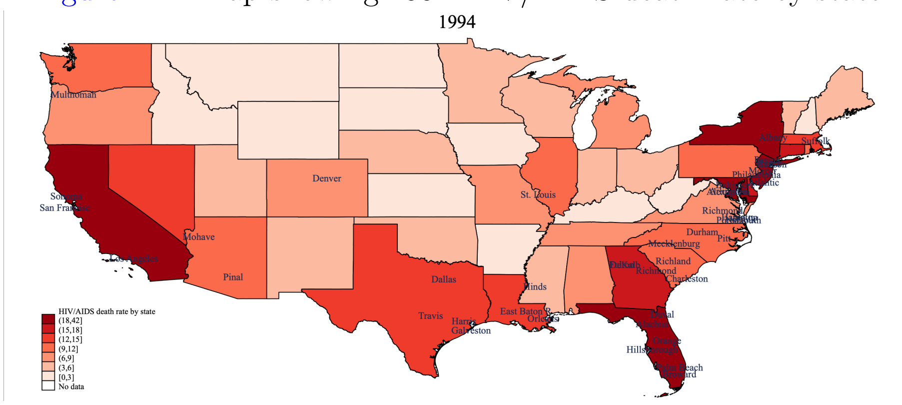
$$\text{Suicide Rate}_{st} = \alpha + \sum_{\substack{m \neq 1994 \\ m=1990}}^{2002} \beta_m \left(\text{Pre-HIV/AIDS deathrate}_t \times 1[t=m]\right) \ + a_t + \mu_s + \epsilon_{st} \tag{8}$$

Now, Suicide Rate$_{st}$ measures the number of suicides per 100,000 population in state s at year t for men aged 25 to 44. Pre-HIV/AIDS deathrate$_s$ is the number of HIV/AIDS deaths per 100,000 population in 1994 in state s. a_t and μ_s represent year and state fixed effects.

The estimates presented in Figure E.2 show that the introduction of HAART lead to statistically significant reductions in suicide rates for men aged 25 to 44. Since the treatment variable in the main analysis is the standardized form of county-level pre-HAART HIV/AIDS death rates and the treatment variable for the state-level analysis is the standardized form of state-level pre-HAART HIV/AIDS death rate, I cannot directly compare coefficients. 1 standard deviation in pre-HAART HIV/AIDS death rates at the state level is approximately half of 1 standard deviation in pre-HAART HIV/AIDS death rates at the county level. Since the state-level estimate is also half as large as the county-level estimate, the overall effect is quantitatively similar.

Although I still find that the introduction of HAART led to statistically significant and similar reductions in suicide rates for men aged 25 to 44, these estimates are significantly less compelling and are only significant in 1999 and following years. This may be because HIV/AIDS was highly concentrated in certain high HIV/AIDS cities and state-level analysis does not allow me to exploit the breadth of variation in pre-HAART HIV/AIDS incidence. This highlights the importance of using more granular data when estimating effects on treated populations that more geographically concentrated. I am also unable to rule out the possibility that suicide rates in counties outside my main analysis sample (counties with fewer than 100,000 people), respond to HAART differently from counties inside my sample based on the state-level results.

Figure E.1: Map showing 1994 HIV/AIDS death rate by state



Appendix Figure E.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Map showing 1994 HIV/AIDS death rate by state. Names of counties in the top 10 percentile of 1994 HIV/AIDS death rates are also labeled.

Figure E.2: State Level Analysis

Appendix Figure E.2. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: The figure presents difference in differences estimates from Equation 8 for men aged 25 to 44 at the state level. I control for time fixed effects and state fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the state level.

F Deaths of Despair

Economists have documented the rise in alcohol, drug, and suicide deaths among Americans without a college degree between 1999 and 2013 (Case and Deaton, 2021). These deaths are often lumped together as "deaths of despair" and could all be the result of poor mental health. Since this study documents such large decreases in suicide rates, I also examine the effect of HAART on other deaths of despair. I reestimate Equation 1, changing the outcome variable from suicide rates to alcohol-related deaths and drug-related deaths. The relevant ICD codes are provided in Table A1. The first panel of Figure F.1 shows trends in each death of despair over time.

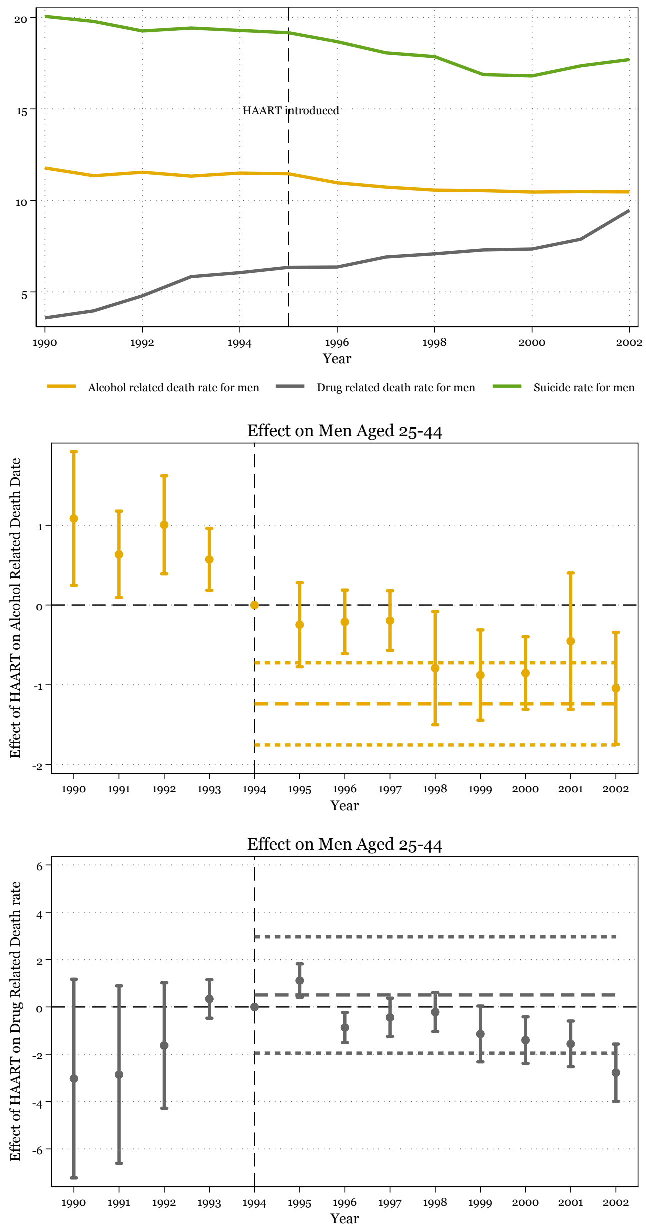
I then provide estimates for equation Equation 1 for men aged 25 to 44 for alcohol-related death rates and drug related death rates in the second and third panels of Figure F.1. My estimates suggest that men experience a large decline in alcohol-related deaths but estimates for drug related deaths are noisy.[45] Estimating the effect on drug-related deaths proves difficult because drug-related deaths are less common, especially in the early years of my analysis. During this period of study, drug-related deaths are increasing rapidly. This results in my estimates being noisy and having large standard errors.

Although the estimates for alcohol related deaths provides some additional evidence of improved mental health outcomes for communities most affected by the introduction of HAART, these coefficients must be interpreted with caution. Unlike suicides, alcohol-related deaths and drug related deaths need not be the result of poor mental health conditions. There is also a body of literature exploring the

[45] Although standard errors appear as similar sizes in Figure F.1, it is important to note that the figures have different scales. Due to the large standard errors for drug related deaths, using the same scale for alcohol related deaths, would make results unreadable.

interaction of HAART treatments and alcohol consumption (Kumar et al., 2012). Additionally, the introduction of HAART could influence drug-related deaths in ways unrelated to mental health since injection drug use is another major mode of HIV/AIDS transmission. Further research is required to better understand the effect of HAART on alcohol consumption and drug use.

Figure F.1: Deaths of Despair



Appendix Figure F.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: In the first figure, I present trends in death rates by suicide, alcohol related deaths, and drug related deaths. Thereafter, I present estimates for Equation 1 while changing my outcome variable to alcohol related death rate and drug-related death rate. The second and third figure present difference-in-differences estimates from Equation 1 for men aged 25 to 44. These figures control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

G Disentangling Effects on Gay Men and Drug Users

This paper finds that the introduction of HAART led to significant reductions in suicide rates for men aged 25 to 44. In subsection 6.2, I find that effects are driven almost entirely by non-firearm suicides suggesting that effects are driven by gay men. However, drug users also represent a significant share of the HIV positive population. Therefore, I attempt to disentangle whether my estimates are a result of falling suicide rates among gay men or drug users.

I use 1994 drug overdose data as a proxy for drug use in a particular county. I use data from the 2000 census in order to identify the proportion of partnership represented by male same-sex couples in a county (Ruggles et al., 2023). I follow the literature and use this as a proxy for the proportion of gay men living in a county (Smith and Gates, 2001).

I estimate the following equation:

$$\begin{aligned}\text{Suicide Rate}_{ct} = \alpha + \beta\ (\text{High Pre-Drug deathrate}_c \times \text{Post}_t) + \gamma(\text{High PropPopGay} \times \text{Post}_t) \\ +\delta(\text{High Pre-Drug deathrate}_c \times \text{High PropPopGay} \times \text{Post}_t) + a_c + \mu_{st} + \epsilon_{ct}\end{aligned} \tag{9}$$

Most features of this equation are similar to Equation 2.

High Pre-Drug deathrate_c is equal to one when a county has above average 1994 Drug related death rate. PropPopGay is equal to one when a county has above average proportion of the partnerships represented by same-sex male couples. I chose to use a binary treatment measure so the coefficients can easily be compared and interpreted. β now represents effects in counties with above average pre-HAART drug deaths but below average proportion of same-sex male partnerships relative to counties with below average pre-HAART drug deaths and below average proportion of same-sex male partnerships. γ represents effects on counties with above average proportion of same-sex male partnerships but below average pre-HAART drug related death rates relative to counties with below average pre-HAART drug deaths and below average proportion of same-sex male partnerships. The sum of β, γ, and δ represents effects on counties with above average proportion of same-sex male partnerships and above average pre-HAART drug related death rates relative to counties with below average pre-HAART drug deaths and below average proportion of same-sex male partnerships.

Estimates are presented in Table G.1. These estimates suggest that the largest effects are observed in counties with above average proportion of same-sex male couples. Although having above average drug related death rate also results in a reduction in suicide rate, the effect on above average gay populations in larger.[46] This provides additional evidence that although drug users may also contribute to falling suicide rates following the introduction of HAART, effects are largely driven by changing suicide rates among gay men.

[46]These estimates must be interpreted with caution. This analysis has several limitations. Proportion of same-sex male couples as per the 2000 census is just a rough estimate of where gay populations live. Single gay men, who might play a significant role in the outcomes observed in this study, may exhibit distinct patterns in their geographic distribution. I also use discretized forms for ease of interpretation. Categorizing county treatment intensities as above or below average may conceal underlying variations in treatment intensities that are driving the observed effects.

Table G.1: Difference in Differences: Disentangling Effects

	Men 25-44	
	(1)	(2)
High Prop Gay=1 × Post=1	-1.38674**	-1.32778**
	(0.640)	(0.621)
High Pre-Drug deathrate=1 × Post=1	-0.46232	-0.92874
	(0.677)	(0.696)
High Prop Gay=1 × High Pre-Drug deathrate=1 × Post=1	-1.24292	-0.81473
	(0.901)	(1.021)
Observations	5070	4979
County FE	Yes	Yes
Time FE	Yes	No
State X Time FE	No	Yes

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table G.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation 9 for men aged 25-44. Estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

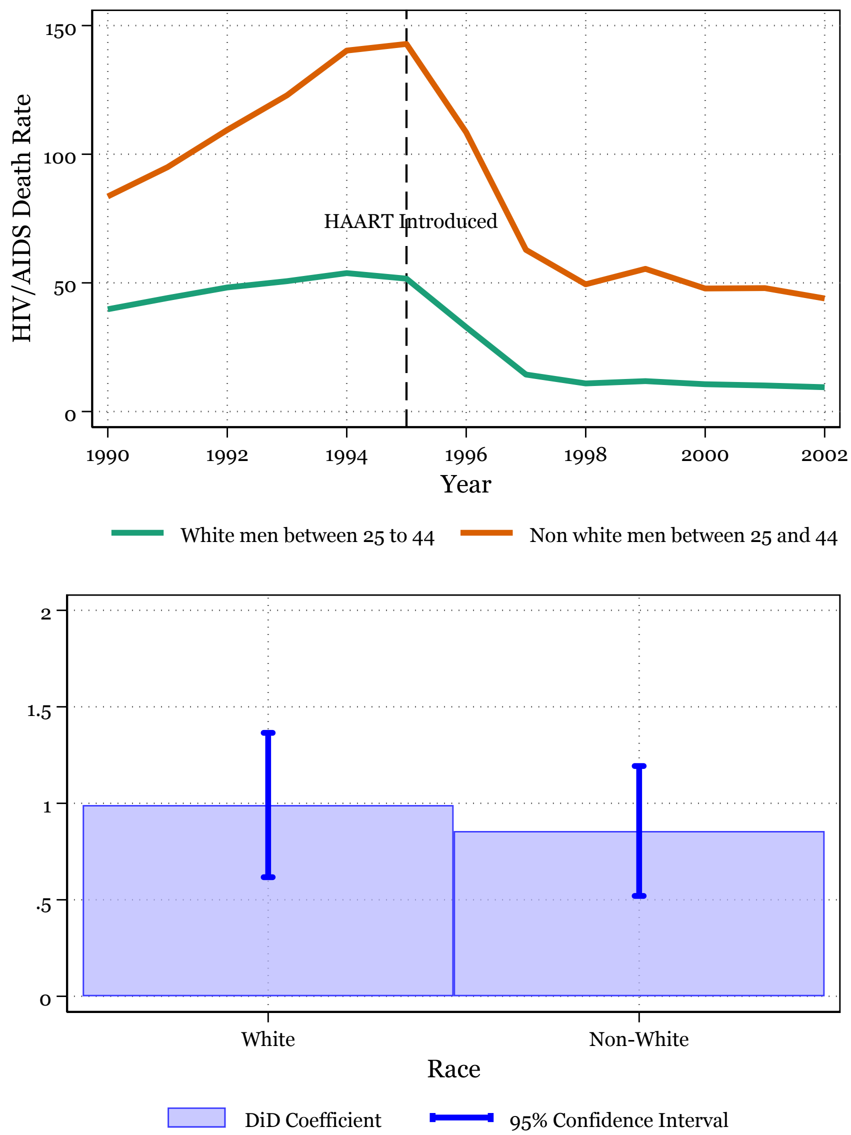
H Effects by Race

There are significant differences in HIV/AIDS incidence and HAART takeup between white and non-white Americans. HIV/AIDS incidence was significantly higher among non-white Americans and some studies have documented how the introduction of HAART widened the Black-White mortality gap (Levine et al., 2007). Although the introduction of HAART significantly reduced HIV/AIDS deaths among both white and non-white men, there remains significant concerns about the rates of HIV/AIDS mortality among non-white men. The first panel of Figure H.1 depicts trends in HIV/AIDS death rates for white and non-white men aged 25 to 44. I observe higher pre-HAART rates of HIV/AIDS deaths amongst non-White men. Even though rates of HIV/AIDS deaths remain high among non-white men, both groups experience a decline in death rates following the introduction of HAART.

In Figure H.1, I present coefficients estimated from Equation 2 for white and non-white men aged 25 to 44 separately. I find that the effects for the two groups are similar in size but pre-existing rates of HIV/AIDS are greater for non-white men. It is possible that I do not see larger effects for non-white men because of differences in access to treatment. The literature documents that non-white men had less access to HAART treatment compared to white men (Zalla et al., 2023).[47]

[47] In other settings, researchers have explicitly studied the role of access to treatment on mental health outcomes. In Malawi, researchers document that availability of HIV treatment improves mental health outcomes of HIV negative and HIV positive individuals (Baranov et al., 2012).

Figure H.1: Effects by Race



Appendix Figure H.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002) Notes: The first figure presents estimates of HIV/AIDS-related death rates for white and non-white men aged 25 to 44. In the next figure, I present coefficients estimates from Equation 2 for white and non-white men aged 25 to 44 separately. These estimates control for county fixed effects and state and time fixed effects. All estimates are weighted by group county level population and standard errors are clustered at the county level.

I Access to Care

Given the high costs of HAART treatment, even after the introduction of HAART, many lacked access to it.[48] In Appendix H, I explore the effect of HAART on suicide rates for whites and nonwhites separately and find that HAART had similar effects on both groups despite higher rates of HIV/AIDS among non-whites. This may be a result of differential access to treatment. In this section I asses how access to care might affect my estimates. Given that the mortality data does not provide insurance information, it is difficult to observe how access to care might affect my results. Although there is no great way of calculating how access to care might affect these estimates, I recalculate my main estimates for states with above and below median proportions of uninsured people at the time HAART was introduced.[49] Estimates for Equation 4 for states above and below median health insurance rates are presented in Table I.1. I find suggestive evidence that effects are greater for states with smaller proportions of uninsured people. This underscores the importance of access to healthcare in driving my results.

In addition to accessing care through health insurance, a significant portion of HIV positive individuals receive care through the Ryan White Care Act. Amidst growing pressure from HIV/AIDS activists, in 1990, congress enacted the Ryan White Comprehensive AIDS Resources Emergency (CARE) Act. The purpose of the act was to provide services to people living with HIV/AIDS. In it's early years, the Ryan White Program provided HIV-positive individuals with greater access to AZT. AZT failed to substantially increase life expectancy's for HIV-positive individuals. After the introduction of HAART, Ryan White funding also provided

[48]Bozzette et al. (2001) estimates that the annual cost of treating an HIV positive patient was 20,300$s per year

[49]Health insurance rates at the county level are unavailable for this period.

greater access to life saving HAART treatment. Ryan White Funding can broadly be defined into two categories: Title 1 and Title 2 funding. Although, the Ryan White program provides a wide array of funding, Title 1 and Title 2 constitute the largest portion of Ryan White funds. Title 1 funding is directed to cities and Title 2 funding is directed towards States. Under the Ryan White Care Act, the AIDS Drug Assistance Program (ADAP) would serve as a payer of last resort for people living with HIV who are uninsured or underinsured, and have a low income[50]. Estimating the effect of ADAP funding on suicide rates proves complicated because the majority of funding is distributed on a need basis. [51] There is, however, some variation in state ADAP funds by HIV/AIDS incidence because many states also supplement their ADAP funds from other sources. Although, more research is required to understand the causal relationship between ADAP funding and suicide rates, I estimate the following equation:

$$\text{Suicide Rate}_{ct} = \alpha + \beta \text{ HIV Incidence}_c \times \text{Post}_t + \text{Avg ADAP budget Per Capita}_s \times \text{Pre-HIV/AIDS deathrate}_c$$

$$+ \mathbf{X}_{ct}\gamma + a_c + \mu_{st} + \epsilon_{ct}(10)$$

Many features of this equation resemble Equation 2 except I also include a term Avg ADAP budget Per Capita_s which is equal to the average ADAP budget per capita in the post period and interact it with 1994 HIV/AIDS incidence.[52] I provide estimates in Table I.2. These results must be interpreted with caution

[50]The AIDS Drug Assistance program began serving clients in 1987. Initially, ADAPs would provide low-income HIV positive Americans with the only HIV treatment available at the time, Zidovudine or AZT. Although AZT was the first FDA approved drug for the treatment of HIV/AIDS, it only observed moderate levels of success in delaying the progression of the virus and was accompanied with severe side effects. In the absence of an effective treatment, ADAP remained a relatively small program serving only a small number of HIV positive individual. The introduction of Highly Active Antiretroviral Therapy (HAART) in 1995 transformed the role of ADAP from a relatively small and cheap program to one of the most expensive government programs in the U.S. which served a critical role in preventing HIV/AIDS deaths.

[51]Areas with higher rates of HIV/AIDS receive larger amounts of federal ADAP funding.

[52]I do not need to interact this with a Post term because Avg ADAP budget per Capita is equal to zero in the years prior to HAART.

because there is uncertainty about how much of the ADAP budget is exogenously determined. Although coefficients for the interaction term are statistically insignificant, they provide suggesting evidence that effects are larger in states with larger per-capita ADAP budgets.

Taken together, these estimates underscore the importance of access to care in driving my estimates. This implies that access to treatment not only had effects on the physical but also the mental health of the affected population. More research is required in order to understand the role of access to care on the mental health of HIV positive populations.

Table I.1: Insurance Rates

	Above Median Uninsured (1)	Below Median Uninsured (2)
Post=1 $\times$ Stdz 1994 HIV death rate	-0.88528***	-1.55111***
	(0.162)	(0.411)
Observations	2496	2483
County FE	Yes	Yes
Time FE	No	No
State X Time FE	Yes	Yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table I.1. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation I for men aged 25 to 44 living in states that have above or below median uninsirance rates. All estimates are weighted by group county level population and standard errors are clustered at the county level.

Table I.2: AIDS Drug Assistance Program (ADAP)

	(1)	(2)
Post=1 × Stdz 1994 HIV/AIDS death rate	-0.71841041***	-0.82549461***
	(0.167752415)	(0.173428545)
Avg total ADAP budget per Capita × Stdz 1994 HIV/AIDS death rate	-0.13946657	-0.08464665
	(0.072963711)	(0.077785966)
Observations	5070	4979
County FE	Yes	Yes
Time FE	Yes	No
State X Time FE	No	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix Table I.2. Source: CDC Multiple Cause of Death data NCHS (1990-2002)
Notes: Table presents difference-in-differences estimates from Equation I for men aged 25 to 44. All estimates are weighted by group county level population and standard errors are clustered at the county level