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ABSTRACT

A key approach used by federal governments to address public health issues is to allocate federal funds to support local responses, but little is known about the effectiveness of this approach for improving health. This study examines the impact of federal public health funds allocated to U.S. cities through the U.S. government's primary mechanism for combating HIV/AIDS for the past three decades. The empirical approach identifies the impact of this funding by studying funding variation that comes from policy features that resulted in large funding differences among cities that were originally on parallel HIV/AIDS trajectories. The findings indicate that an HIV/AIDS death has been prevented for every$334,000 allocated through the city-level funding and that the $19 billion allocated to cities through this program through 2018 has saved approximately 57,000 lives, which represents over $560 billion of value in terms of lives saved under the commonly assumed value of a statistical life of $10 million. The findings also indicate that funding differences across cities have been a major contributor to the uneven progress in combating HIV/AIDS currently observed across the United States that has alarmed public health leaders. Thus, while this analysis supports allocating federal funds to local areas as part of a public health strategy, these funds being effective means that sustained differences in areas' receipt of federal public health funds can contribute to the development of health disparities across areas, as has occurred with HIV/AIDS.

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1 Introduction

A key approach that federal governments use to address public health issues is to allocate federal funds to local areas to support local efforts to improve health. In the United States, this approach has been used in public health campaigns against specific diseases, including HIV/AIDS, diabetes, opioid addiction, COVID-19, and heart disease, and in addressing broader issues related to access to care for underserved areas and people. Knowing the impacts of allocating federal funds to local areas for the purpose of improving public health is important for understanding health production and for forming optimal policy to address public health issues.

Public health funding levels and approaches are the subject of much debate, but despite federal governments regularly providing local governments with large amounts of federal money aimed at improving health, few studies exist of the impacts of these funds on health measures. A challenge in studying the impact of federal public health funding is that funding mechanisms are often set so that funding is allocated to areas with the most need. Thus, naive ordinary least squares regressions of health outcomes on public health funding would suggest that increased funding harms health.

This paper examines the impact of the federal government providing funding to U.S. cities to address the HIV/AIDS epidemic, which has been one of the largest public health crises in recent history[1] and has claimed the lives of tens of millions of people worldwide. While the burden of HIV/AIDS in the United States has fallen hardest on gay men and intravenous drug users—two groups that make up a relatively small share of the U.S. population—the impact of HIV/AIDS on these groups has been so devastating that HIV/AIDS has been a major factor in aggregate health statistics. For example, from 1993 to 1995 HIV/AIDS was the leading cause of death among all people ages 25 to 44 in the United States. Though treatment emerged in 1996 that could drastically lengthen the lives of people with HIV/AIDS, no cure for HIV exists, and nearly 40 million people currently live with HIV worldwide. While HIV/AIDS death rates have fallen in the United States over the past few decades, the progress in combating HIV/AIDS has been uneven across the country, with large cities that were the early epicenters of HIV/AIDS having experienced much larger reductions in AIDS death and case rates since the height of the AIDS crisis than many other parts

[1] While comparing the overall impacts of various public health crises would require aggregating across different metrics, HIV/AIDS stands out both for the large number of people that it has affected and for its persistence as a public health concern. Having killed over 700,000 Americans, HIV/AIDS has resulted in the deaths of more Americans than all military conflicts since the Civil War combined. All recent presidents have emphasized the importance of fighting HIV/AIDS for their administrations, and public health leaders and policymakers often assess the importance of emerging public health crises by comparing their possible impacts to the impact of HIV/AIDS (e.g., Benjamin 2020; Joint Economic Committee 2017).

of the country have. The slow progress in certain parts of the country, along with the emergence of major HIV/AIDS disparities by race, has contributed to concerns that the U.S. response to HIV/AIDS is failing.[2]

As HIV/AIDS treatment is expensive and lifelong, many resources have been spent treating the disease. Because an untreated HIV infection can impose negative externalities by increasing the spread of HIV and because many people in the United States who have contracted HIV or are at risk of contracting HIV are socioeconomically disadvantaged, the U.S. federal government has had a large role in funding HIV/AIDS treatment. In 2019 alone, the U.S. federal government spent $34.8 billion on HIV/AIDS, with most of that funding spent on treating and limiting the spread of HIV/AIDS domestically (Kaiser Family Foundation 2019a).[3] HIV/AIDS funding levels have been controversial. Some observers have argued that too many resources have been spent combating HIV/AIDS (England 2007), and even though the U.S. federal government has the ambitious goal of eliminating the HIV/AIDS epidemic in the United States by 2030 (Fauci et al. 2019), policymakers often target HIV/AIDS funding for budget cuts (Hatcher 2020).

Despite HIV/AIDS having been one of the largest public health crises in modern history and despite the federal government having spent hundreds of billions of dollars to combat the disease, little is known about the impact of federal funding to combat HIV/AIDS or about the role that the large amounts of federal funding have played in the trajectory of the HIV/AIDS epidemic in the United States. More generally, little is known about the ability of allocating funds to local areas to support flexible public health responses to improve population health. The lack of research into the U.S. government's response to HIV/AIDS stands in contrast to economics research into the health impacts of other U.S. public health campaigns (e.g., Anderson et al. 2019, Anderson, Charles, and Rees 2020; Bailey and Goodman-Bacon 2015; Bleakley 2007; Bleakley 2010) and of various federal safety net programs (e.g., Almond, Hoynes, and Schanzenbach 2011; Goodman-Bacon 2018, 2021a; Hoynes, Miller, and Simon 2015; Miller, Johnson, and Wherry 2021).

The goal of this study is to understand the impact of federal funds allocated to cities to combat HIV/AIDS and the role that this funding has had in the course of the HIV/AIDS epidemic in the United States. Specifically, I examine the impact of funding from the first title of the Ryan White Comprehensive AIDS Resources Emergency (CARE) Act. Since its passage in 1990, the Ryan White CARE Act has been the U.S. federal government's main mechanism for combating HIV/AIDS in the United States. Unlike many other federal programs, the Ryan White program does not provide benefits directly to the targeted population. Instead, the Ryan White CARE Act provides funding directly to cities and states to support local efforts to

[2]Refer to El-Sadr, Mayer, and Hodder (2010) and El-Sadr et al. (2019). See also the comments from Tom Frieden, then-director of the Centers for Disease Control and Prevention, in "U.S. Still in Danger of Losing War on AIDS, C.D.C. Director Says," which was published in *The New York Times* on December 1, 2015.

[3]Note that this amount of annual spending is more than the federal government spends on many important safety net programs, including Head Start, the Children's Health Insurance Program, Temporary Assistance for Needy Families, and the Federal Pell Grant Program. Refer to Center for Poverty and Inequality Research (2020) for a discussion of federal spending levels for these programs.

develop, coordinate, and operate systems to provide health care and support services to low-income individuals with HIV/AIDS (Institute of Medicine 2004). Through its first title, which is the title that allocates funding to cities and is the focus of this study, the Ryan White CARE Act has allocated over $20 billion (in 2018 dollars) to 52 U.S. cities through 2020.

To identify the impact of Ryan White funding, this study implements a difference-in-differences research design that uses variation in eligibility for Title 1 funds that comes from two aspects of the Ryan White CARE Act. The first driver of the variation in Title 1 eligibility studied in this paper comes from the staggered timing of cities gaining Title 1 status that resulted from the original Ryan White legislation granting cities Title 1 status only after they had at least 2,000 AIDS cases. The second driver of the variation in Title 1 status studied in this paper comes from a 1996 rule change that stipulated that a new AIDS case would only count towards eligibility for five years rather than in perpetuity and was implemented along with a grandfather clause that allowed cities that had obtained Title 1 status under the original rules by March 31 of 1995 to maintain their Title 1 status even if they did not meet the new standard. Immediately after these changes were made, treatment was discovered that could prevent people with HIV from developing AIDS. The interaction of the simultaneous occurrence of the rule change, the grandfather clause, and the discovery of effective treatment resulted in the de facto criteria for receiving Title 1 funding in the coming years largely being that cities had to have had at least 2,000 AIDS cases by March 31 of 1995 and led to cities that originally had similar HIV/AIDS burdens and that were initially on parallel HIV/AIDS trajectories receiving dramatically different amounts of federal funding to combat HIV/AIDS.

Using variation in Title 1 eligibility that has arisen for these reasons, I identify the impact of Title 1 status by estimating how the difference in HIV/AIDS outcomes between Title 1 cities and other cities changed after Title 1 cities obtained Title 1 status. To keep the treatment and control groups comparable, the main sample includes the final 25 cities to clear the threshold for Title 1 status under the original eligibility rules as the treatment cities and the 25 cities with the most AIDS cases through 1995 not qualifying for Title 1 status under the original rules as the control cities. In essence, cities that were near but not quite to 2,000 AIDS cases ever reported by March 31 of 1995—such as Birmingham, Cincinnati, Providence, and Richmond—serve as the control group for cities that had just reached 2,000 cases by March 31 of 1995—such as Cleveland, Fort Worth, Hartford, and Sacramento.

The main outcome studied in this paper is cities' annual HIV/AIDS death rates from 1988 to 2018 calculated from the restricted-use Vital Statistics Multiple Cause of Death Files. Estimating difference-in-differences models indicates that a city obtaining Title 1 status reduced the city's annual HIV/AIDS death rates by about 15-17% on average. The composition of lives saved corresponds to HIV/AIDS prevalence rates across demographic groups with disproportionately large shares of the lives saved being male, prime-

aged, and Black relative to these groups' shares of non-HIV/AIDS deaths. The estimates imply that one HIV/AIDS death has been avoided for every $334,000 allocated through Title 1 and that Title 1 has saved approximately 57,000 lives through 2018. The number of HIV/AIDS deaths from 1991 to 2018 would have been approximately 13% higher if not for these city-level HIV/AIDS funds. In addition to estimating the impact of Title 1 status on HIV/AIDS deaths, I also estimate the impact of Title 1 status on rates of new AIDS cases and find that a city obtaining Title 1 status reduced the city's annual rates of new AIDS cases by approximately 25% on average.

Descriptive analysis of long differences in HIV/AIDS measures from the year the Ryan White CARE Act was passed through 2018 highlights the role that Title 1 funding disparities have had in the disparities in HIV/AIDS progress across cities. Even with changes in both the Ryan White CARE Act and the U.S. health care system in recent years that would be expected to alleviate cross-city differences in HIV/AIDS progress caused by Title 1 disparities, cities that obtained Title 1 status under the original Ryan White rules experienced a 24% larger reduction in AIDS death rates from 1990 to 2018 than cities that did not obtain Title 1 status under the original rules. To assess the impact of Title 1 funding on HIV transmissions, I study cities' numbers of residence living with HIV in 2008, which is the first year HIV data are available across cities. I find that despite reducing HIV/AIDS death rates, Title 1 had decreased cities' numbers of people living with HIV by 2008, which indicates that Title 1 reduced the spread of HIV. By 2008, Title 1 reduced the marginal cities' numbers of people living with HIV by 40%. Assuming this estimate is representative of the effect for all Title 1 cities implies that Title 1 of the Ryan White CARE Act prevented over 350,000 HIV transmissions through 2008.

The significant health impacts of this funding speak to the promise of providing targeted federal funding to local areas to improve health. Assuming a value of a statistical life of $10 million, the estimates imply that the $19 billion allocated to cities from 1991 to 2018 has produced over $560 billion of value in terms of lives saved alone. This funding yielding a benefit-cost ratio of 30 is especially notable in light of studies that find negligible health gains from marginal health care spending (e.g., Doyle 2011; Doyle et al. 2015; Einav, Finkelstein, and Mahoney 2018). Even with Ryan White funds supporting holistic care, the cost of an additional life year through Ryan White is similar to the cost of an additional life year from Medicaid paying for HIV antiretroviral treatment (Duggan and Evans 2008). The Ryan White program being designed for people with HIV—who have a high marginal benefit of health care—results in Ryan White's cost to save a life being far lower than the cost to save a life through expanded Medicaid coverage. These findings provide evidence that funding mechanisms that focus on improving access to effective health care for a particularly vulnerable population can be a cost-effective approach for increasing population health relative to less targeted alternatives. Federal funds allocated through the Ryan White CARE Act likely yield benefits

that are high relative to costs because the Ryan White program provides health care to low-income, socially vulnerable people with a deadly infection that will spread for years before killing them if left untreated.

In addition to providing a better understanding of the role of federal funding in producing health, the findings from this study also help explain the disparate HIV/AIDS progress across the United States that has alarmed public health stakeholders at all levels, ranging from local health departments to multiple presidential administrations, and that has largely remained a puzzle (El-Sadr, Mayer, and Hodder 2010; El-Sadr et al. 2019; U.S. Department of Health and Human Services 2010, 2021). Despite the large size of the Ryan White program, the funding disparities arising from the Ryan White CARE Act have been poorly understood, and surprisingly little work has assessed their implications. This paper shows how the confluence of a Ryan White rule change, a grandfather clause, and the unexpected advent and nature of the HIV treatment that emerged has led to large HIV/AIDS funding disparities across cities from the federal government's main mechanism for combating HIV/AIDS domestically. By identifying the large funding disparities, their source, and their effects, this study shows how and why differences in federal HIV/AIDS funding across cities became a key driver of the divergent HIV/AIDS trajectories across the country seen today. The role that disparities in federal funding have had in establishing the disparities in HIV/AIDS progress highlights the importance of funding mechanisms' allocation rules and points to issues that can arise with place-based funding.

The paper proceeds as follows. The next section provides a brief overview of HIV/AIDS in the United States and of the Ryan White CARE Act and discusses the expected effects of federal funding to combat HIV/AIDS. Section 3 describes the eligibility rules for Title 1 funding in more detail and discusses the empirical approach and data sources used in the study. Section 4 presents the results, and Section 5 concludes.

2 Background

This section first provides background information on the HIV/AIDS epidemic in the United States. Since the timing and nature of the HIV/AIDS treatment that emerged in the mid-1990s played a role in establishing the large disparities in federal funding studied in this paper, this discussion includes a brief summary of the search for effective HIV/AIDS treatment. The section then discusses the Ryan White CARE Act and describes the potential impact of HIV/AIDS funding.

2.1 HIV/AIDS in the United States and the Search for Effective Treatment

Human immunodeficiency virus (HIV) is a retrovirus that can be spread through unprotected sex, needle sharing, blood transfusions, and from mother to child during pregnancy, delivery, or breastfeeding. HIV harms infected people by lowering their white blood cell counts and thus weakening their immune

systems. While HIV is a virus, acquired immunodeficiency syndrome (AIDS) is a set of symptoms that people with HIV develop after HIV has caused significant damage to their immune systems. People with AIDS are susceptible to opportunistic infections and cancers that a healthy immune system could typically combat but that aggressively take hold in someone with AIDS. Infections that lead to diseases like pneumocystis carinii pneumonia, Kaposi's sarcoma, and cytomegalovirus, which can be easily controlled by healthy immune systems, have been common killers of people with AIDS. Without treatment, HIV usually progresses to AIDS within 8 to 10 years. Life expectancy for people with untreated AIDS is 1.5 years. Though deaths from AIDS occurred earlier, AIDS was first recognized in 1981. Annual deaths from AIDS in the United States rose from 451 in 1981 to their height of over 50,000 in 1995.

Prior to 1987, the care that HIV/AIDS patients received was largely palliative and aimed at treating the opportunistic infections that developed as a result of HIV/AIDS. In 1987, the Food and Drug Administration (FDA) approved zidovudine (AZT, formerly azidovudine) as the first medicine to treat HIV/AIDS. Originally developed in the 1960s to be a form of chemotherapy, AZT received FDA approval to treat HIV/AIDS after it was shown to temporarily increase white blood cell counts in people with HIV/AIDS. Despite early excitement about AZT, its side effects proved to be unbearable for many people, and whether the transient increase in white blood cell counts induced by AZT was meaningful remained an open question (Hamilton et al. 1992).

In the early 1990s, the outlook for the HIV/AIDS epidemic looked bleak. AIDS had become the leading cause of death for prime-aged adults in the United States, and the rapid rise in AIDS cases and deaths showed no signs of slowing. The search for effective treatment was proving elusive. Frustrated by a lack of progress and a perceived lack of research attention, HIV/AIDS activists staged thousands of demonstrations between 1987 and 1996, including ones at the National Institutes of Health and FDA campuses in the 1990s. At these demonstrations, protestors staged die-ins, held signs that read "NIH–Nothing Is Happening" and "Federal Death Administration", and set up mock graveyards with tombstone epithets stating "Dead from a Lack of Drugs" and "Poisoned from AZT".[4]

In 1996, however, a breakthrough in HIV/AIDS treatment emerged that would alter the course of the fight against HIV/AIDS. Antiretroviral treatments were introduced that could prevent HIV from replicating in the body and could reduce HIV's damage to the immune system. While the full effects and implications of these drug cocktails were not understood immediately, studies would eventually show that within 30 days of treatment initiation, these drugs could lead to HIV being undetectable in the blood of a person with an HIV infection as long as treatment was maintained and could prevent people with HIV from developing

[4]Refer to Fernández, Parsa, and Viarengo (2019) and Mansour, Rees, and Reeves (2020) for discussions and studies about the organizational efforts of AIDS activists.

AIDS. Research would also eventually show that these new antiretrovirals drastically reduce the likelihood that a person with an HIV infection transmits the infection to others.

The first of these new antiretrovirals was approved by the FDA in December of 1995 under an accelerated approval process that allows drugs to be used before their effectiveness has been established. After being disappointed by several drugs that initially seemed promising only to eventually turn out to be ineffective against HIV/AIDS, HIV/AIDS patients and physicians were at first skeptical about the likely effectiveness of these new drugs. However, reports of emaciated and demented HIV/AIDS patients whose deaths seemed imminent quickly returning to health after taking these antiretrovirals would soon become common, and HIV/AIDS communities soon realized that these new antiretrovirals marked a turning point in the search for effective HIV/AIDS treatment. In *How to Survive a Plague*, a book about the search for effective HIV/AIDS treatment written by the director of the Oscar-nominated documentary of the same name, David France describes the moment that many people realized that these new antiretrovirals were a momentous advance in HIV/AIDS treatment. At a 1996 event about the new treatment, a scientist interrupted his otherwise technical presentation about a study showing the dramatic effect of the antiretrovirals on HIV/AIDS survival rates to tell a room full of disoriented HIV/AIDS activists, researchers, and health care providers the following:

> Maybe you are not understanding what I am saying. This is the biggest news ever in this epidemic...This is what we've been working for all these years. They're not a cure. We don't know what they are, in effect. But this is the first major piece of good news we have had in all these years. They're calling it the Lazarus effect. People who were in hospitals on their last breath are getting up and going back to work. We've never seen anything like it. (France 2016)

The use of antiretroviral treatment accelerated throughout 1996 and became the standard treatment for HIV/AIDS by the start of 1997. As a result of these new antiretrovirals, deaths from HIV/AIDS began a major decline in 1996. The number of HIV/AIDS deaths fell by over 20% from 1995 to 1996 and by nearly 50% from 1996 to 1997, which has been the largest single-year decline for a major cause of death ever recorded (Centers for Disease Control and Prevention 1998). The life expectancy of a young adult who begins antiretrovial treatment immediately after contracting HIV is now near the life expectancy of a similar person without HIV (Marcus et al. 2020). While research into HIV/AIDS treatments has continued, the emergence of effective treatment ushered in a new chapter in the fight against HIV/AIDS: How to ensure that people with HIV/AIDS have access to these effective but expensive treatments and how to maximize the impact of these new drugs in the fight against HIV/AIDS.

Though progress has been made in the HIV/AIDS pandemic, the United States still faces many issues

related to HIV/AIDS.[5] Despite initial speculation that antiretroviral therapy was a cure for HIV, it was soon realized that the antiretrovirals suppress HIV only for as long as they are taken. Though the antiretrovirals cause HIV to be undetectable in the blood, the HIV virus lies dormant in a small number of cells and will take hold again if a person discontinues the antiretrovirals. In the United States, over 700,000 people have died of HIV/AIDS, and approximately 1.2 million people are currently infected. Half of all people with HIV infections in the United States do not have their infections suppressed through antiretroviral therapy and can therefore still spread the infections to others, which contributes to the number of HIV infections continuing to climb (Centers for Disease Control and Prevention 2017). Large disparities in HIV/AIDS burden by race and socioeconomic status exist in the United States, with low-income and Black people accounting for disproportionately large shares of HIV/AIDS cases and deaths (Rubin, Colen, and Link 2010).

2.2 The Ryan White CARE Act

The cost to treat a patient with the new antiretroviral drugs in 1996 was high at a mean annual cost of $20,300 (in 1996 dollars) (Bozzette et al. 2001), but even before the emergence of the effective antiretroviral drugs, treating HIV/AIDS was expensive.[6] Exacerbating access issues arising from the cost of treatment are the facts that many people with HIV/AIDS have below-average incomes and that people with AIDS are often unable to work for health reasons and have often reported employment discrimination when they try to work.[7] These challenges have resulted in many people with HIV/AIDS having difficulties accessing and paying for health care.

In response to growing pressure to provide financial resources to address the HIV/AIDS epidemic, Congress passed the Ryan White CARE Act on August 18, 1990.[8] As the largest federally funded program in the United States for people living with HIV/AIDS, the Ryan White program is the backbone of the federal government's strategy to address the HIV/AIDS epidemic in the United States and has a goal of improving access to health care for low-income, uninsured, and under-insured people affected by HIV/AIDS who could not otherwise access treatment. According to the Health Resources and Services Administration (HRSA), the branch of the Department of Health and Human Services that administers the Ryan White program, over half of people with HIV/AIDS receive care through the Ryan White program, a majority of

[5] While this paper focuses on HIV/AIDS in the United States, HIV/AIDS is a global issue and remains a leading cause of death worldwide. Sub-Saharan Africa has been hit particularly hard. In 2017, HIV/AIDS accounted for over a quarter of all deaths in South Africa and Botswana (Roser and Ritchie 2018).

[6] Treating HIV/AIDS remains expensive and continues to cost around $20,000 per year on average (Gebo et al. 2010). Because the Ryan White program reimburses providers at Medicaid's rates, it has costs below the national average.

[7] Prior to the passage of the Affordable Care Act (ACA), people with HIV have also had difficulties accessing health insurance coverage through the individual market. By requiring insurers in the individual market to accept all who apply for coverage and by expanding Medicaid coverage for childless adults, the ACA has expanded health insurance coverage for people with HIV/AIDS.

[8] The Ryan White CARE Act is named in honor of a hemophiliac who contracted HIV through a blood transfusion and became an advocate for HIV/AIDS awareness and research before dying in his teens from HIV/AIDS.

whom have incomes at or below the federal poverty level (Health Resources and Services Administration 2019). Since Ryan White funds are discretionary, the Ryan White CARE Act must be periodically reauthorized and has been reauthorized in 1996, 2000, 2006, and 2009. With each reauthorization, Congress has made changes to the Ryan White program.[9] The amount appropriated to the program has grown from $260 million in 1991 to $2.5 billion in 2020.

Rather than establishing an entitlement program for people with HIV or having the federal government directly provide HIV/AIDS treatment, Congress decided to structure the Ryan White CARE Act to provide financial resources to state and local governments to support local responses to HIV/AIDS. Ryan White funds are administered through five titles, though most of the funding—nearly 90 percent—is allocated through its first two titles. Title 1 administers funds directly to eligible cities, while Title 2 administers funds directly to states. The remaining Ryan White funds are allocated to community-based organizations to provide primary care to people living with HIV, to AIDS education centers, and for dental care for people with HIV.

The focus of this paper is on Title 1 funds. Title 1 funds are administered directly to mayors, who then typically immediately turn the funds over to health departments (Health Resources and Services Administration 2013). Cities receiving Title 1 funds are required to establish HIV Health Services Planning Councils that set local priorities for care delivery. While cities have some discretion in how they administer their programs, an initial step for most programs is to assign low-income, HIV-positive people who might face barriers in accessing health care to Ryan White case managers (López, Shacham, and Brown 2018). These case managers assess financial needs and can link people to health care that can be paid for by Ryan White funds if needed.

Although a majority of Title 1 funds must go towards core medical services, an important feature of the Ryan White program is that it aims to provide holistic care to low-income people with HIV. As such, Title 1 funds can be used to pay for various health care services in addition to basic HIV medications and provider office visits. For example, Title 1 funds can be used to provide counseling to people newly diagnosed with HIV about how to cope with the diagnosis and on what they need to do to not spread the infection. Case managers can also arrange substance abuse treatment or transportation services paid for by Title 1 funds for HIV-positive people struggling with addiction or with traveling to health care appointments. Additional services that Ryan White funds can pay for include early intervention services, like testing and contact

[9] I summarize the Ryan White CARE Act and discuss the provisions that have led to the large funding disparities analyzed in this study, as well as aspects of the Ryan White CARE Act that are relevant to interpreting the results. The Ryan White CARE Act is a complex piece of legislation with many policy parameters and formulas that have changed over time. Refer to Health Resources and Services Administration (2013), Institute of Medicine (2004), and Kaiser Family Foundation (2019b) for additional information on the Ryan White CARE Act.

tracing, and mental health treatment more broadly.[10] According to Ryan White Title 1 expenditure reports, a majority of Title 1 funds go to HIV-related outpatient care, HIV medications, and case management services, while the rest of the funds are spread over many different types of services (Health Resources and Services Administration 2020a). Appendix Table A.1 shows the share of spending for broad spending categories calculated from expenditure reports submitted by Title 1 cities to HRSA for fiscal year 2010. The rules for obtaining Title 1 status and for allocating Title 1 funds are crucial to the empirical approach of this study and are discussed in detail in Section 3.

Title 2 funds are allocated to states to support the planning and coordination of HIV/AIDS care and can be used for similar services as Title 1 funds. The Title 2 allocation rules are complex, but most of the Title 2 funds are allocated independently of Title 1 funds. The partial double counting of cases in Title 1 cities for Title 1 and Title 2 funding has led to disparities in total Ryan White funds relative to HIV/AIDS burdens across states. I briefly summarize the Title 2 funding rules as they relate to Title 1 funding. Refer to Health Resources and Services Administration (2013), Institute of Medicine (2004), and Kaiser Family Foundation (2019b) for additional details about Title 2 funding. While Title 2 funding initially did not take into account Title 1 funds, the 1996 reauthorization set aside approximately 5% of Title 2 funds to be allocated based on a state's share of national AIDS cases that occur outside of Title 1 cities. Since 2000, Title 2 also includes a separate category of funds that provides a small amount of additional funding to states with non-Title-1 cities with high AIDS burdens. As discussed in more detail in Section 3, these city-directed Title 2 funds are much lower than the funding provided by Title 1. Through 2020, Title 2 has allocated $33 billion (in 2018 dollars) to states.

Throughout its history, the Ryan White CARE Act has been the subject of contentious disagreements. Although the initial bill received bipartisan support, politicians have expressed opposition to the Ryan White CARE Act for both moral and fiscal reasons. For instance, Congressman Jesse Helms objected to the bill based on his view that "deliberate, disgusting, revolting conduct" was responsible for people contracting HIV, while then-Congressman Mike Pence argued unsuccessfully for directing Ryan White funds to organizations "which provide assistance to those seeking to change their sexual behavior." Facing the threat of a veto, President George H. Bush signed the Ryan White CARE Act into law, but the White House had initially expressed its opposition to the bill, stating that "The bill's narrow approach, dealing with a specific disease, sets a dangerous precedent, inviting treatment of other diseases through similar arrangements." Throughout Ryan White's history, Title 1 cities have fought efforts to allocate Ryan White funds more equitably. For example, in 2005, areas struggling to address HIV/AIDS that received low Ryan White funding relative to their HIV/AIDS burdens argued for implementing rules to distribute Ryan White funds

[10] Refer to Health Resources and Services Administration (2013) for the complete rules about how Title 1 funds may be used.

more equitably in the 2006 reauthorization. In response to these calls for changes in funding, *The New York Times*—a newspaper from a city that had received over $1 billion in Title 1 funds through 2005—published an editorial arguing that the lack of relative progress in addressing HIV/AIDS in much of the country was the result of those areas not caring about the plight of people with HIV/AIDS rather than from disparities in Ryan White funds. The editorial argued that the progress that Title 1 cities had made in addressing HIV/AIDS relative to other cities justified future funding disparities, seemingly ignoring the possibility that wide funding disparities up to that point could have played a role in the disparities in HIV/AIDS outcomes that had emerged by the mid 2000s.[11]

2.3 The Expected Effects of Federal Funding to Combat HIV/AIDS

The effect of federal HIV/AIDS funding on HIV/AIDS deaths depends on the health care paid for by the funds as well as on the health care that patients would have received absent the funds. Since the Ryan White program is supposed to be the last payer for treatment, the care paid for with Ryan White funds should in principle be care that people would not have otherwise received. In practice, though, Ryan White funds have the potential to displace care paid for by other sources. If patients receiving treatment paid for by Ryan White funds could have accessed their desired health care absent the Ryan White program, the funding's health impacts would be minimal. Similarly, if the productivity of additional health care provided by Ryan White funds is low or if health departments use the funds inefficiently, HIV/AIDS funding could have no health impacts.

On the other hand, Ryan White funds also have the potential to have large health impacts, especially since the program focuses on providing treatment to low-income people with an infectious disease that spreads much more easily if untreated. Over 60% of people that Ryan White programs serve have incomes under the federal poverty level, and 90% have incomes under 250% of the federal poverty level (Health Resources and Services Administration 2020b). For most of the HIV/AIDS epidemic, HIV would preclude someone from purchasing health insurance on the individual market since HIV is a pre-existing condition, and childless adults under 65 would not be eligible for Medicaid or Medicare until after HIV/AIDS had left them disabled. Moreover, some of the health department services paid for by Ryan White funds, such as HIV/AIDS outreach and case management services, could have large health impacts even though they would typically not be provided by the private market. If Ryan White funds reduce HIV transmission rates, the effects of the funding on health measures would likely grow over time and persist even if the funds were discontinued.

The main outcome of interest for the study is HIV/AIDS deaths. By reducing the spread of HIV and

[11] See "Guarding the Fight Against AIDS", which was written by *The New York Times* editorial board and published on August 18, 2005.

by preventing or slowing the development of AIDS in HIV-positive people, the first order expected impact of federal funding to combat HIV/AIDS would be to decrease AIDS cases and HIV/AIDS deaths. Because HIV takes about ten years to become deadly, changes in HIV/AIDS deaths from changes in HIV transmission rates would be slower to manifest than would changes in HIV/AIDS deaths rates for people currently living with HIV.

The impact of federal HIV/AIDS funding on HIV transmission rates and HIV prevalence rates is unclear ex ante. Antiretrovirals' shrinking an HIV-positive person's chances of transmitting HIV to other people to essentially zero if taken properly has led to "treatment as prevention" being a public health mantra for combating HIV/AIDS. If federal HIV/AIDS funding leads to fewer people having an untreated HIV infection, it has the potential to reduce the spread of HIV. But if federal funding reduces HIV/AIDS deaths without reducing the spread of HIV, it will lead to more people living with HIV. Increases in the number of people living with HIV could then lead to additional HIV infections if the people whose deaths were avoided remain infectious from inconsistent treatment adherence. By reducing the costs of living with an HIV infection, federal HIV/AIDS funding could also increase the spread of HIV by causing HIV-negative people to take fewer precautions against contracting HIV. If these countervailing effects are great enough, they could lead to federal HIV/AIDS funding increasing HIV infections, AIDS cases, and HIV/AIDS deaths.[12] The analysis of HIV/AIDS deaths and AIDS diagnoses presented in this paper is of the net impact of HIV/AIDS funding and thus captures the effects of any of these potentially offsetting mechanisms.

3 Empirical Approach and Data Sources

This section discusses the rules for becoming a Title 1 city and how these rules led to vast differences in Ryan White funds across cities. The section then discusses the empirical approach and the data sources used for the study.

3.1 The Rules for Becoming a Title 1 City and the Empirical Approach

As explained in more detail in the following paragraphs, the variation in Title 1 status examined in this study comes from the three following aspects of the Ryan White CARE Act: 1) The original rules for Title 1 eligibility did not prioritize recent changes in AIDS cases and used a sharp cutoff for determining eligibility that led to cities with similar AIDS burdens having different Title 1 statuses, 2) Once cities obtain

[12] To be clear, behavioral responses could occur through multiple channels and would have unclear normative implications. Consider male-to-male sexual encounters. HIV-negative gay men engaging in riskier sexual behavior because the Ryan White program functions as social insurance against an HIV infection would be moral hazard and would potentially reduce net welfare. In contrast, if Ryan White funding leads to more HIV-positive men receiving treatment, HIV-negative gay men would be expected to have additional sexual encounters because Ryan White funds lowered their risk of contracting HIV. This increase in male-to-male sexual encounters would occur even if individuals fully bore the cost of an HIV infection and could increase net welfare.

Title 1 status, they do no lose it even if they no longer meet the current eligibility criteria, and 3) The 1996 reauthorization changed the Title 1 eligibility rules in a way that made obtaining Title 1 status much more difficult. The eligibility rules being changed immediately prior to effective treatment emerging led to large differences in HIV/AIDS funding across cities that were orthogonal to cities' initial HIV/AIDS trajectories.

According to the original 1990 Ryan White legislation, cities that had reported a cumulative total of 2,000 AIDS cases to the Centers for Disease Control and Prevention (CDC) by March 31 of a particular year became eligible for Title 1 funding in the following fiscal year. Prior to reaching the 2,000-case threshold, cities received no Title 1 funds. Under the initial rules, a reported AIDS case would still count towards eligibility and funding levels even after the person with AIDS had died. In an April 1995 report to Congress, the General Accounting Office (GAO, later renamed the Government Accountability Office) argued that using a more current measure of AIDS severity would more effectively direct funds based on need (General Accounting Office 1995). When the Senate first passed its Ryan White reauthorization in June 1995, it incorporated the GAO's recommendation by changing the Title 1 funding rules so that a city had to have at least 2,000 AIDS cases reported in the last five years to be designated as a Title 1 city. This change remained in the final bill that President Bill Clinton signed into law in May 1996. At the time the eligibility rule was changed, many cities that had qualified to be Title 1 cities under the original rules did not have 2,000 AIDS cases reported in the last five years. To prevent current Title 1 cities from experiencing large funding drops because of the new rules, the 1996 Ryan White CARE Act reauthorization instituted provisions to maintain funding levels and allowed cities that qualified under the original Ryan White rules by March 31 of 1995 to maintain their eligibility for Title 1 funds even if they had fewer than 2,000 AIDS cases reported in the past five years.

As AIDS cases were rising sharply in 1995 when the GAO originally recommended the switch to using a more contemporaneous measure of AIDS cases, many cities would have cleared the new threshold within the next few years if the AIDS trends of the early 1990s had continued past 1995. However, treatment that could prevent AIDS but not cure HIV emerging immediately after the eligibility rules changed meant that cities that had not qualified for Title 1 status under the original rules would obtain Title 1 status only if they were experiencing HIV/AIDS outbreaks that were outliers in severity relative to other cities. Thus, immediately prior to effective but expensive treatment for HIV/AIDS finally emerging, Congress implemented funding rules that would provide some cities with billions more dollars for combating HIV/AIDS in the coming years than other cities.

Before the initial eligibility rules were changed, 44 cities became eligible for Title 1 funding. If Congress had not changed the rules and if effective treatment had not emerged, approximately 50 cities would have achieved Title 1 status by 2006, assuming the growth in AIDS cases in 1995 continued through 2006. Even

with the new rule Congress put in place in 1996, approximately 35 cities would have obtained Title 1 status by the end of 2006 if effective treatment had not emerged. Similarly, approximately 35 cities would also have still achieved Title 1 status by 2006 with effective treatment emerging if Congress had not changed the eligibility rules. However, with the combination of the rule change and effective treatment emerging, only two additional cities gained Title 1 status from 1996 to 2006.

Within a few years of the 1996 rule change, several cities that were not eligible for Title 1 funding had worse HIV/AIDS outcomes than Title 1 cities, and yet the cities without Title 1 status did not directly receive any Ryan White funds. In response to the slow progress in addressing HIV/AIDS in cities without Title 1 status, the 2000 Ryan White CARE Act reauthorization implemented a new provision that would provide additional Title 2 funds to states with non-Title 1 cities that had reported 500 to 1,999 AIDS cases in the previous five years. Even with these additional city-directed Title 2 funds, though, the large disparities in HIV/AIDS funding across cities persisted. In 2004, Title 1 cities received a mean funding per AIDS case through Title 1 of $2,380, while states qualifying for the city-directed Title 2 funds from the 2000 reauthorization were allocated an extra $414 per AIDS case in those cities on average. Throughout the early 2000s, the allocation of funds became increasingly unaligned with HIV/AIDS burdens. By 2006, some non-Title-1 cities had rates of new AIDS cases that were several times the rate of the Title 1 city with the lowest rate.

To provide the non-Title-1 cities that were on the worst HIV/AIDS trajectories with additional funding, Congress changed the eligibility rules in the 2006 Ryan White CARE Act reauthorization to allow cities with at least 1,000 AIDS cases reported in the previous five years to become eligible for Title 1 status.[13] Five cities obtained Title 1 status immediately after this rule change went into effect in 2007, and one other city has obtained Title 1 status since 2007. Even with the 2006 reauthorization allowing some of the cities on the worst HIV/AIDS trajectories to gain Title 1 status, large disparities in federal funding that stem from the 1996 reauthorization rules still exist today.

In effect, the 1996 Ryan White CARE Act reauthorization resulted in cities with similar HIV/AIDS burdens and on parallel HIV/AIDS tracks receiving drastically different amounts of federal funding to combat HIV/AIDS, particularly from 1996 to 2006. This study estimates the effect of Title 1 funds by comparing how the difference in HIV/AIDS outcomes between Title 1 cities and other cities changed after Title 1 cities gained Title 1 status. Because the 1996 reauthorization led to cities needing to have substantially worse HIV/AIDS trajectories relative to other cities to obtain Title 1 status, I consider cities to be treated only if

[13]The 2006 reauthorization created two different categories of Title 1 cities. Eligible Metropolitan Areas, which was a label previously applied to all Title 1 cities, are those that have reported at least 2,000 AIDS cases in the past five years. Transitional Grant Areas are cities that have reported 1,000 to 1,999 AIDS cases in the past five years or that qualified for Title 1 status under an earlier set of rules. The main difference between the two designations is that Eligible Metropolitan Areas have hold harmless provisions that prevent sudden funding drops, while Transitional Grant Areas do not have to set up planning councils. Transitional Grant Areas can also lose Title 1 status if they cease to have a cumulative total of 1,500 or more people living with HIV infection ever classified as AIDS. In practice, no city has come close to losing Title 1 status.

they achieved Title 1 status under the original rules, meaning that they had at least 2,000 cases by March 31, 1995. I typically refer to these cities as Title 1 cities, even though some other cities eventually obtained Title 1 status.[14]

To keep the control and treatment groups comparable, the main analysis sample focuses on cities that were closest to the original threshold of 2,000 AIDS cases ever reported by March 31, 1995. For the baseline analysis, I set the control cities to be the 25 cities with the most AIDS cases reported by March 31, 1995, that did not qualify for Title 1 funding under the original rules and the treatment cities to be the 25 cities with the fewest AIDS cases reported by March 31, 1995, that qualified for Title 1 status under the original rules. In Appendix Table A.4, I show that the results are robust to using different sets of treatment and control cities. Appendix Table A.2 contains the full list of control cities and Title 1 cities.

Title 1 cities receive both formula-based funds and supplemental funds. The formula funds made up half of Title 1 funding in the original legislation and make up two-thirds of Title 1 funding as of 2007. While the formula for the non-supplemental funding was initially based on a city's share of AIDS cases ever reported by Title 1 cities, the 1996 reauthorization changed the formula to instead use estimates of a city's share of people living with AIDS in Title 1 cities. The 2006 reauthorization changed the formula to include HIV cases. The supplemental funding is allocated by the Secretary of Health and Human Services based on cities' reported need for additional HIV/AIDS funding. Throughout the Ryan White CARE Act's history, policymakers have included hold-harmless provisions to prevent cities from experiencing large drops in their Title 1 funds.

While Title 1 funding varies across Title 1 cities, the funding differences per eligible AIDS case among Title 1 cities tend to be small. In 2004, for instance, the fifth and ninety-fifth percentiles of Title 1 funding per AIDS case among Title 1 cities were $2,361 and $2,492. Rather than attempt to identify the impact of these small, endogenous funding differences among Title 1 cities, the approach of this study is to estimate the impact of a binary treatment variable for a city having Title 1 status. I then use information on Title 1 funding amounts to produce an estimate of the amount of Title 1 funding spent for each HIV/AIDS death avoided.

The basic model that I estimate is as follows:

$$y_{jt} = \gamma_j + \delta_t + X_{jt}\alpha_t + Title1_{jt}\beta + \epsilon_{jt}, \tag{1}$$

[14]Appendix C analyzes trends in HIV/AIDS deaths in cities gaining Title 1 status in 2007 and shows that, in contrast to cities gaining Title 1 status under the original Ryan White CARE Act rules, cities gaining Title 1 status in 2007 experienced rising HIV/AIDS deaths relative to other cities in the years before they obtained Title 1 status, which means that the parallel trends assumption required for difference-in-differences estimation is not satisfied for these cities. Appendix C also shows, however, that the estimated impact of Title 1 status from a specification that demeans HIV/AIDS death rates to account for city-specific trends indicates that Title 1 status reduced HIV/AIDS death rates in cities obtaining Title 1 status under the new eligibility rules put in place by the 2006 reauthorization, which corroborates the findings from the main analysis.

where j indexes the city, t indexes the year, y represents the various measures of HIV/AIDS, γ is a vector of city fixed effects, δ is a vector of fiscal year fixed effects, X is a vector of control variables, and $Title1$ is an indicator variable equal to 1 if the city is a Title 1 city in year t. The baseline set of control variables is the share of the population that is male, younger than 18, older than 64, Black, and Hispanic with the coefficients on these controls being allowed to vary by year.

Interpreting the Title 1 coefficient in Equation (1) as the causal impact of Title 1 status requires the assumption that, absent the differences in Title 1 funding, HIV/AIDS outcomes in the Title 1 cities in the sample would have trended in parallel to the cities in the sample that did not qualify for Title 1 status under the original rules. As I have explained in this section, the institutional environment supports the plausibility of this assumption. However, given how central this assumption is for the analysis, I take additional steps to assess the validity of the assumption and to relax it. These steps include estimating event-study specifications of the effect of Title 1 status, varying the control and treatment groups, and incorporating additional time-varying controls.

As has been noted elsewhere, the concurrent emergence of effective treatment for HIV/AIDS is a central part of why the 1996 rule change for obtaining Title 1 status largely locked Title 1 statuses in place for the next decade. The independent effects of advances in HIV/AIDS treatment are captured by the year fixed effects in Equation (1), but it is important to remember that the expected impact of federal funding depends on the productivity of available treatment. I estimate a specification of Equation (1) that considers the possibility that Title 1 status had a different effect before 1996, but most of the wide differences in funding between Title 1 cities and other cities occurred during a period for which effective treatment is available, meaning the estimates presented in this paper are of the effect of federal funding to combat HIV/AIDS when effective treatment exists.

I estimate Equation (1) for two time periods. Because the 2006 reauthorization made several changes to the Ryan White program, one specification focuses only on years 1988 to 2006. However, as the 2006 reauthorization left large funding disparities in place and because large infusions of funding to combat an infectious disease likely have persistent effects, I also estimate specifications that include years 1988 to 2018.

3.2 Data

This study draws on several data sources. As described in the previous section, the sample is selected based on the number of AIDS cases that cities had reported by March 31, 1995. For information on reported AIDS cases, I use the AIDS Public Information Data Set (Department of Health and Human Services 2005), which the CDC created from AIDS case reports submitted by state and local health departments. The AIDS Public Information Data Set contains annual counts of AIDS cases through 2002 for each city that had at

least 500,000 people as of the 2000 Census.[15] I impute AIDS cases reported as of March 31, 1995, by adding 25% of cities' AIDS cases reported in 1995 to their AIDS cases reported by the beginning of 1995.

Figure 1 plots the log of AIDS cases by March 31, 1995, for each city in the AIDS Public Information Data Set in rank order. Cities to the right of the solid vertical line in Figure 1 had more than 2,000 AIDS cases by March 31, 1995, and thus gained Title 1 status under the original Ryan White rules. Cities to the left of the line had fewer than 2,000 AIDS cases by March 31, 1995, and thus did not qualify for Title 1 status under the original eligibility rules. The blue diamonds in Figure 1 represent the two cities that eventually became eligible for Title 1 funding under the 1996 reauthorization rules. The red squares in Figure 1 represent cities that have become Title 1 cities under the rules that were put in place starting in fiscal year 2007. The cities between the right dashed line and the solid line are the treatment cities, while cities between the left dashed line and the solid line are the control cities.

Numbers of HIV/AIDS deaths from fiscal years 1988 to 2018 come from restricted-use Vital Statistics Multiple Cause of Death Files (Department of Health and Human Services 2020), which have information on the universe of civilian deaths in the United States. In addition to containing basic demographic information on decedents and the underlying Internal Classification Diagnosis Code for each death, the restricted-use files contain information on the decedent's county. To have a consistent mapping from counties to cities over time, I attribute HIV/AIDS deaths to cities based on the city definitions in place in 1990, which are the city definitions used in the AIDS Public Information Data Set. I use annual data on county-level populations from SEER (2019) to calculate HIV/AIDS deaths per 100,000 people and to calculate the demographic controls.[16]

Appendix Table A.3 compares HIV/AIDS deaths to other deaths over the sample period. Relative to their share of non-HIV/AIDS deaths, Black people account for a disproportionately high share of HIV/AIDS deaths (44% compared to 12%). Men also account for disproportionately more HIV/AIDS deaths relative to their share of non-HIV/AIDS deaths (81% compared to 50%). The mean age at death from HIV/AIDS was approximately 30 years younger than the mean age for non-HIV/AIDS deaths from 1988 to 2018 (42 years compared to 72 years). Finally, 84% of HIV/AIDS deaths occurred in cities in the AIDS Public Information Data Set compared to 61% of non-HIV/AIDS deaths.

HIV/AIDS death rates are the main outcome studied. In addition to being important, deaths from HIV/AIDS are consistently measured across cities and can be computed for each year from 1988 to 2018. In

[15]The analysis excludes cities from Puerto Rico. Because the information used to create the control variables is not available for all years of the sample for Honolulu, Honolulu is also excluded from the analysis. Appendix Table A.2 contains the full list of remaining cities in the AIDS Public Information Data Set and indicates which cities are in the main sample. Appendix Figure A.1 displays a map that indicates cities in the AIDS Public Information Data Set.

[16]The first year of the sample is 1988 because 1988 is the first full fiscal year that records HIV/AIDS deaths. Since the SEER data do not contain information on counties' shares of people who are Hispanic before 1990, I set cities' 1988 and 1989 shares of the population who are Hispanic equal to their 1990 values.

contrast, 2008 is the first year that information on city-level HIV outcomes is available, and the AIDS Public Information Data Set, which has information on AIDS cases that correspond to the city definitions used in the main analysis, does not have information past 2002. Despite these issues, understanding how Title 1 affects the spread and progression of the disease is important and can help in interpreting the analysis of HIV/AIDS death rates. I assess the impact of Title 1 status on multiple measures of AIDS diagnoses with the difference-in-differences design. Information on AIDS cases from 1988 to 2002 come from the AIDS Public Information Data Set and have information for all cities in the sample. To have years that correspond to the years of HIV/AIDS deaths, I also use data on city-level AIDS cases each year from 1988 through 2018 that were received from a special request to the CDC. The city definitions in the data from the CDC do not perfectly correspond to the city definitions used in the main analysis[17], but these data have a major advantage in that they span 1988 to 2018.

Data on Ryan White Title 1 allocations come from multiple sources. Information on recent years of Title 1 allocations come from the Tracking Accountability in Government Grants System and the HRSA website. Information on earlier years of Title 1 allocations come from GAO reports, Office of Inspector General reports, HRSA budget justifications, and HRSA press releases. Through these sources, I have been able to assemble a data set with information on 96% of Ryan White Title 1 allocations from 1991 to 2018.[18] Years 1994 to 1996 of this assembled data set have incomplete funding information, and information is sporadically missing for a few city-year combinations throughout the data. For the observations with missing or incomplete information, I impute missing values for a city in year t using the city's funding in year $t+1$ assuming that the change in total Title 1 funding from year t to year $t+1$ was distributed proportionally based on the city's year t Title 1 funding. I inflation adjust annual funding amounts to 2018 dollars.

Descriptive statistics for the baseline sample are shown separately for the treatment and control cities in Table 1. As would be expected based on the original rules for Title 1 eligibility, the mean of HIV/AIDS death rates per 100,000 people is higher for the treatment cities. However, the mean percent increase in the death rate in the year before the Ryan White CARE Act was passed was 17% for both the treatment and control cities. In Section 4, I show that HIV/AIDS death rates continue to trend in parallel for the two sets of cities until the treatment cities gain Title 1 status. Despite similar trends in HIV/AIDS deaths in the early 1990s, the differences in Title 1 funding between the two sets of cities in subsequent years have been large. From 1996 to 2006, cities that did not qualify for Title 1 status under the original Ryan White CARE Act

[17]Some cities in the AIDS Public Information Data Set are not in the CDC data or are reported combined with other cities. For this reason, the main sample for the CDC analysis includes 46 rather than 50 cities. The CDC also provided numbers of new HIV diagnoses and of people living with HIV for the same set of cities beginning in 2008.

[18]I contacted HRSA to inquire about obtaining its information on Ryan White allocations through an open records request, but HRSA unfortunately does not maintain complete records on Ryan White allocations, which is why data had to be collected from these different sources.

rules received $3.9 million on average, while cities that qualified under the original rules received $68.9 million on average. Through 2018, the treatment cities received approximately $3.2 billion more in Title 1 funding than the control cities did.

4 The Effect of Federal Funding to Combat HIV/AIDS

The results presented in this section indicate that a city obtaining Title 1 status under the original Ryan White CARE Act rules led to dramatically fewer HIV/AIDS deaths in the city in subsequent years. The section begins by estimating the impact of Title 1 status on HIV/AIDS deaths. Next, I test for heterogeneous effects of Title 1 status on HIV/AIDS deaths for different sub-groups and estimate the impact of Title 1 status on AIDS cases. I then evaluate the implications of the effect of Title 1 status by estimating the total lives saved by Title 1 and by using estimates of the value of a statistical life to produce an estimate of the benefit-cost ratio of Title 1 funds. Finally, I assess Title 1's impact on HIV cases and transmissions.

The Impact of Title 1 Status on HIV/AIDS Death Rates

Figure 2 plots coefficients and 95% confidence intervals from a single regression of Equation (1) where the effect of Title 1 status is allowed to vary flexibly with time using data from 1988 to 2018. The coefficients in Figure 2 indicate how the difference in HIV/AIDS death rates between Title 1 cities and the control cities changed at different durations of Title 1 eligibility relative to the difference in the year before Title 1 cities obtained their Title 1 status. The first vertical line marks Title 1 eligibility. The second vertical line indicates the event time when the last Title 1 cities under the original rules are past 2006. The estimates indicate that the log of HIV/AIDS death rates trended similarly for the two sets of cities prior to Title 1 cities obtaining Title 1 status. Once cities obtained Title 1 status, HIV/AIDS death rates began falling in Title 1 cities relative to cities that did not achieve Title 1 status under the original Ryan White CARE Act rules.

Table 2 displays estimates of the effect of Title 1 status on HIV/AIDS death rates. The first column of Table 2 shows estimates of the average effect of Title 1 using data from 1988 to 2006. The estimate suggests that Title 1 status lowered annual HIV/AIDS death rates by 0.185 log points on average. Because the funding differences between the two sets of cities are sharpest through 2006, specification 1 provides the cleanest estimate of the effect of Title 1 status. However, large funding disparities still exist after 2006, and the effect of funding to halt an infectious disease is likely to persist. To consider the effect of Title 1 funding through more recent years, the remaining columns in Table 2 show results from specifications that include data through 2018. Column 2 shows the baseline estimated effect of Title 1 status using data through 2018. The estimate is similar to the estimate from column 1 at -0.163 log points.

Column 3 presents an estimate of the effect of Title 1 status from a regression weighted by cities' popu-

lations. The estimated effect is similar to the estimate in column 2. Column 4 expands the sample to include all cities in the AIDS Public Information Data Set in the sample. When all cities are included, the estimated effect of Title 1 status is a 0.196 log point reduction in HIV/AIDS death rates. The final column in Table 2 tests for evidence that Title 1 reduced HIV/AIDS deaths prior to effective treatment being available by restricting the sample to years prior to 1996 and to cities gaining Title 1 status under the original rules. This specification identifies the effect of Title 1 status by comparing the initial Title 1 cities to the cities that obtained Title 1 status later. The Title 1 coefficient in column 5 is statistically insignificant with a point estimate of the effect of Title 1 on logged HIV/AIDS death rates of -0.008. This result is consistent with Title 1 status having a negligible impact prior to effective treatment emerging, though it is important to note that this estimate is also consistent with the effect of Title 1 status growing with Title 1 duration.

Table 3 assesses the robustness of the estimates from specifications 1 and 2 of Table 2 to various alternative specifications. Specifications 1 and 2 of Panel A of Table 3 show the baseline estimates. The remaining specifications in Panel A supplement Equation (1) with additional controls. Specifications 3 and 4 supplement Equation (1) with controls for city-level unemployment rates since economic conditions have been shown to be related to health and also affect health insurance access (Ruhm 2000). Specifications 5 and 6 control for same-sex marriage being legal in the state since same-sex marriage is associated with increased health insurance and health care access for gay men (Carpenter et al. 2021). Specifications 7 and 8 supplement Equation (1) with year-by-Census-region fixed effects to account for the possibility of region-specific trends in HIV/AIDS deaths that are correlated with Title 1 status. The estimates across these additional specifications are similar to the main estimates.

Prior to 2014, one of the few options for people with HIV/AIDS to obtain non-employer-based health insurance was through the disability insurance system after AIDS had resulted in them being unable to work. In most states, people who qualify for Supplemental Security Income (SSI) are automatically eligible for Medicaid. Approximately 15 states, however, require people to fill out separate applications for Medicaid and SSI, which has the potential to lead to differential Medicaid access across states for people disabled because of HIV/AIDS (Lakdawalla et al. 2006). Though there is little variation in these rules over time, these rules could still be a threat to this study's empirical approach if they are correlated with Title 1 status and if they have an effect on HIV/AIDS death rates that varies over time. Reassuringly for the validity of the baseline specification, an equal number of treatment and control cities have separate application processes at 7 for each set of cities, but to assess the relevance of potential differential trends related to Medicaid application rules for the analysis, I supplement Equation (1) with controls for the interaction of year indicator variables with an indicator variable equal to one for cities in states with separate SSI and Medicaid applications. The estimated effect of Title 1 status varying dramatically with the addition of these controls

would suggest that trends related to Medicaid application rules for low-income disabled people hinder the empirical strategy. The results from including these additional controls are shown in specifications 9 and 10 of Table 3 and are similar to the baseline estimates.

Specifications 11 and 12 supplement the baseline specifications with an indicator variable for cities being in states that allow low-income, non-disabled childless adults to be on Medicaid. Most of the variation in this measure starts in 2014 after the ACA expanded Medicaid, but the measure also incorporates the few states that expanded Medicaid eligibility prior to the ACA.[19] The results in specifications 11 and 12 do not change dramatically when this control is included, which suggests that the estimated effect of Title 1 status on HIV/AIDS deaths is not spuriously driven by differential Medicaid access across cities in the sample.

Panel B of Table 3 assesses the robustness of the results to alternative dependent variables. Columns 1 and 2 of Panel B of Table 3 show estimated effects on the log of age-adjusted HIV/AIDS mortality rates per 100,000 people calculated using the 2000 age distribution from the SEER data. Columns 3 and 4 use the log of HIV/AIDS deaths as the dependent variable instead of the log of HIV/AIDS death rates per 100,000 people. As long as major population changes correlated with Title 1 status have not occurred, the estimates should be similar regardless of whether the dependent variable is based on rates or counts. The estimates in columns 1 through 4 of Table 3 Panel B are similar to the baseline estimates.

Columns 5 and 6 of Table 3 Panel B show estimates of the impact of Title 1 status on non-HIV/AIDS deaths per 100,000 people. Title 1 status has the potential to increase or decrease non-HIV/AIDS deaths. By reducing HIV/AIDS deaths, Title 1 status could increase non-HIV/AIDS deaths since people not dying from HIV/AIDS will eventually die from other causes, but large amounts of funding to fight HIV/AIDS could also allow cities to spend money they would have spent on HIV/AIDS on other types of health initiatives. Similarly, Title 1 funds have the potential to build public health infrastructure that can be used more broadly. Despite these potential mechanisms for how Title 1 status could affect non-HIV/AIDS deaths, finding similarly sized effects on non-HIV/AIDS deaths would raise concerns about the validity of the empirical approach for identifying the impact of Title 1 status on HIV/AIDS outcomes. Figure 3 further considers the relationship between Title 1 status and non-HIV/AIDS death rates by displaying estimated effects of Title 1 status on each of the five leading causes of death in the United States, which are cardiovascular disease, cancer, accidents, chronic lower respiratory disease, and cerebrovascular disease, as well as on suicide rates. The estimates displayed in columns 5 and 6 of Table 3 Panel B and in Figure 3 do not indicate that Title 1 status is associated with large changes in non-HIV/AIDS death rates.

[19] Information on the timing of state adoption of the ACA's Medicaid expansion comes from the Kaiser Family Foundation website. The list of states with pre-ACA Medicaid eligibility for childless, non-disabled adults comes from McMorrow et al. (2017). The shares of observations from 1988 to 2018 with non-disabled childless adults being eligible for Medicaid is similar for treatment and control cities at 14% and 12%, respectively.

Appendix Table A.4 further assesses the robustness of the analysis by showing estimates from broadening and narrowing the set of cities included in the sample. Specifically, Appendix Table A.4 considers the robustness of the results to including the 20 and 30 cities on either side of the original threshold of AIDS cases for Title 1 eligibility through 1995 that were closest to the threshold. Appendix Table A.4 also assesses robustness to excluding the five cities that were closest to the original threshold on either side of the threshold, which removes from the sample the two cities that eventually qualified for Title 1 status under the new rules put in place in 1996. Appendix Table A.4 also shows estimates from a specification that limits the set of treated cities to those that obtained Title 1 status from 1994 to 1996 and excludes observations from 1994 to 1996, which ensures that none of the identifying variation for the Title 1 coefficient comes from comparisons between cities changing Title 1 status and Title 1 cities that have already gained Title 1 status.[20] Finally, Appendix Table A.4 shows results from a specification that includes all cities in the AIDS Public Information Data Set and supplements Equation (1) with state-by-year fixed effects. This specification identifies the effect of Title 1 status as how differences in HIV/AIDS death rates between Title 1 cities and non-Title-1 cities in the same state change after Title 1 cities obtain Title 1 status, which rules out the possibility that the estimated effect of Title 1 is spuriously driven by state-level policies. While the standard errors rise as fewer cities are included in the regressions, the point estimates of the effect of Title 1 status do not vary dramatically.

Appendix B further assesses the robustness of the baseline results by matching Title 1 cities to cities without Title 1 status based on observable characteristics. First, Appendix B uses the fact that the 2,000 case threshold in the original rules implicitly combined AIDS cases relative to the population and population size in determining Title 1 status. Larger cities could gain Title 1 status with a lower rate of 1995 AIDS cases per capita relative to smaller cities. Appendix B estimates one set of regressions that compares Title 1 cities to similarly sized cities and one set of regressions that compares Title 1 cities to cities with similar per-capita rates of AIDS cases ever reported. Appendix B also matches Title 1 cities to the non-Title-1 cities that were trending most similarly in terms of AIDS deaths and AIDS cases being reported in the year the Ryan White CARE Act was passed. Additionally, Appendix B uses inverse propensity scores to reweight comparison cities to more closely match Title 1 cities' baseline observables. The point estimates vary with these alternative approaches and precision suffers in some specifications, but the results are in line with the baseline estimates.

[20] As explained in de Chaisemartin and D'Haultfoeuille (2020), Callaway and Sant'Anna (2021), Goodman-Bacon (2021b), and Sun and Abraham (2020), models with two-way fixed effects can produce estimates of treatment effects that are biased towards zero when treatment timing varies across groups and when treatment effects evolve with treatment duration. As most of the treated cities in the sample obtained Title 1 status within a few years of each other, differential treatment timing is arguably unlikely to lead to major bias in this setting. The results in Appendix Table A.4 support this idea by showing that the estimated effects are similar when the set of treated cities is limited to cities that obtained Title 1 status within three years of each other and the years included in the regression exclude the few years when some but not all Title 1 cities have achieved Title 1 status.

Appendix Figure A.2 tests for differential trends in HIV/AIDS death rates from 1988 to 2006 among cities with fewer than 2,000 AIDS cases reported by March 31, 1995. Evidence of differential percent changes in HIV/AIDS death rates over time among cities not obtaining Title 1 eligibility under the original rules would raise concerns about the validity of the empirical approach used in this study. Appendix Figure A.2 shows one set of event-study coefficients from a regression that estimates changes over time in the difference in logged HIV/AIDS death rates between the 12 cities in the control group with the most AIDS cases by March 31, 1995, and the other 13 control cities. Appendix Figure A.2 also shows event-study coefficients from a second regression that estimates changes over time in the difference in logged HIV/AIDS death rates between the control cities and the 25 cities with the most AIDS cases reported by March 31, 1995, that were not included in the main sample. The analysis in Appendix Figure A.2 provides evidence that cities having reported more AIDS cases through 1995 is not associated with differential changes in HIV/AIDS death rates in percent terms from 1988 to 2006 among cities that did not meet the original threshold for Title 1 eligibility.

The analysis presented so far suggests that the large amounts of federal funding allocated to combat HIV/AIDS through Title 1 of the Ryan White CARE Act were transformative for the cities receiving the funds. Figure 4 provides descriptive evidence that supports this finding by showing how both Title 1 funding and reductions in HIV/AIDS death rates differ for cities that reached 2,000 AIDS cases by March 31, 1995, and for cities that did not. Graph A plots means of Title 1 funds received from 1996 to 2006 per AIDS case reported by March 31, 1995, for cities in the AIDS Public Information Data Set grouped based on their rank order in AIDS cases reported through 1995 relative to the original Title 1 threshold. While cities crossing the 2,000 case threshold by March 31, 1995, received roughly $22,500 in Title 1 funding per AIDS case reported through 1995, cities with fewer than 2,000 AIDS cases by March 31, 1995, received less than $900 in Title 1 funding per AIDS cases reported through 1995.

Graph B of Figure 4 plots the mean change in HIV/AIDS death rates from the year before Ryan White funding began to 2006 for the same grouping of cities. As the estimated effects from Table 2 suggest would be the case, cities that qualified for Title 1 status under the original Ryan White CARE Act rules experienced dramatically greater declines in HIV/AIDS death rates between 1990 and 2006 than the cities that did not. The average decrease in HIV/AIDS death rates from 1990 to 2006 is 60% for cities obtaining Title 1 status under the original rules and 36% for other cities. Graph C shows differences in HIV/AIDS death rates from 1990 to 2012 and from 1990 to 2018. Even with the broader changes in health care and health insurance occurring in recent years and even with subsequent changes to the Ryan White CARE Act to partially offset funding disparities put in place by the 1996 reauthorization, disparities in progress reducing HIV/AIDS

death rates between cities that qualified for Title 1 status under the original rules and those that did not still exist through 2018.[21]

Impacts of Title 1 by Sex, Age, and Race

The HIV/AIDS epidemic has had heterogeneous impacts across demographic groups. As Appendix Table A.3 indicates, males, prime-aged people, and Black people have accounted for disproportionate shares of HIV/AIDS deaths in the United States relative to their shares of deaths more broadly. Table 4 evaluates the implications of Title 1 by sex, age, and race.[22]

Columns 1 and 2 of Table 4 display estimated effects of Title 1 status separately for males and females, for different age groupings, and for Black people, White people, and people of other races. For these regressions, I compute HIV/AIDS death rates and controls separately for each demographic group. Because some of the groups have no HIV/AIDS deaths in some city-year combinations, I use the inverse hyperbolic sine transformation rather than the log transformation. Column 1 displays estimated effects using data from 1988 to 2006, while column 2 displays estimated effects using data from 1988 to 2018.

Panel A of Table 4 estimates separate effects for males and females, and Panel B estimates separate effects for people younger than 18, people 18 to 64, and people 65 or older. The estimates in columns 1 and 2 of these panels are statistically significantly different from 0 for males and for people ages 18 to 64. Likely in part because of the lower baseline HIV/AIDS death rates for non-prime-aged adults and for females, the estimates of the effects for females, people younger than 18, and people 65 and older are less precise than the estimates for males and people ages 18 to 64.

Panel C of Table 4 estimates separate effects for Black people, White people, and people of other races. Since Black people are less likely to have health insurance coverage and more likely to lack financial resources than White people, Title 1 status has the potential to have disproportionately large effects on Black HIV/AIDS death rates. However, given other hurdles that Black people often face in accessing care, such as lower levels of trust for doctors (Alsan and Wanamaker 2018), Title 1 also has the potential to have smaller impacts on Black people than on people of other races. The point estimates shown in Table 4 are larger

[21] As Figure 4 suggests, regression discontinuity and regression discontinuity difference-in-differences designs are alternative approaches for studying the impact of Title 1 status. The difference-in-differences approach employed in this study is preferred over these alternatives because of the staggered treatment timing and because cities just under the original threshold were more likely to eventually receive some Title 1 funding than other non-original-Title-1 cities were. I have explored the sensitivity of the HIV/AIDS death findings to using these alternative approaches. Estimates from regression discontinuity and regression discontinuity difference-in-differences tend to vary across modeling choices more than the estimates from difference-in-differences models do, but as would be expected based on Figure 4, estimates from the discontinuity-based research designs corroborate the findings from the difference-in-differences analysis. I later use a regression discontinuity design to analyze the effect of Title 1 on HIV measures since HIV data were not widely tracked prior to the 2000s and cannot be studied with the difference-in-differences design.

[22] The analysis in this section does not focus on sexual orientation for data availability reasons. However, note that HIV/AIDS disparities are much sharper still when sexual orientation is considered. For example, in 2016 the CDC estimated the lifetime risk of HIV infection for different sexual orientation, race, and sex groupings and found that, among the groups considered, White heterosexual men have the lowest lifetime risk of contracting HIV at less than 0.04% while Black gay men have the highest lifetime risk of contracting HIV at approximately 50%. Refer to "CDC: 1 in 2 Black Gay Men in US Will Be Diagnosed with HIV," which was written by Mike Stobbe and published by the *Associated Press* on February 23, 2016.

in magnitude for Black HIV/AIDS death rates than for White HIV/AIDS death rates, but the estimates indicate that Title 1 has decreased HIV/AIDS death rates for both groups.

To assess statistical significance of the differences in estimates between groups, I draw 1,000 bootstrap samples with replacement and then replicate the analysis in Table 4 with the bootstrap samples. A t-test based on these bootstrap estimates does not allow for rejecting the null hypothesis that the effect of Title 1 status on HIV/AIDS death rates for people ages 18 to 64 is the same in percent terms as the effect for people ages 65 and older (t-statistics of 0.2 for the column 1 estimates and 0.1 for the column 2 estimates). The evidence is stronger for a larger effect for people ages 18 to 64 than for people younger than 18 (t-statistics of 2.2 and 1.1) and for Black people than for White people (t-statistics of 1.8 and 0.6) and stronger still for a larger impact for men than for women (t-statistics of 2.0 and 2.4).

To assess the demographics of the HIV/AIDS deaths avoided by Title 1, I calculate the implied number of HIV/AIDS deaths avoided by Title 1 for each demographic group through 2018 assuming that the estimate in column 2 of Table 4 represents the effect of Title 1 status on the group's HIV/AIDS death rates in all Title 1 cities and then calculate each group's share of deaths avoided out of the total implied number of deaths avoided for the panel.[23] This calculation is an estimate of each group's share of HIV/AIDS deaths avoided by Title 1 through 2018. Column 3 of Table 4 displays these estimates and indicates that the majority of the HIV/AIDS deaths averted by Title 1 are male, ages 18 to 64, and Black, though the shares of avoided HIV/AIDS deaths for Black and White people are not statistically significantly distinguishable from each other.

Figure 5 plots how each group's estimated share of the total HIV/AIDS deaths avoided by Title 1 compares to the group's 2010 population share and to the group's share of all deaths occurring in the study period. The x-axis of graph A of Figure 5 indicates each group's share of the 2010 U.S. population. The x-axis of graph B of Figure 5 indicates each group's share of all 1988 to 2018 U.S. deaths. The y-axes in both graphs indicate each group's estimated share of the total HIV/AIDS deaths avoided by Title 1 from column 3 of Table 4. Each marker represents a different demographic group. If the HIV/AIDS deaths avoided from Title 1 were proportional to the U.S. population or to all U.S. deaths, markers would lie along each graph's 45-degree line. Figure 5 highlights that, relative to both the 2010 U.S. population and to all U.S. deaths occurring during the study period, the lives saved from Title 1 are disproportionately male, prime-aged, and Black.

[23]Note that my preferred approach for estimating the total number of HIV/AIDS deaths avoided by Title 1 of the Ryan White program, which I discuss later, accounts for the Title 1 funds received by the control group. The approach and calculations are summarized in Table 6.

The Impact of Title 1 Status on Rates of New AIDS Cases

Figure 6 shows duration-specific estimates of the effect of Title 1 status on three annual measures of rates of new AIDS cases: 1) AIDS cases by year reported to the CDC, 2) AIDS cases by diagnosis year in the AIDS Public Information Data Set, and 3) AIDS cases by diagnosis year in the data received directly from the CDC. AIDS cases reported to the CDC is the measure of AIDS cases used to administer the Ryan White program in the 1990s. Year reported and year diagnosed could differ if cities vary in their reporting efficiency, but the two measures are highly correlated in practice. As explained earlier, the first two measures match the original city definitions more closely than the third measure but are only available through 2002. Figure 6 and the subsequent analysis indicate that results are similar across all three measures for estimates that can be computed for each. As with the HIV/AIDS death rates, Figure 6 indicates that rates of new AIDS cases trend similarly for both the treated and untreated cities until the treated cities obtain Title 1 status. Once cities obtain Title 1 status, their rates of new AIDS cases fall relative to other cities.

Table 5 shows estimates of the average effect of Title 1 status on rates of new AIDS cases. Columns 1 and 2 show the estimated effect of Title 1 status using data on new AIDS cases diagnosed and reported from the AIDS Public Information Data Set. These specifications include data from years 1988 to 2002 for the 50 cities in the baseline sample. The next three columns show the estimated effect using the data on annual AIDS diagnoses received directly from the CDC. Column 3 displays an estimate from a specification that uses data from years 1988 to 2002 to show how the estimates from using the different measures compare when the analysis period is the same. The estimate in column 4 is from a specification that uses data from 1988 to 2006. The estimate in column 5 is from a specification that uses data from 1988 to 2018. The estimates in columns 1 through 5 of Table 5 are similar across specifications and indicate that Title 1 status reduced annual rates of new AIDS cases by an average of 0.227 to 0.271 log points.

These results imply that Title 1 funding led to large reductions in rates of new AIDS cases in the cities receiving the funds. Figure 7 shows how AIDS diagnosis and prevalence rates have changed since the year the Ryan White CARE Act was passed for cities grouped by rank order in AIDS cases reported through the end of 1995 relative to the original threshold for Title 1 eligibility. Graphs A and B show diagnosis rates and mirror the equivalent analysis for HIV/AIDS death rates in Figure 4. From 1990 to 2006, AIDS diagnosis rates fell by 46% in cities that qualified for Title 1 status under the original Ryan White CARE Act rules and by 16% in cities that had fewer than 2,000 AIDS cases reported by the end of the eligibility window for the original rules.

The reductions in HIV/AIDS death rates along with continued spread of HIV have led to the number of people with HIV growing each year in the United States. Even with effective treatment lowering the

likelihood that HIV leads to AIDS over time, the number of people alive who have ever been diagnosed as having AIDS (indicated as AIDS prevalence in Figure 7) has also risen over time. In 2018, the United States had its highest number of people alive who have had ever had AIDS up to that point. From 1990 to 2006, the share of the U.S. population that had ever been diagnosed as having AIDS increased more than four-fold. As shown in Graph C of Figure 7, however, growth in AIDS prevalence was much lower for cities that qualified for Title 1 status under the original Ryan White rules. In contrast to Title 1 cities, which experienced a 315% increase in AIDS prevalence on average through 2006, non-Title 1 cities experienced a 470% increase in AIDS prevalence through 2006. The differential changes in AIDS prevalence continue through 2012 and 2018 as well.

Spending per Live Saved, Total Lives Saved, and Cost-Benefit Analysis

I now further assess the implications of the estimated impact of Ryan White's city-level funding by calculating the implied cost to avoid an HIV/AIDS death and the implied number of lives saved by Title 1. Table 6 summarizes the analysis.

Using the coefficient estimate from column 2 of Table 2, I first estimate the number of lives saved for each treated city in the sample from 1991 to 2018. I then sum those annual city-level estimates across years and cities to get an estimate of total lives saved across time for the treated cities in the sample. The estimated number of lives saved by Title 1 status for the treated cities in the sample is 9,421. An alternative approach to estimating the number of lives saved for the treated cities in the sample is to allow the effect of Title 1 in Equation (1) to vary with the duration that each city received Title 1 funds and then to use these duration-specific estimates to calculate the number of lives saved. Calculating lives saved with duration-specific estimates implies that Title 1 status saved 9,132 lives in the treated cities. Because the analysis with the duration-specific estimates is similar to the baseline analysis, I focus the remaining discussion on the estimate calculated using the average effect, but column 2 of Panel B of Table 6 displays calculations that use the duration-specific estimates.

Relative to cities that did not qualify for Title 1 status under the original eligibility rules, cities in the sample that qualified for Title 1 status under the original eligibility rules received an additional $3.15 billion in Title 1 funding through 2018. This difference in funding along with the estimated number of lives saved implies that Title 1 reduced one HIV/AIDS death for every $334,000 spent. This estimated spending per life saved applies to cities in the sample that received Title 1 funds and is not necessarily the same amount of Title 1 spending that would be required to avoid an HIV/AIDS death in non-Title-1 cities. However, given the arbitrariness of Title 1 status for cities in the baseline sample, the assumption that the impact of Title 1 funding on control cities would have been similar to the impact on the treatment cities is plausible. The

plausibility of this assumption is further supported by the graphical analysis in Figure 4 and by analysis in Appendix C that suggests that the effect of Title 1 status on cities gaining Title 1 status in 2007 is similar to the effect estimated in the baseline analysis after accounting for the differential pre-Title-1 trends for the 2007 Title 1 cities. The assumption that the marginal effect of Title 1 funding is the same as the average effect on the treatment cities allows for making two equivalent statements about Title 1 funding decisions that are relevant given debates about levels of HIV/AIDS funding. First, if the federal government valued the lives that could be saved by Title 1 at at least $334,000, it should have allocated more money through Title 1 than it did. Second, Title 1 funding levels from 1991 to 2018 implicitly value the lives that could be saved through Title 1 of the Ryan White CARE Act at $334,000 per life.

The estimated impact of Title 1 on HIV/AIDS death rates from the specification in Table 2 that includes data from all Title 1 cities is similar to the baseline estimate from the main analysis sample, which suggests that the treatment effect of Title 1 status does not vary widely for Title 1 cities in the baseline sample and for Title 1 cities not included in the baseline sample. Under the assumption that the effect of Title 1 is the same across Title 1 cities, the estimate of spending per life saved implies that the $19 billion allocated through Title 1 saved 56,728 lives through the end of 2018. This estimate implies that total HIV/AIDS deaths in the United States from 1991 to 2018 would have been 13% higher if not for Title 1 of the Ryan White CARE Act.

As noted above, the estimates from this study can be used to calculate the government's implied valuation of the lives that could be saved by Title 1 funding. However, to the extent that Title 1 funding levels have been set for idiosyncratic reasons, the estimates also allow for calculating the implied value of Title 1 spending under different assumptions about the value of a statistical life. Under the assumption that the value of a statistical life is $10 million, the estimates from this study imply that the $19 billion allocated through Title 1 of the Ryan White CARE Act through 2018 resulted in a value of $567 billion and had a benefit-cost ratio of 30.[24] Note that the only benefit from Title 1 included in this calculation is its reduction in HIV/AIDS deaths. As Title 1 reduces HIV/AIDS morbidity and likely improves the lives of people with HIV/AIDS in other ways, such as by reducing out-of-pocket costs, meaningful benefits are not reflected in this benefit-cost ratio.

As was previously discussed, the Title 2 funding rules include provisions that partially offset the Title 1 funding disparities. Specifically, the formula used to allocate part of Title 2 funds excludes HIV/AIDS cases from Title 1 cities, and the 2000 Ryan White reauthorization provides additional Title 2 funds to states with non-Title-1 cities that have high numbers of AIDS cases. If states direct less Title 2 funding to Title 1 cities in response to the effect of Title 1 funds on Title 2 funds, then the amount of federal spending required

[24]Estimates of the value of a statistical life vary widely. The value of a statistical life of $10 million is in line with recent evidence and with values of a statistical life used by federal agencies (Lee and Taylor 2019).

to avoid an HIV/AIDS death would be less than $334,000. To assess the scale of potential offset funds, I produce a rough estimate of the impact of a city receiving an additional dollar of Title 1 funding on state Title 2 funding. To produce this estimate, I first create a state-year level data set from 2000 to 2018 that contains information on each state's AIDS cases, Title 1 funding, and Title 2 funding. I then regress Title 2 funding on year fixed effects, each state's share of AIDS cases out of all AIDS cases each year, and the total Title 1 funding that cities in each state received each year. Because a state's share of AIDS cases is highly predictive of states' Title 2 funding absent a city in the state receiving Title 1 funding, the coefficient on Title 1 funding in this model is an estimate of the impact of a city receiving an additional dollar of Title 1 funding on the state's Title 2 funding, apart from the increase in Title 2 funding that the state would receive from the city's AIDS cases contributing to the state's AIDS burden.[25] The coefficient on Title 1 funds from this regression is $-\$0.23$. This coefficient indicates that while states receive additional Title 2 funds from an additional AIDS diagnosis in a Title 1 city, the additional amount they receive is 23% less than the amount they would have received had the person diagnosed with AIDS resided outside of a Title 1 city. If we assume that states redirect support away from Title 1 cities to completely offset the differential, then a dollar of Title 1 funds would effectively net the city $0.77 of additional Ryan White funds, which would imply that Title 1 avoided an HIV/AIDS death for every $257,000 spent in federal funding and that the benefit-cost ratio of Title 1 is 39.

The estimate of lives saved can be converted to life years saved. For this calculation, I use Social Security's actuarial life table for 2005. For each AIDS death from 1991 to 2018, I calculate the life years lost from an AIDS death as the life expectancy for people with the decedent's sex and age at death. I then multiply the average life years lost from an AIDS death each year by the estimate of AIDS deaths avoided by Title 1 each year. Assuming that people would have lived the full number of expected years in Social Security's life table if not for AIDS implies that an additional year through Title 1 funding cost $20,000 per life year through 2018. This calculation likely understates the cost per life year saved because people with HIV have shorter lives on average than people without HIV and because the Ryan White CARE Act targets people with low socioeconomic statuses, who also have below-average life expectancy. Assuming instead that

[25] In principle, if one had complete information on all parameters used to determine Title 2 allocations, it would be possible to calculate the impact of Title 1 funds on Title 2 funds using the Title 2 allocation rules. However, because Title 2 has different categories of funds, numerous inputs, a mixture of formula and discretionary funding, changes to both formula structures and input definitions over time, and hold harmless provisions, the allocation of Title 2 funds is complex, and assessing the impact of an additional dollar of Title 1 funding on Title 2 funds through the allocation rules is challenging. For this reason, I opt to produce an empirical estimate of the offset rather than to attempt to collect data on Title 2 inputs and then calculate an estimate of the offset using the allocation rules. For a discussion of how Title 2's complex allocation rules complicate efforts to determine the exact impact of Title 1 funding on Title 2 funds using the allocation rules, refer to HRSA administrator Elizabeth Duke's 2006 Congressional testimony about double counting in the Ryan White CARE Act (U.S. Congress Senate Committee on Health, Education, Labor, and Pensions 2006).

each decedent would have lived an additional ten years at most would imply that Title 1 of the Ryan White CARE Act has saved a life year for every $37,000 and has saved over half a million life years in total.[26]

This estimate can be compared to the cost of an additional life year through other programs. One relevant comparison is the cost of a life year through Medicaid providing antiretroviral therapy to a person with AIDS. Using Medicaid claims data from California, Duggan and Evans (2008) estimated that the cost to the California Medicaid program in 2001 of an additional life year from covering antiretroviral therapy for someone with AIDS was approximately $31,000 (in 2018 dollars). Thus, even with Ryan White funds also going towards services in addition to anti-retrovirals, the cost of Title 1 funding per additional life year through Ryan White is similar to the cost through Medicaid paying for anti-retrovirals.[27] Moreover, while understanding the cost per life year from a pharmaceutical intervention is useful for knowing whether Medicaid should cover the intervention, it does not necessarily speak to the costs of combating HIV/AIDS by scaling up Medicaid since Medicaid does not target specific health issues. Miller, Johnson, and Wherry (2021) find that the ACA's Medicaid expansion saved 4,800 lives per year among a vulnerable population of adults in the first four years after the expansion, which is an important finding, particularly given the contentiousness of the ACA's Medicaid expansion and because such a large share of the U.S. population has health insurance through Medicaid. However, comparing the number of lives saved to the total cost of expanded Medicaid coverage in 2018 of $74.2 billion (CMS 2021) implies a cost per life saved through Medicaid that is over 40 times the cost per life from Ryan White. Ryan White funds are productive when compared to other health care programs as well. The cost per life year through Ryan White is near to but lower than the cost per life year through Community Health Centers of $59,000, while the cost of a life year through Medicare is 5 to 14 times the cost through Ryan White (Bailey and Goodman-Bacon 2015; Chay, Kim, and Swaminathan 2011).

[26]The additional life expectancy from an HIV/AIDS death avoided varies over time, by consistency of treatment, and when in the course of the disease people begin treatment. Using 2000-2003 data, Marcus et al. (2020) estimate an increase in life expectancy of roughly 25 years for a 21-year-old beginning treatment immediately after contracting HIV, while Duggan and Evans (2008) estimate an increased life expectancy of approximately five years using slightly earlier data on people who received treatment after developing AIDS. Given that the Ryan White program supported people at various stages of HIV and across different time periods, the number of additional years of life gained from an HIV/AIDS death avoided from Ryan White is likely between the estimates of these two studies. Assuming ten additional years at most is arguably conservative since the empirical approach used in this study would not count an HIV/AIDS death that was delayed until later in the sample period as an HIV/AIDS death avoided, which indicates that the people whose deaths were avoided either died of something other than HIV/AIDS or were still alive through 2018.

[27]Making an apples-to-apples comparison with Duggan and Evans (2008) is difficult because the estimates differ in meaningful ways. One difference is that the estimated impact of Ryan White funds presented in this paper captures the net effect of treating a person with HIV/AIDS on city-level HIV/AIDS outcomes, including any spillovers through altered HIV spread. In contrast, Duggan and Evans calculate the net increase in Medicaid's expenditures for the treated individual from paying for the individual's antiretroviral therapy. Another difference is that, unlike the estimates presented in this paper, the estimates of Duggan and Evans consider treatment for people with HIV who had already developed AIDS. Additionally, the cost for an additional life year that I calculate assumes that all lives saved by the Ryan White program would have ended immediately in 2019 if Ryan White funding were taken away. For reasons discussed in this paper, the effects of HIV/AIDS funding are likely to persist after funding differences are eliminated.

Spillovers and HIV Transmission

Federal HIV/AIDS funding has the potential to have spillover impacts on people without HIV by affecting the spread of HIV. The HIV National Strategic Plan advocates "treatment as prevention" as a key tool for halting the spread of HIV (U.S. Department of Health and Human Services 2021), arguing that ensuring that HIV-positive people receive treatment can reduce the spread of HIV since the antiretrovirals that are a part of treatment plans lower HIV's transmissibility. Some evidence supports there being positive spillovers of treating HIV-positive people. For example, Chan et al. (2016) develop a framework to measure the value of medical innovations to combat infectious diseases and apply the framework to antiretroviral treatment for HIV. They find that providing antiretrovirals to people with HIV reduces the spread of HIV. At the same time, increasing access to health care for HIV-positive people also has the potential to harm people without HIV by increasing HIV's spread. As Lakdawalla et al. (2006) argue, a potential downside of providing life-saving treatment to people with HIV is that, by leading to more people with HIV being alive, providing treatment to people with HIV has the potential to have large negative impacts on people without HIV by increasing their likelihood of contracting HIV. The empirical and normative analysis of Lakdawalla et al. suggest that providing treatment to people with AIDS increases the prevalence of AIDS and reduces overall welfare. These findings are at odds with HIV treatment preventing the spread of HIV in practice and indicate that a social planner might not even provide treatment to people with HIV at all, let alone view treating people with HIV as a prevention strategy.

The difference-in-differences analysis presented in this paper does not directly assess the impact of Title 1 status on the spread of HIV because the CDC only began systematically collecting HIV data from across the nation in 2008, which precludes estimating the impact of Title 1 on the spread of HIV using data on HIV transmission rates from when cities originally obtained Title 1 status. I now outline and implement an approach for examining the impact of Title 1 status on HIV transmission rates using CDC data on the number of people living with HIV in 2008.

If there is no net migration of people with HIV across cities, cities' number of residents living with HIV in any given year can be expressed as a function of a prior HIV stock and of HIV transmission and death rates in the intervening years. Ryan White funds can affect both HIV transmission rates and HIV/AIDS death rates. Consider the following equation:

$$Num\_HIV_t = Num\_HIV_{t-x} * [1 + (1 + p) * trans - (1 + q) * death]^x, \tag{2}$$

where t indexes the current year, x is the number of years since the base year $t-x$, Num_HIV_t is the number

of people living with HIV in the city in year t, $trans > 0$ is the annual rate of new HIV transmissions relative to the existing HIV population, $death > 0$ is the share of people with HIV who die each year, p is the impact of Title 1 funds on HIV transmission rates, and q is the impact of Title 1 on the share of people with HIV who die each year. For ease of exposition, HIV transmission rates ($trans$) and death rates ($death$) absent Title 1 are modeled as being constant over time. In practice, these baseline rates have varied over time. The p parameter includes Ryan White's effect on the transmissibility of HIV through increasing treatment as well as the effects of any behavioral responses to the Ryan White program and could be positive or negative. The earlier analysis of the impact of Title 1 on HIV/AIDS death rates indicates that Title 1 reduces cities' numbers of HIV/AIDS deaths, or that $q < 0$.

The Ryan White program leading to additional HIV transmissions would indicate that it has negative spillovers on people without HIV and could occur through two channels. First, the Ryan White program could lead to behavioral responses that increase HIV transmission rates conditional on the stock of people living with HIV being held constant (i.e., by $p > 0$). Second, even if Title 1 reduces HIV transmission rates relative to the stock of HIV positive people, it could still lead to additional HIV transmissions if people with HIV whose deaths were avoided from Title 1 infect enough additional people with HIV to offset Ryan White's reduction in the transmissibility of HIV through treatment. Because of this second channel, $p < 0$ is not enough for Title 1 to have beneficial net spillovers. Instead, Title 1 must reduce HIV transmissions by enough to offset any increased HIV transmission from the HIV/AIDS deaths it avoids.

Determining the effect of Title 1 on the number of people with HIV can help assess spillovers from Title 1. Title 1's reduction in HIV/AIDS death rates means that Title 1 will reduce the number of people with HIV only if it leads to fewer HIV transmissions. Taking logs of Equation (2) allows for deriving a formula for the effect of Title 1 status on the log of the number of people living with HIV that is independent of HIV stocks in the base year:

$$\begin{aligned}\gamma =& log(Num\_HIV_t^{\textit{Title 1}}) - log(Num\_HIV_t^{\textit{No Title 1}}) \\ =& x * log\Big[\frac{1 + (1+p) * trans - (1+q) * death}{1 + trans - death}\Big],\end{aligned} \tag{3}$$

where $Num\_HIV_t^{\textit{Title 1}}$ is a Title 1 city's number of people living with HIV after x years of Title 1 status and $Num\_HIV_t^{\textit{No Title 1}}$ is the number of people living with HIV the city would have had in year t if the city had not received Title 1 status. As Equation (3) indicates, the percent impact of Title 1 status on cities' number of people living with HIV is equal to the compounded net effect of Ryan White on HIV transmission rates and HIV/AIDS death rates.

Graph A of Figure 8 plots the log of cities' numbers of people living with HIV in 2008 relative to the

log of cities' 1995 AIDS cases. Since 1995 AIDS cases ever reported would presumably have been positively correlated with 1995 HIV cases and thus with 2008 HIV cases, we would expect 2008 HIV cases to increase with 1995 AIDS cases reported, which Graph A indicates is the case. The log of cities' numbers of people living with HIV in 2008 increases linearly with the log of AIDS cases ever reported by 1995 until reaching the log of 2,000 AIDS cases ever reported by March 31 of 1995, at which point the log of 2008 HIV cases appears to gap down before continuing to increase linearly again.

This discontinuity provides an estimate of the local effect of having received Title 1 status by 1995 on cities' 2008 HIV cases under the assumption that 2008 HIV cases would have trended smoothly with 1995 AIDS cases if not for the discontinuous increase in HIV/AIDS funding for cities reporting 2,000 AIDS cases by 1995. I am aware of no other change occurring at the log of 2,000 AIDS cases reported by 1995. Given that the log of 2008 HIV cases trends smoothly elsewhere in the distribution, the assumption of no discontinuity at the log of 2,000 AIDS cases reported by 1995 if not for Ryan White is plausible. The two cities just under 2,000 AIDS cases ever reported by 1995 gaining Title 1 status in 1999 have the potential to cause the estimated effect of Title 1 status from this approach to be biased towards zero. To estimate the size of the discontinuity, I focus on the 46 cities from the main sample with non-missing HIV information in 2008 and estimate the following equation:

$$log(Num\_HIV_{j,\,2008}) = \lambda + f(AIDS\_Cases_{j,\,1995}) + Title1_j\gamma + \eta_j, \tag{4}$$

where λ is a constant and $f(AIDS\_Cases_{1995})$ is a smooth function of AIDS cases ever reported by March 31 of 1995. I model f as a linear polynomial of the log of AIDS cases reported by 1995 on either side of the cutoff. The coefficient on γ from estimating Equation (4) is -0.510 (SE: 0.152; p-value: 0.002), which translates to Title 1 reducing HIV populations for cities at the threshold by 40.0% by 2008. This estimate indicates that a city receiving Title 1 status in the 1990s reduced the city's number of people living with HIV in 2008, which means that Ryan White has positive spillovers on people without HIV by reducing HIV transmissions. This estimate is of the effect of Title 1 status on the marginal cities, which may differ from the average effect of Title 1, but assuming this estimated reduction in HIV cases applies to all Title 1 cities would indicate that Title 1 of the Ryan White program prevented over 350,000 transmissions of HIV through 2008.

A city's number of new HIV transmissions in 2008 is a product of its HIV case counts at the start of 2008 and its 2008 HIV transmission rate:

$$Num\_Trans_{2008} = Num\_HIV_{2008} * [1 + (1 + p) * trans]$$

To study the impact of Title 1 status on HIV transmission rates, I consider new HIV diagnoses, which proxy for new infections. Graph B of Figure 8 plots the log of cities' new HIV diagnoses in 2008 by the log of 1995 AIDS cases ever reported. The pattern is similar to the pattern in Graph A. New HIV diagnoses rise with 1995 AIDS cases ever reported but gap down at the 2,000 case threshold. The coefficient from estimating Equation (4) with the log of new HIV diagnoses in 2008 as the dependent variable is -0.628 (SE: 0.219; p-value: 0.006), which indicates that new HIV diagnoses were 46.6% lower in 2008 for the marginal Title 1 cities receiving Title 1 status under the original rules.

Knowing the impact of Title 1 on 2008 HIV stocks and 2008 infections allows for calculating the effect of Title 1 on HIV transmission rates, since Title 1's effect on the log of new HIV infections in 2008 ($\tau = -0.628$) can be expressed as follows:

$$\begin{aligned} \tau =& log(Num\_Trans_{2008}^{\textit{Title 1}}) - log(Num\_Trans_{2008}^{\textit{No Title 1}}) \\ =& \underbrace{\gamma}_{1} + \underbrace{log(1+p)}_{2}. \end{aligned} \tag{5}$$

Equation (5) decomposes the effect of Title 1 status on the number of 2008 HIV infections into two terms: 1) its effect from all transmissions avoided in the past leading to a smaller population being at risk of transmitting HIV in 2008 (term 1; $\gamma = -0.510$) and 2) its contemporaneous effect on the transmission rate in 2008 (term 2). Equation (5) and the estimates from Equation (4) indicate that approximately 81% of Title 1's reduction in new HIV diagnoses in 2008 came from Title 1 having led to lower stocks of people with HIV by 2008. This estimated effect of Title 1 on contemporaneous HIV transmission rates likely suffers more from attenuation bias from the additional cities gaining Title 1 status because of the 2006 reauthorization than the effect coming through the cumulative reduction in HIV stocks through 2008 does. Equation (5) implies that Title 1's effect on HIV transmission rates p in 2008 is -11%, though this estimate is imprecise with a bootstrapped 95% confidence interval of -32% to 10%.[28]

In summary, despite having clear benefits for people with HIV and having net positive impacts on cities' HIV/AIDS death rates and AIDS rates, Title 1 still could have had net negative spillovers on people without HIV by providing HIV-positive people more opportunities to spread HIV by leading to them living longer. Similarly, the Ryan White program reducing hardships from HIV could have led to behavioral responses from the uninfected that would have led to increases in HIV transmissions. These adverse effects of treating people with HIV would suggest that "treatment as prevention" is a misguided approach to reducing the

[28]Title 1 lowering the number of people living with HIV despite the magnitude of its impact on HIV transmissions being smaller in percent terms than its impact on HIV/AIDS deaths occurs because the annual base rates of HIV transmissions are larger than the base rates of HIV/AIDS deaths. The impact of Title 1 on HIV/AIDS death rates estimated in this study is equal to $\widetilde{\gamma} + log(1+q)$, where $\widetilde{\gamma}$ incorporates the fact that an avoided HIV case is not relevant for the number of HIV/AIDS deaths for at least ten years.

spread of HIV and might even support policies that purposefully limit access to HIV treatment. The analysis presented here, however, is not consistent with Title 1 status having harmful spillovers on HIV-negative people by increasing the spread of HIV. Instead, Title 1 of the Ryan White CARE Act appears to have had positive spillovers on HIV-negative people by reducing HIV transmissions.

5 Conclusion

HIV/AIDS has claimed over 700,000 lives in the United States and tens of millions of lives worldwide, and the U.S. federal government spends billions of dollars each year to treat HIV/AIDS. This paper examined the impact of federal funding to combat HIV/AIDS provided to cities through the largest federal program aimed at addressing HIV/AIDS in the United States. The results indicate that the federal funding allocated to cities has had large impacts on the cities receiving the funds. The estimates imply that Title 1 of the Ryan White CARE Act has saved approximately 57,000 lives as of 2018 and avoided one HIV/AIDS death for every $334,000 spent. This amount of spending to save a life is far less than typical estimates of the value of a statistical life. Assuming a value of a statistical life of $10 million, these estimates imply a benefit-cost ratio of 30. Given that the benefits in this calculation do not take into account the reduced morbidity from Title 1 or the fact that Title 1 funds have likely displaced other governmental payments and private payments for treatment, this estimate of the benefit-cost ratio is likely conservative. Analysis of 2008 HIV data showed that Title 1 led to cities having fewer people living with HIV. This finding indicates that the Ryan White program has had positive spillovers on people without HIV and supports the U.S. strategy of preventing the spread of HIV by increasing HIV-positive people's access to treatment.

The benefits from the Ryan White CARE Act are high relative to the program's costs, especially when compared to other government programs aimed at increasing health in the United States. The high value of the funding likely stems from three related factors. First, Ryan White beneficiaries have a deadly infection for which effective treatment is available. Unlike many other health care programs, the Ryan White program is a mechanism for targeting treatment to people with a high marginal benefit of additional health care on beneficiary's own health. Second, the nature of HIV and of HIV treatment leads to HIV treatment having large positive spillovers on people without HIV by preventing HIV transmissions. Third, the Ryan White CARE Act provides health care to people with low incomes who would otherwise have struggled to access care, since for most of the HIV/AIDS epidemic, the majority of HIV-positive people in the United States would not have been able to purchase insurance directly from an insurer and would not have been eligible for Medicaid or Medicare until they had become disabled.

In opting to address HIV/AIDS by allocating federal funds to support local responses rather than by establishing a federal entitlement program, Congress set up the Ryan White CARE Act as a place-based

funding mechanism. Place-based funding has advantages over other ways of structuring funding, including that the federal government can allocate funding to places most in need and that flexible funding can allow local officials to tailor the use of funds to their specific communities and to engage in proactive strategies. In part for these reasons, people often advocate for increasing the use of place-based funding and policies in a number of domains, including in health, education, economic development, and infrastructure (Shambaugh and Nunn 2018). This study provides evidence that allocating federal funding to local areas can have large health impacts. However, the results from this study also highlight the importance of funding rules and indicate that place-based funding can lead to disparities across places, especially if funding is allocated using sharp, arbitrary cutoffs. In the case of HIV/AIDS, many years of large funding disparities have resulted in divergent progress in combating HIV/AIDS across U.S. cities.

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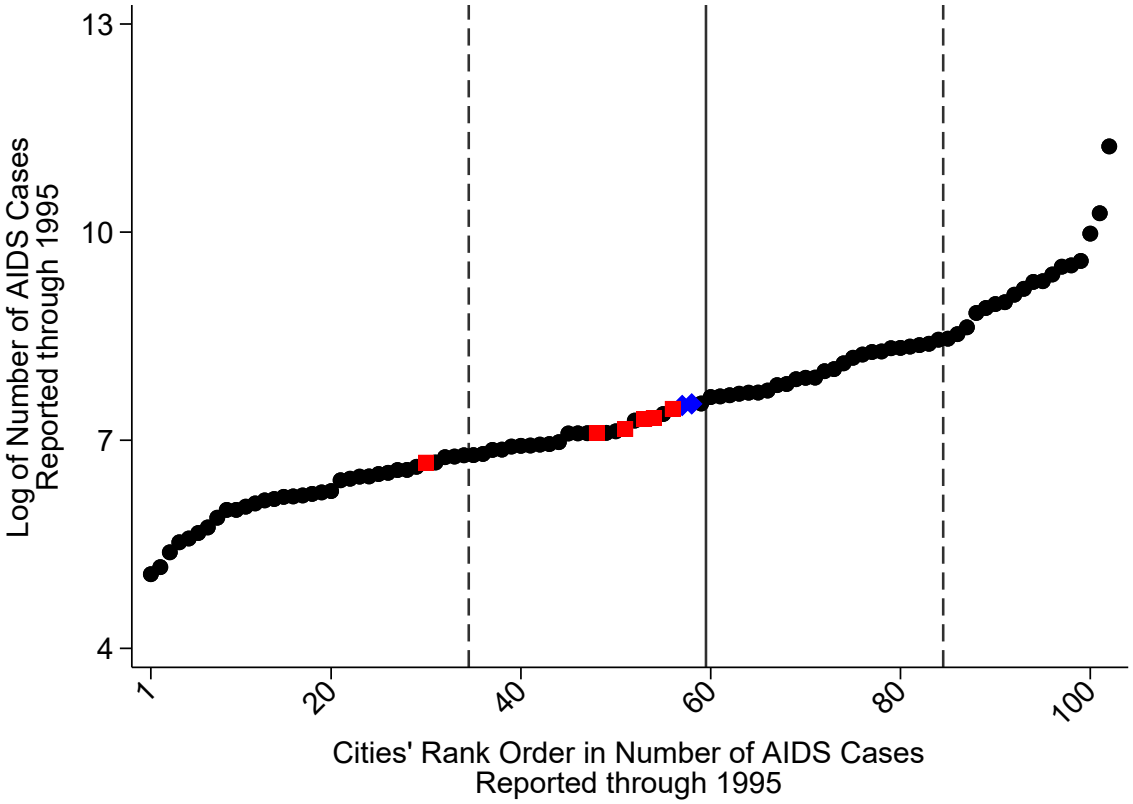
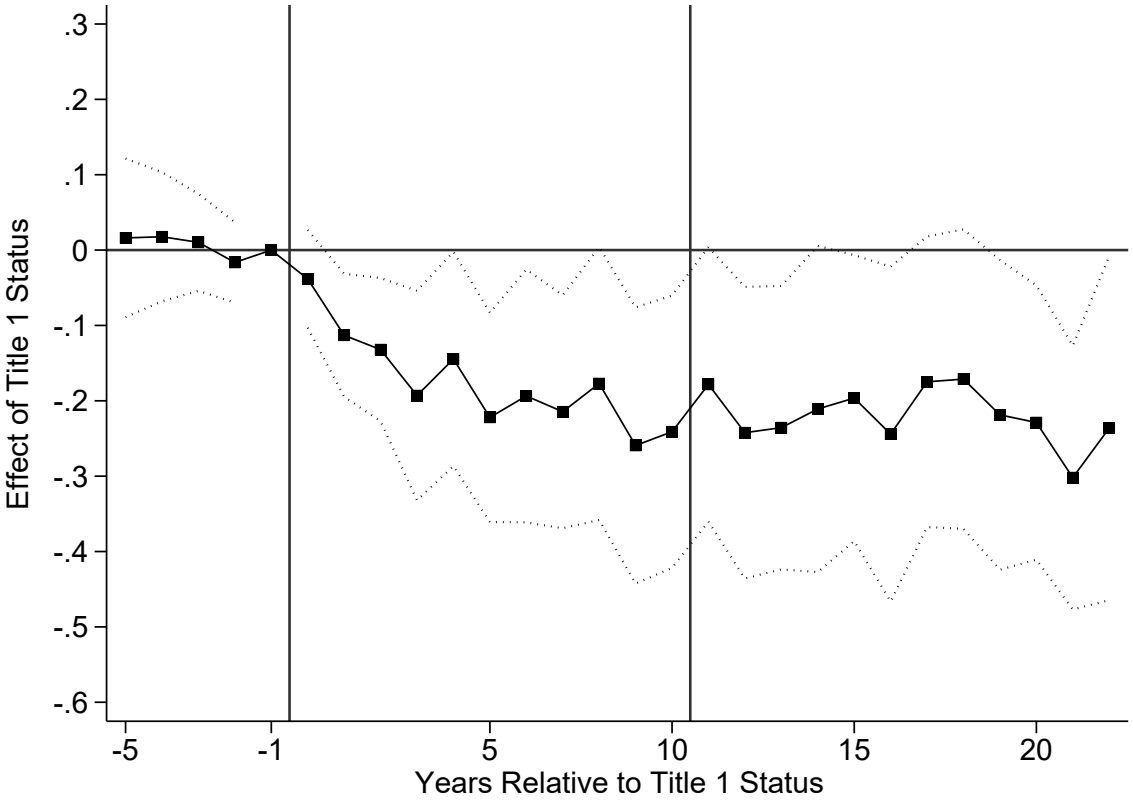
Figure 1: Cities' AIDS Cases by March 31, 1995



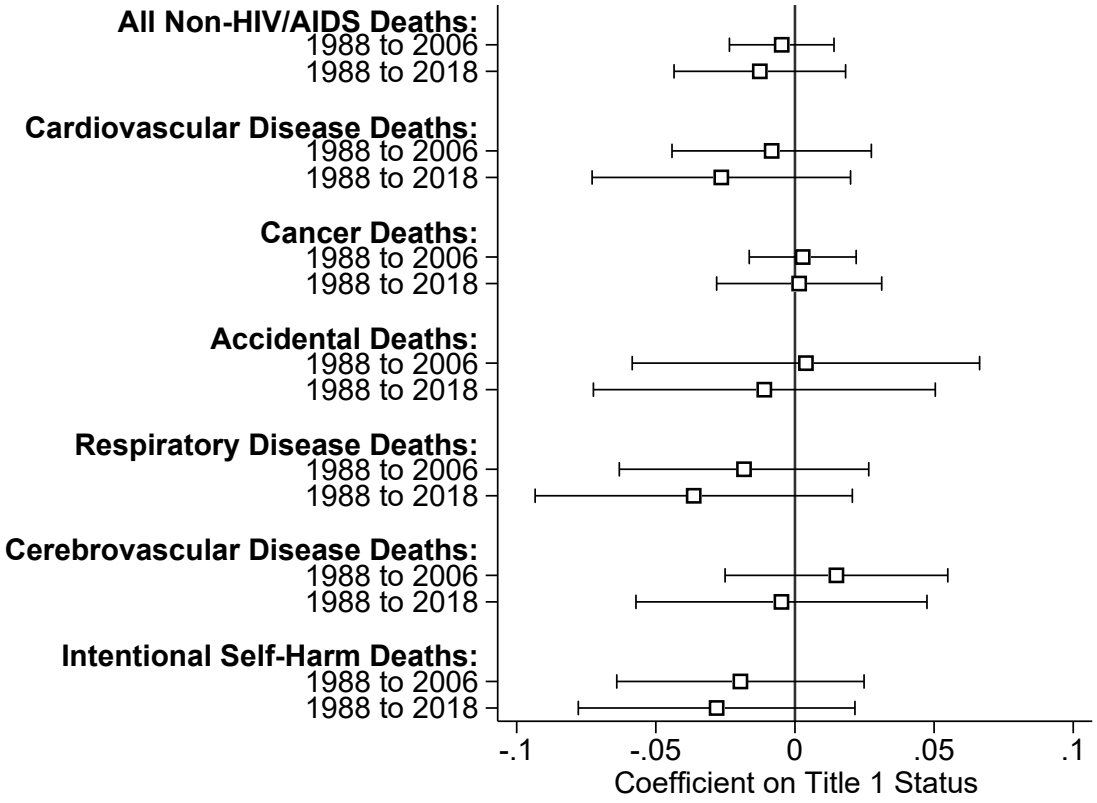
Notes: Each marker represents a separate city. The x-axis indicates cities' rank order in AIDS cases reported by March 31, 1995. The y-axis indicates the log of cities' AIDS cases reported by March 31, 1995. Cities to the right of the solid vertical line qualified for Title 1 status under the original rules for Title 1 eligibility. Cities to the left of the line did not. The blue diamonds represent cities that became eligible for Title 1 status under the rules put in place in 1996. The red squares represent cities that became eligible for Title 1 status under the rules put in place in 2007. Cities between the dashed lines are included in the main sample. Data on AIDS cases come from the AIDS Public Information Data Set.

Figure 2: Relationship between Title 1 Status and HIV/AIDS Death Rates



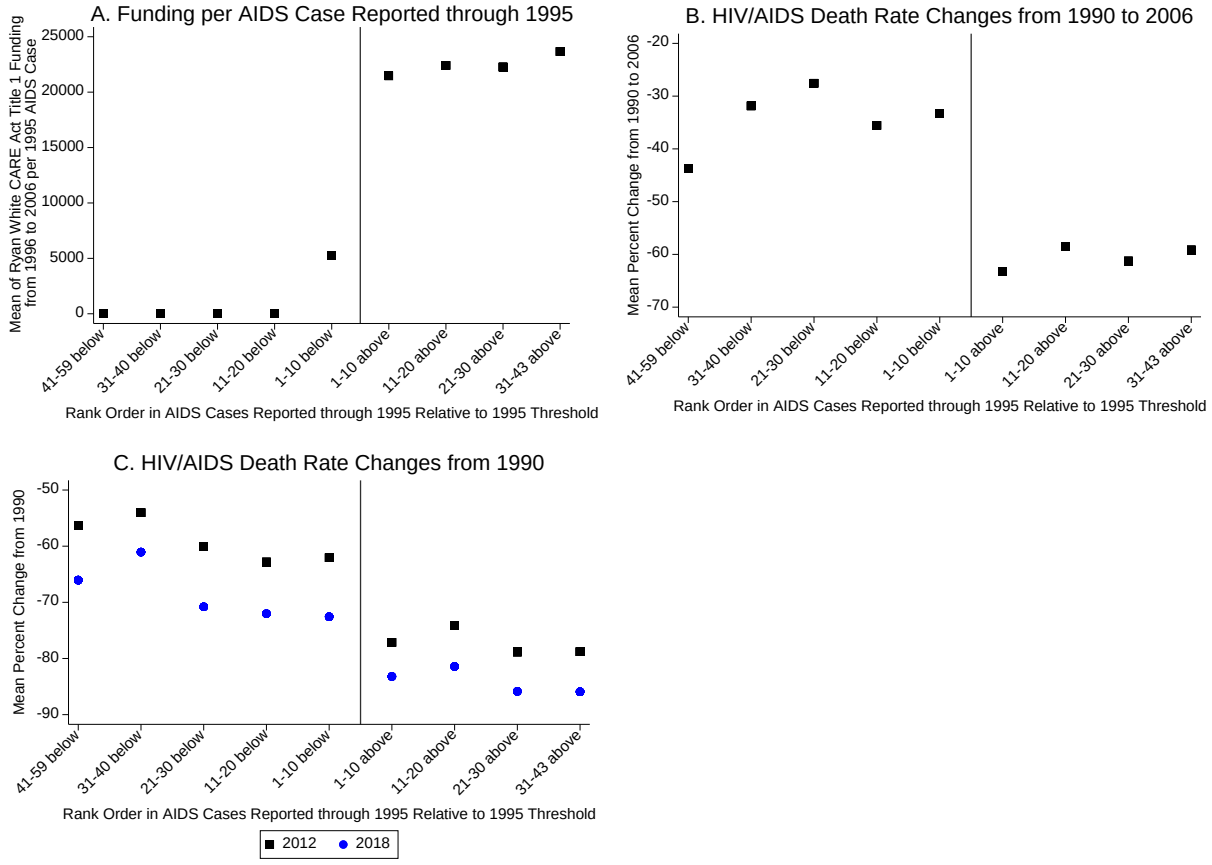
Notes: Each marker is a coefficient on Title 1 status interacted with number of years from initial Title 1 status eligibility from a single regression with the log of HIV/AIDS death rates as the dependent variable. The year before cities obtained Title 1 status is the omitted category. The x-axis indicates the number of years from Title 1 status. The y-axis indicates the coefficient estimate. The sample contains 850 observations from 50 cities from 1988 to 2018. The regression includes city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. The sample does not contain observations with event times of more than 5 years before or more than 22 years after initial eligibility for all treated cities in the sample. Bins for event times outside of this range are included in the regression as separate indicator variables for each year but are not reported. The dashed lines indicate 95% confidence intervals calculated using standard errors clustered by city. The first vertical line indicates the start of Title 1 status. The second vertical line indicates when in event time all treated cities' observations are beyond 2006.

Figure 3: Relationship between Title 1 Status and Non-HIV/AIDS Death Rates



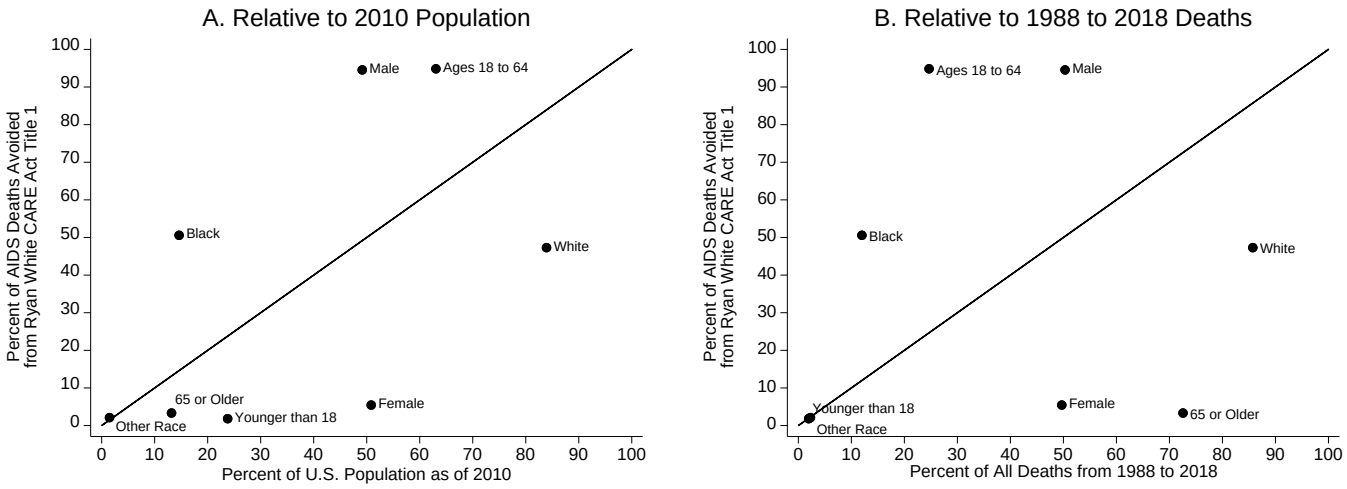
Notes: Each marker represents an estimate of the coefficient on Title 1 status from separate regressions of Equation (1) with the dependent variable being the log of deaths per 100,000 people for the indicated cause of death. The unit of observation in the regressions is a city and year combination. Numbers of deaths come from the Vital Statistics Mortality data. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. The sample includes 50 cities and contains 850 observations from 1988 to 2006 and 1,450 observations from 1988 to 2018. The graph displays 95% confidence intervals for each estimate calculated using standard errors clustered at the city level.

Figure 4: Title 1 Funding and Changes in HIV/AIDS Death Rates since 1990 by Cities' Rank Order in AIDS Cases Reported by March 31, 1995



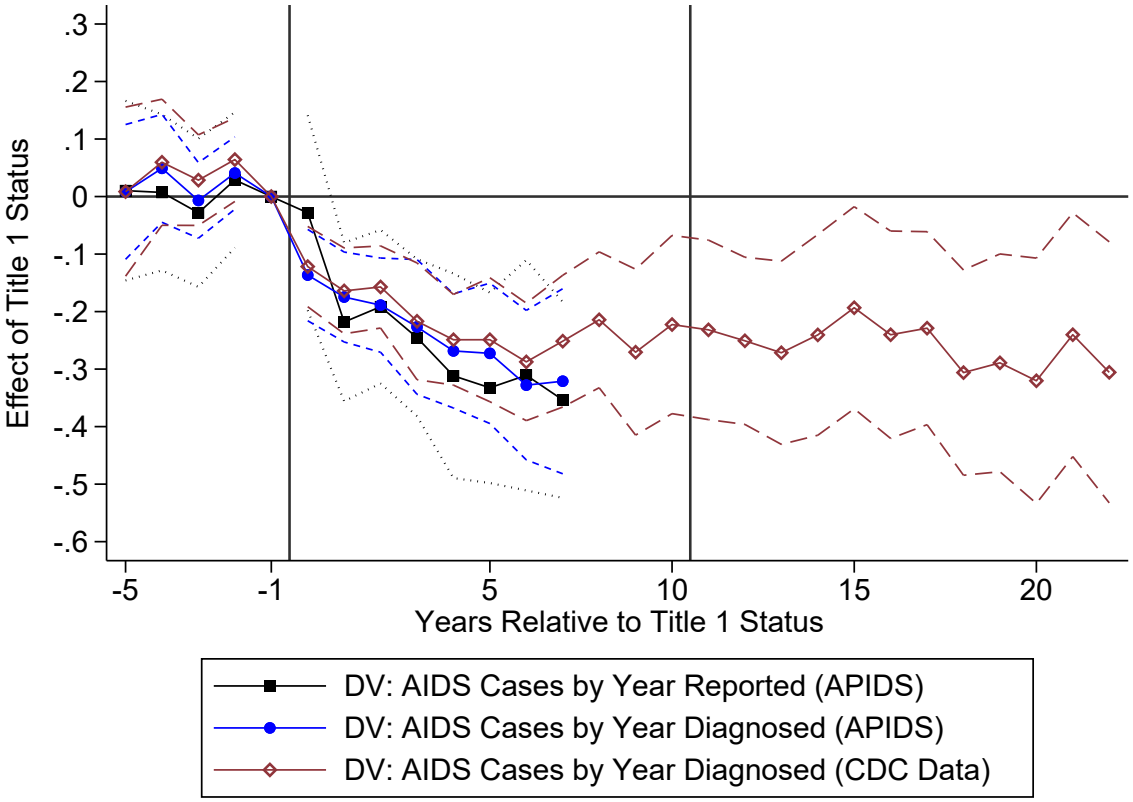
Notes: Each marker represents a set of cities grouped based on rank order in AIDS cases reported by March 31, 1995. The x-axes for all graphs indicate cities' rank order in AIDS cases reported by March 31, 1995, relative to the original threshold for Title 1 eligibility. The y-axis in graph A indicates mean Title 1 funding from 1996 to 2006 per AIDS case reported by March 31, 1995. The y-axes in graphs B and C indicate the mean percent change in HIV/AIDS death rates in the indicated year since 1990.

Figure 5: Demographics of AIDS Deaths Avoided from Ryan White Title 1 Funding Relative to Demographics of the 2010 U.S. Population and of All 1988 to 2018 U.S. Deaths



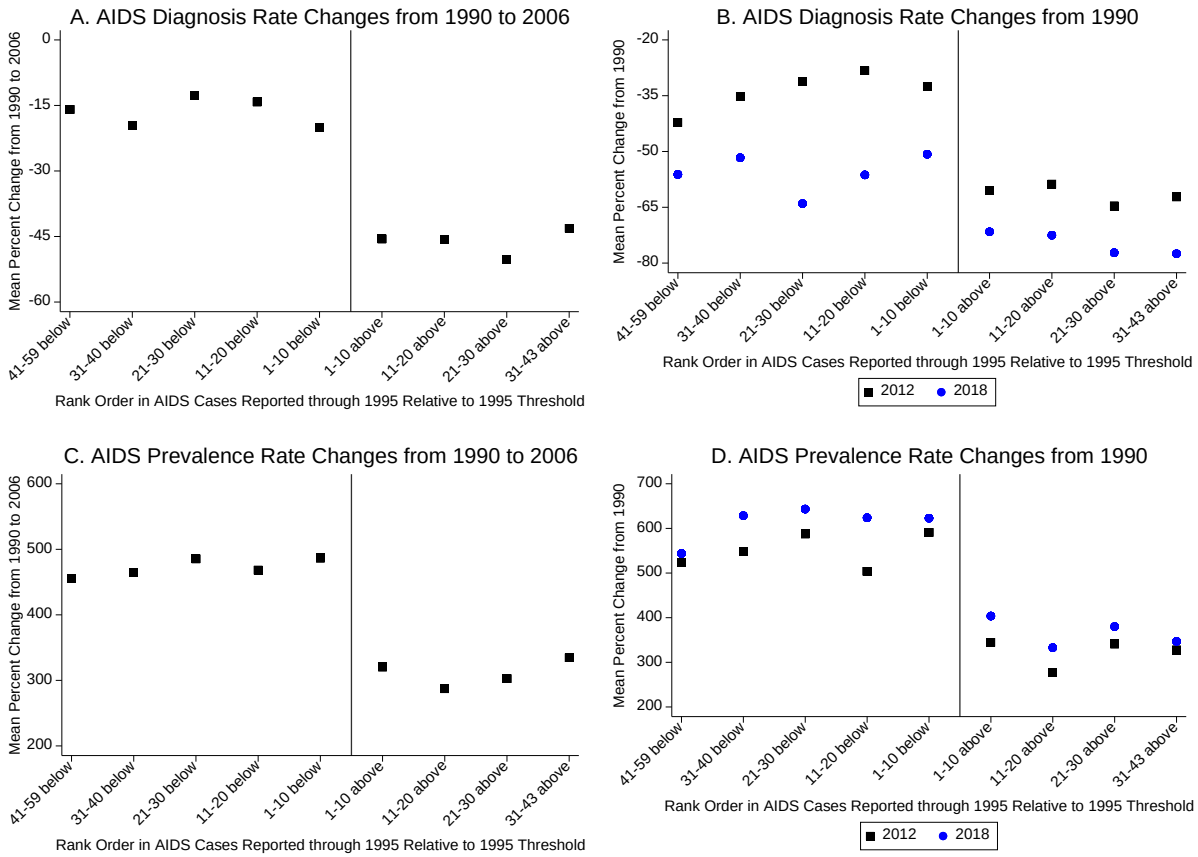
Notes: Each marker represents a demographic group. The x-axis in graph A indicates each group's share of the 2010 population calculated using SEER data. The x-axis in graph B indicates each group's share of all 1988 to 2018 deaths calculated using Vital Statistics Mortality data. The y-axes indicate the estimated share of AIDS deaths avoided from Ryan White Title 1 for each group through 2018. The 45-degree lines represent where each marker would be if the demographics of the AIDS deaths avoided from Ryan White Title 1 mirrored the demographics of the 2010 U.S. population or of all U.S. deaths from 1988 to 2018.

Figure 6: Relationship between Title 1 Status and Rates of New AIDS Cases



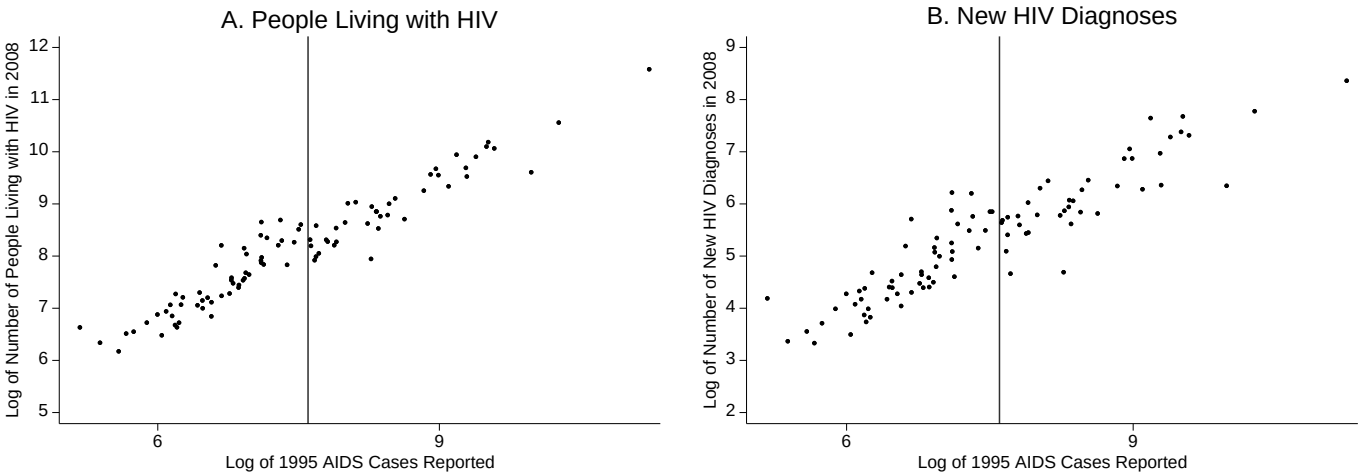
Notes: Each marker is a coefficient on Title 1 status interacted with number of years from initial Title 1 status eligibility. The year before cities obtained Title 1 status is the omitted category. The x-axis indicates the number of years from Title 1 status. The y-axis indicates the coefficient estimate. The black squares are from a single regression with the log of rates of new AIDS cases by year reported from the AIDS Public Information Data Set as the dependent variable. The blue circles are from a single regression with the log of rates of annual AIDS cases by year diagnosed from the AIDS Public Information Data Set as the dependent variable. The sample for these regressions contains 750 observations from 50 cities from 1988 to 2002. The maroon diamonds are from a single regression with the log of annual AIDS diagnosis rates from the CDC as the dependent variable. The sample contains 1,426 observations from 46 cities from 1988 to 2018. Each regression includes city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. The sample does not contain observations with event times outside of the ranges shown for all treatment cities. Bins for event times outside of those shown are included in the regression as separate indicator variables for each year but are not reported. The dashed lines indicate 95% confidence intervals calculated using standard errors clustered by city. The first vertical line indicates the start of Title 1 status. The second vertical line indicates when in event time all treated cities' observations are beyond 2006.

Figure 7: Changes in AIDS Diagnosis and Prevalence Rates since 1990 by Cities' Rank Order in AIDS Cases Reported by March 31, 1995



Notes: Each marker represents a set of cities grouped based on rank order in AIDS cases reported by March 31, 1995. The x-axes for all graphs indicate cities' rank order in AIDS cases reported by March 31, 1995, relative to the original threshold for Title 1 eligibility. The y-axes indicate mean percent changes in the indicated measure and year since 1990.

Figure 8: 2008 HIV Measures by AIDS Cases Reported by March 31, 1995



Notes: Each marker represents a separate city. The x-axes indicate the log of cities' AIDS cases reported by March 31, 1995. The y-axis of Graph A indicates the log of cities' numbers of people living with HIV in 2008. The y-axis of Graph B indicates the log of cities' numbers of new HIV diagnoses in 2008. The vertical line indicates the log of 2,000 AIDS cases reported by March 31, 1995. The HIV data come from the CDC and are non-missing for 96 of the cities in the AIDS Public Information Data Set.

Table 1: Characteristics of Control and Treatment Cities

	Fewer than 2,000 AIDS Cases Reported through March 31, 1995 (Control Cities)		More than 2,000 AIDS Cases Reported through March 31, 1995 (Treatment Cities)	
	Mean	St. Dev.	Mean	St. Dev.
Panel A. City-by-Year Level Data (n=1,550)				
Population Size	1,229,969	463,227	1,949,754	826,643
Fraction of Population Male	0.49	0.01	0.49	0.01
Fraction of Population Younger than 18	0.25	0.02	0.25	0.02
Fraction of Population 65 or Older	0.13	0.02	0.12	0.03
Fraction of Population White	0.79	0.10	0.81	0.08
Fraction of Population Black	0.18	0.11	0.12	0.07
Fraction of Population Hispanic	0.07	0.07	0.18	0.13
Panel B. City Level Observations (n=50)				
HIV/AIDS Deaths per 100,000 People Year before RWCA	7.3	2.6	12.0	7.8
Percent Increase in HIV/AIDS Death Rate Year before RWCA	17	29	17	11
Total Title 1 Dollars from 1991 to 1996	0	0	7,284,073	6,876,145
Total Title 1 Dollars from 1997 to 2006	3,852,918	13,346,971	68,864,959	22,426,453
Total Title 1 Dollars from 2006 to 2018	17,804,023	30,787,974	71,477,627	23,817,116
Total Title 1 Dollars through 2018	21,656,941	39,689,725	147,626,659	48,692,930

Notes: The control and treatment groups include 25 cities each. The descriptive statistics in panel A are for years 1988 to 2018.

Table 2: The Effect of Title 1 Status on HIV/AIDS Death Rates

	(1)	(2)	(3)	(4)	(5)
	-0.185	-0.163	-0.154	-0.196	-0.008
	(0.069)	(0.075)	(0.063)	(0.056)	(0.035)
	[0.010]	[0.036]	[0.018]	[0.001]	[0.828]
Years	1988-2006	1988-2018	1988-2018	1988-2018	1988-1995
Number of Cities	50	50	50	102	36
n	950	1,550	1,550	3,162	288
Mean of D.V. in Levels	8.7	6.3	5.3	6.6	21.0
Population Weights			x		

Notes: Each column displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable is the log of HIV/AIDS deaths per 100,000 people. Numbers of HIV/AIDS deaths each year come from the Vital Statistics Mortality data. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets.

Table 3: Alternative Specifications for Estimates of the Effect of Title 1 Status

Panel A. Dependent Variable: Log(HIV/AIDS Deaths per 100,000 People)						
	(1)	(2)	(3)	(4)	(5)	(6)
	-0.185	-0.163	-0.198	-0.173	-0.183	-0.163
	(0.069)	(0.075)	(0.070)	(0.074)	(0.069)	(0.076)
	[0.010]	[0.036]	[0.007]	[0.024]	[0.011]	[0.036]
Additional Controls	Baseline		Unemployment Rate		Same-Sex Marriage	
	(7)	(8)	(9)	(10)	(11)	(12)
	-0.189	-0.181	-0.179	-0.163	-0.188	-0.166
	(0.076)	(0.087)	(0.070)	(0.078)	(0.069)	(0.075)
	[0.016]	[0.042]	[0.014]	[0.040]	[0.009]	[0.031]
Additional Controls	Region-by-Year Effects		SSI/Medicaid-by-Year		Medicaid for Childless Adults	
Panel B. Alternative Dependent Variables (in Logs)						
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Age-Adjusted HIV/AIDS Deaths per 100,000 People		HIV/AIDS Deaths		Non-HIV/AIDS Deaths per 100,000 People	
	-0.187	-0.163	-0.197	-0.170	-0.005	-0.014
	(0.069)	(0.075)	(0.076)	(0.085)	(0.009)	(0.015)
	[0.009]	[0.035]	[0.012]	[0.052]	[0.613]	[0.363]
Years	1988-2006	1988-2018	1988-2006	1988-2018	1988-2006	1988-2018

Notes: Each cell displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable in Panel A is the log of HIV/AIDS deaths per 100,000 people. The dependent variables for the regressions in Panel B are indicated in the table. Numbers of deaths each year come from the Vital Statistics Mortality data. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. Additional controls are indicated in the table for the regressions in Panel A. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets.

Table 4: The Effect of Title 1 Status on HIV/AIDS Death Rates for Different Demographic Groups

	Mean HIV/AIDS Deaths per 100,000 People	(1)	(2)	Estimated Share of Deaths Avoided out of All Deaths Avoided (3)
Panel A. Sex				
Male	11.3	-0.189	-0.170	94%
		(0.067)	(0.072)	
		[0.007]	[0.023]	
Female	2.4	-0.083	-0.036	6%
		(0.071)	(0.081)	
		[0.251]	[0.660]	
Panel B. Age				
Younger than 18	0.3	-0.061	-0.086	2%
		(0.080)	(0.093)	
		[0.447]	[0.358]	
Ages 18 to 64	10.4	-0.180	-0.147	95%
		(0.064)	(0.072)	
		[0.007]	[0.045]	
65 or Older	1.8	-0.150	-0.110	3%
		(0.111)	(0.100)	
		[0.183]	[0.277]	
Panel C. Race				
Black	18.4	-0.234	-0.204	50%
		(0.073)	(0.073)	
		[0.002]	[0.008]	
White	5.1	-0.155	-0.180	48%
		(0.066)	(0.073)	
		[0.023]	[0.017]	
Other	1.1	-0.236	-0.245	2%
		(0.171)	(0.163)	
		[0.174]	[0.141]	
Years	1988-2018	1988-2006	1988-2018	1988-2018

Notes: Each cell in columns 1 and 2 displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable is the inverse hyperbolic sine of HIV/AIDS deaths per 100,000 people for each group. Numbers of HIV/AIDS deaths each year come from the Vital Statistics Mortality data. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents of each group who are Black, Hispanic, younger than 18, 65 and older, and male. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets. The sample for each regression contains 850 observations from 1988 to 2006 and 1,450 observations from 1988 to 2018.

Table 5: The Effect of Title 1 Status on Rates of New AIDS Cases

	(1)	(2)	(3)	(4)	(5)
	D.V.: AIDS Cases Reported	D.V.: AIDS Cases Diagnosed			
	-0.227	-0.233	-0.271	-0.254	-0.248
	(0.063)	(0.055)	(0.053)	(0.051)	(0.055)
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Source	AIDS Public Information Data Set	AIDS Public Information Data Set	CDC	CDC	CDC
Years	1988-2002	1988-2002	1988-2002	1988-2006	1988-2018
Number of Cities	50	50	46	46	46
Mean of D.V. in Levels	19.9	19.6	18.2	16.9	13.4
n	750	750	690	874	1,426

Notes: Each column displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable is the log of new AIDS cases reported or diagnosed per 100,000 people. Numbers of new AIDS cases by year reported and by year diagnosed come from the AIDS Public Information Data Set and from the CDC. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets.

Table 6: Comparing the Costs of Title 1 to Benefits from Lives Saved

Panel A. Title 1 Funding Information

Total Title 1 Funding Received by Treated Cities through 2018: $3.69 billion
Total Title 1 Funding Received by Comparison Cities through 2018: $0.54 billion
Additional Title 1 Funding Received by Treated Cities through 2018: $3.15 billion
Total Title 1 Funding through 2018: $18.96 billion

Panel B. Cost-Benefit Calculation

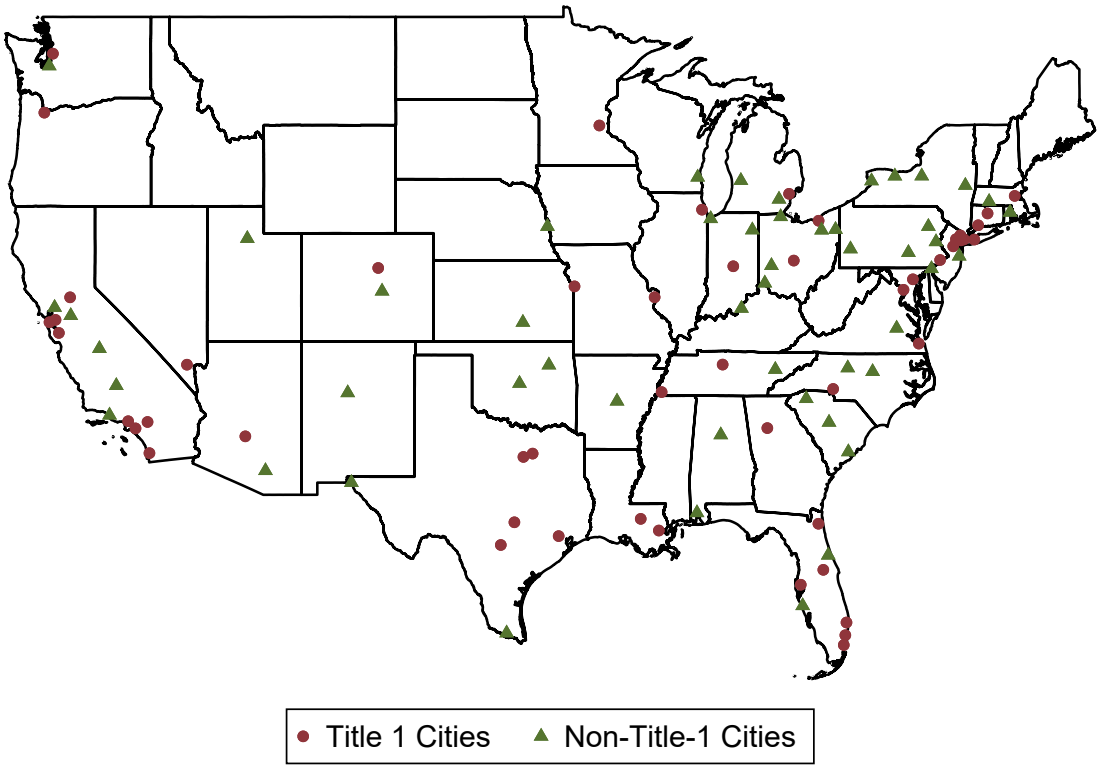
	(1) Single Title 1 Estimate	(2) Duration-Specific Title 1 Estimates
Estimated Lives Saved for Treated Cities in Sample	9,421	9,132
Title 1 Funding per Life Saved	$334,290	$344,847
Implied Total Lives Saved by All Title 1 Funding through 2018	56,728	54,991
Benefits from Title 1 for a Value of Statistical Life of $10 million	$567 billion	$550 billion
Benefit-Cost Ratio	30	29

Notes: Panel A summarizes basic Title 1 funding information. Column 1 of Panel B assesses the implications of the estimated impact of Title 1 from the baseline specification for years 1988 to 2018, while column 2 of Panel B assess the implications of estimates from a specification that allows the effect of Title 1 status to vary with the number of years that a city has had Title 1 status for years 1988 to 2018.

APPENDIX

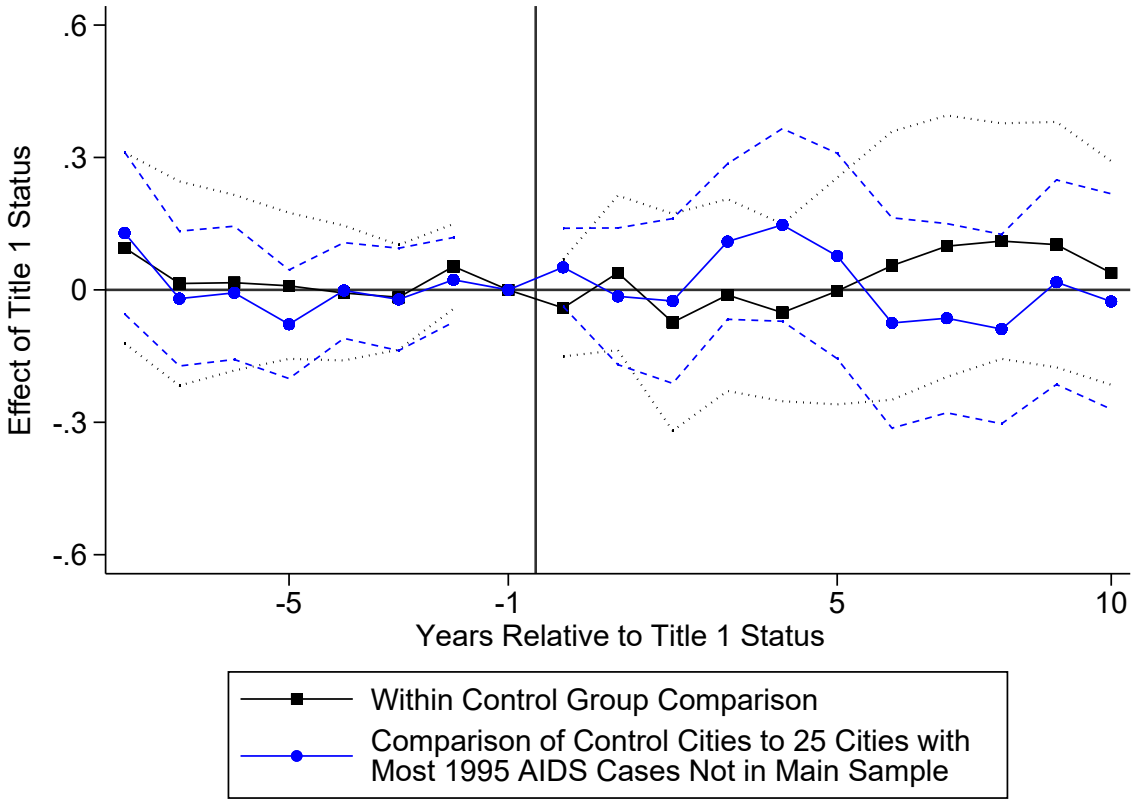
A Appendix Tables and Figures

Figure A.1: Cities in the AIDS Public Information Data Set



Notes: The graph shows Title 1 status as of 2018 for cities in the AIDS Public Information Data Set.

Figure A.2: Placebo Analysis of Differential Trends among Cities with Fewer than 2,000 AIDS Cases Reported through March 31, 1995



Notes: Each marker is a coefficient on a placebo treatment indicator variable interacted with number of years from 1995 from a regression with the log of HIV/AIDS death rates as the dependent variable. The interaction with the year 1995 is the omitted category. The x-axis indicates the number of years from 1995. The y-axis indicates the coefficient estimate. The black squares are from a single regression that includes the 425 observations from 1988 to 2006 from the main analysis sample's 25 control cities. The coefficients plotted are time indicator variables interacted with an indicator variable equal to one for the 12 cities in the sample with the most AIDS cases by March 31, 1995. The blue circles are from a single regression that includes the 850 observations from 1988 to 2006 from the 50 cities with the most AIDS cases by March 31, 1995, that did not qualify for Title 1 under the original Ryan White rules. The coefficients shown are time indicator variables interacted with an indicator variable equal to one for the 25 cities in the sample with the most March 31, 1995, AIDS cases. The regressions include city fixed effects and year fixed effects. The dashed lines indicate 95% confidence intervals calculated using standard errors clustered by city.

Table A.1: Percent of Title 1 Spending by Category in Fiscal Year 2010

Type of Care	Percentage
Outpatient Care and Pharmacy	35.2%
Case Management and Treatment Adherence	18.3%
Mental Health	5.8%
Substance Abuse Services	4.9%
Nutrition and Food Services	4.4%
Early Intervention and Outreach Services	4.2%
Other Medical Services	9.3%
Support Services	5.7%
Clinical Quality Management	3.2%
Administration Costs	9.1%

Notes: The data come from the Health Resources and Services Administration's 2010 Ryan White expenditure report.

Table A.2: Cities in the AIDS Public Information Data Set

City	AIDS Cases by Original Cutoff	Ranking	Main Sample	Year Title 1 Status Achieved
Akron, OH	312	7	no	
Albany-Schenectady, NY	1,001	39	yes	
Albuquerque, NM	651	24	no	
Allentown, PA	461	13	no	
Ann Arbor, MI	252	4	no	
Atlanta, GA	9,729	93	no	1991
Austin, TX	2,466	68	yes	1995
Bakersfield, CA	527	20	no	
Baltimore, MD	7,811	90	no	1992
Baton Rouge, LA	794	30	no	2007
Bergen-Passaic, NJ	3,602	75	yes	1994
Birmingham, AL	1,038	43	yes	
Boston, MA	8,938	92	no	1991
Buffalo, NY	883	34	no	
Charleston, SC	885	35	yes	
Charlotte, NC	1,216	48	yes	2007
Chicago, IL	13,385	97	no	1991
Cincinnati, OH	1,211	46	yes	
Cleveland, OH	2,044	60	yes	1996
Colorado Springs, CO	288	6	no	
Columbia, SC	1,012	40	yes	
Columbus, OH	1,512	54	yes	2013
Dallas, TX	8,020	91	no	1991
Dayton, OH	616	21	no	
Daytona Beach, FL	649	23	no	
Denver, CO	3,945	78	yes	1994
Detroit, MI	4,742	85	no	1993
El Paso, TX	488	16	no	
Fort Lauderdale, FL	7,380	89	no	1991
Fort Wayne, IN	159	1	no	
Fort Worth, TX	2,063	61	yes	1996
Fresno, CA	715	28	no	
Gary, IN	402	10	no	
Grand Rapids, MI	485	15	no	
Greensboro, NC	1,016	41	yes	
Greenville, SC	796	31	no	
Harrisburg, PA	517	19	no	
Hartford, CT	2,244	66	yes	1996
Houston, TX	11,965	96	no	1991
Indianapolis, IN	1,725	56	yes	2007
Jacksonville, FL	2,697	70	yes	1995
Jersey City, NJ	4,406	83	yes	1991
Kansas City, MO	2,705	71	yes	1994
Knoxville, TN	402	9	no	
Las Vegas, NV	1,810	57	yes	1999
Little Rock, AR	630	22	no	
Los Angeles, CA	28,912	101	no	1991
Louisville, KY	748	29	no	

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Table A.2 – continued

City	AIDS Cases Original Cutoff	Ranking	Baseline Sample	Year Title 1 Status Achieved
McAllen-Edinburg-Mission, TX	176	2	no	
Memphis, TN	1,490	53	yes	2007
Miami, FL	14,545	99	no	1991
New Brunswick, NJ	2,098	62	yes	1996
Milwaukee, WI	1,214	47	yes	
Minneapolis-St Paul, MN	2,180	65	yes	1996
Mobile, Al	674	25	no	
Ocean City, NJ	1,862	59	yes	
Nashville, TN	1,291	51	yes	2007
Nassau-Suffolk, NY	4,230	81	yes	1993
New Haven, CT	3,913	77	yes	1994
New Orleans, LA	4,132	79	yes	1993
New York, NY	75,781	102	no	1991
Newark, NJ	10,861	95	no	1991
Norfolk, VA	1,852	58	yes	1999
Oakland, CA	5,588	87	no	1992
Oklahoma City, OK	1,067	44	yes	
Omaha, NE	441	12	no	
Orange County, CA	3,773	76	yes	1993
Orlando, FL	3,324	74	yes	1994
Philadelphia, PA	10,750	94	no	1991
Phoenix, AZ	3,057	73	yes	1994
Pittsburgh, PA	1,600	55	yes	
Portland, OR	2,644	69	yes	1995
Providence, RI	1,220	49	yes	
Raleigh-Durham, NC	1,209	45	yes	
Richmond, VA	1,456	52	yes	
Riverside-San Bernardino, CA	4,322	82	yes	1994
Rochester, NY	1,247	50	yes	
Sacramento, CA	2,177	64	yes	1996
Saint Louis, MO	2,968	72	yes	1994
Salt Lake City, UT	954	37	yes	
San Antonio, TX	2,427	67	yes	1995
San Diego, CA	6,868	88	no	1991
San Francisco, CA	21,560	100	no	1991
San Jose, CA	2,145	63	yes	1996
Sarasota, FL	867	33	no	
Scranton, PA	266	5	no	
Seattle, WA	4,672	84	yes	1993
Springfield, MA	958	38	yes	
Stockton, CA	470	14	no	
Syracuse, NY	714	27	no	
Tacoma, WA	506	18	no	
Tampa-Saint Petersburg, FL	5,060	86	no	1993
Toledo, OH	359	8	no	
Tucson, AZ	900	36	yes	
Tulsa, OK	686	26	no	
Vallejo-Fairfield-Napa, CA	859	32	no	
Ventura, CA	495	17	no	

Continued on next page

Table A.2 – continued

City	AIDS Cases Original Cutoff	Ranking	Baseline Sample	Year Title 1 Status Achieved
Washington, DC	13,635	98	no	1991
West Palm Beach, FL	4,151	80	yes	1994
Wichita, KS	421	11	no	
Wilmington, DE	1,030	42	yes	
Youngstown, OH	218	3	no	

Table A.3: Characteristics of HIV/AIDS and Non-HIV/AIDS Deaths from 1988 to 2018

	HIV/AIDS Deaths	Non-HIV/AIDS Deaths
Fraction Male	0.81	0.50
Fraction Female	0.19	0.50
Fraction Younger than 18	0.01	0.02
Fraction Ages 18 to 64	0.95	0.24
Fraction 65 or Older	0.04	0.73
Mean Age	42.1	72.1
Fraction Black	0.44	0.12
Fraction White	0.55	0.86
Fraction Other Race	0.01	0.02
Fraction in City in APIDS	0.84	0.61
Total	514,430	74,648,275

Notes: The data come from the Vital Statistics Mortality data from 1988 to 2018.

Table A.4: The Effect of Title 1 Status on HIV/AIDS Death Rates from Alternative Samples

	Number of Cities	(1)	(2)
Baseline	50	-0.185	-0.163
		(0.069)	(0.075)
		[0.010]	[0.036]
n		950	1,550
All Cities in AIDS Public Information Data Set	102	-0.184	-0.196
		(0.052)	(0.056)
		[0.001]	[0.001]
		1,938	3,162
30 Cities Closest to Original Threshold on Both Sides of Threshold	60	-0.165	-0.152
		(0.065)	(0.069)
		[0.014]	[0.032]
		1,140	1,860
n			
20 Cities Closest to Original Threshold on Both Sides of Threshold	40	-0.163	-0.164
		(0.089)	(0.092)
		[0.076]	[0.083]
n		760	1,240
Excluding 5 Cities Closest to Original Threshold on Both Sides of Threshold	40	-0.220	-0.167
		(0.089)	(0.098)
		[0.018]	[0.096]
n		760	1,240
Excluding Cities Obtaining Title 1 Status before 1994	47	-0.199	-0.160
		(0.088)	(0.093)
		[0.029]	[0.092]
n		765	1,305
All Cities, Controls for State-by-Year Fixed Effects	102	-0.134	-0.157
		(0.064)	(0.069)
		[0.039]	[0.025]
		1,672	2,728
Years		1988-2006	1988-2018

Notes: Each cell displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable is the log of HIV/AIDS deaths per 100,000 people. Numbers of HIV/AIDS deaths each year come from the Vital Statistics Mortality data. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets.

B Matched Control Groups

The main analysis exploits the fact that the switch to the new Title 1 rules, along with the grandfather clause and the timing of the emergence of HIV treatment, led to an arbitrary cutoff that did not prioritize contemporaneous AIDS burden for Title 1 funding. The validity of the analysis rests on the assumption that cities on either side of the cutoff would have had similar trends in HIV/AIDS deaths absent the differences in Title 1 status. This appendix relaxes this assumption by considering alternative comparisons between treatment and control cities.

The 2,000 case threshold in the initial Ryan White rules can be viewed as a combination of a city's number of AIDS cases relative to its population and its population size as follows:

$$cases\_reported_{1995} = \frac{cases\_reported_{1995}}{population_{1995}} * population_{1995}.$$

On March 31 of 1995, some Title 1 cities had lower rates of AIDS cases than cities not receiving Title 1 status because of differences in population size. To consider if HIV/AIDS dynamics varying by population size or by initial AIDS severity accounts for the patterns documented in the main analysis, I re-estimate the main specifications using separate control groups for each Title 1 city in the sample based either on AIDS cases reported per 100,000 people by March 31 of 1995 or on 1995 population.

I begin by implementing this approach based on AIDS cases reported by March 31 of 1995 per 100,000 people. I first match each Title 1 city in the sample to the cities with the next highest and next lowest rates of AIDS cases reported by 1995 so that each Title 1 city has its own control group. I then estimate the following model:

$$y_{gjt} = \gamma_j + \delta_{gt} + X_{jt}\alpha_t + Title1_{jt}\beta + \epsilon_{gjt}, \tag{6}$$

where g indexes each control group, δ is a vector of group-by-year fixed effects, and the other variables are defined as before. Because Equation (6) includes group-by-year fixed effects, identification of the effect of Title 1 now comes from how HIV/AIDS deaths in Title 1 cities changed after these cities gained Title 1 status relative to how HIV/AIDS deaths changed in their individual control groups. Title 1 cities without two comparison cities are excluded from the regression. Control cities can be in the control group for multiple treatment cities. As an example of a Title 1 city's control group, Providence and Memphis, which had 131 and 138 AIDS cases per 100,000 people in 1995 and were not Title 1 cities by 1995, serve as comparison cities for Fort worth, which achieved Title 1 status under the original Ryan White rules with 137 AIDS cases per 100,000 people in 1995.

In addition to implementing this process separately for AIDS cases reported by 1995 per 100,000 people

and for population size, I also implement it for the change in HIV/AIDS death rates from 1990 to 1991 and for the change in new AIDS cases reported from 1990 to 1991.[1] The estimated effect of Title 1 status falling to zero with these alternative control groups might suggest that differences in pre-Title-1 characteristics between the treatment and control cities—rather than differences in Title 1 funding—account for the documented empirical patterns. The baseline results and these four alternative specifications are shown in Table B.1. The estimates vary as the treatment and comparison cities change, but the results shown in Table B.1 generally corroborate the baseline results.

The final set of results in Table B.1 considers the robustness of the results to reweighting the control cities to be a closer match to the treatment cities using inverse propensity scores. To create the new weights, I first estimate a probit regression with eventual Ryan White Title 1 status using demographic characteristics from 1990. I then estimate propensity scores, $\hat{p}(x_j)$, for receiving Title 1 status for each non-Title-1 city. I then estimate Equation (1) without controls and weight comparison cities by $\frac{\hat{p}(x_j)}{1-\hat{p}(x_j)}$. This approach follows Abadie (2005) and Cunningham and Goodman-Bacon (2019). As can be seen in Table B.1, the estimates from using this approach are less precise than the baseline estimates, but the point estimates from this propensity score matching approach are similar to the baseline estimates.

[1] To continue with the Fort Worth example, when basing the control group on population size, Fort Worth is compared to Indianapolis and Norfolk, which have 1995 populations of 1,503,775 and 1,534,236. For the change in HIV/AIDS death rates, Fort Worth is compared to Greensboro and Charlotte, which had changes in logged HIV/AIDS death rates from 1990 to 1991 of 0.242 and 0.258. For the change in new AIDS cases reported, Fort Worth is compared to Oklahoma City and Milwaukee, which had changes in logged AIDS cases reported from 1990 to 1991 of -0.137 and -0.103. As discussed in the main text, the city definitions include all counties that are at least partially in a city.

Table B.1: The Effect of Title 1 Status on HIV/AIDS Death Rates from Alternative Specifications

	Number of Treatment Cities	Number of Control Cities	(1)	(2)
Baseline	25	25	-0.185	-0.163
			(0.069)	(0.075)
			[0.010]	[0.036]
n			950	1,550
Matched on 1995 AIDS Cases per 100,000 People	15	16	-0.279	-0.283
			(0.082)	(0.094)
			[0.002]	[0.005]
n			855	1,395
Matched on 1995 Population	19	17	-0.164	-0.152
			(0.095)	(0.099)
			[0.094]	[0.134]
n			1,083	1,767
Matched on % Change in AIDS Death Rate from 1990 to 1991	22	19	-0.211	-0.188
			(0.059)	(0.070)
			[0.001]	[0.010]
n			1,254	2,046
Matched on % Change Reported AIDS Cases from 1990 to 1991	25	17	-0.202	-0.193
			(0.076)	(0.082)
			[0.011]	[0.023]
n			1,425	2,325
Inverse Propensity Score Reweighting	25	25	-0.158	-0.196
			(0.119)	(0.120)
			[0.191]	[0.107]
			950	1,550
Years			1988-2006	1988-2018

Notes: Each cell displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable is the log of HIV/AIDS deaths per 100,000 people. Numbers of HIV/AIDS deaths each year come from the Vital Statistics Mortality data. All regressions except for those using inverse propensity score reweighting include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets.

C Estimating the Effect of Title 1 Status Using Variation in Title 1 Status from the 2006 Ryan White CARE Act Reauthorization

As described in the main text, the primary analysis defines the Title 1 status treatment variable as an indicator variable equal to one for cities obtaining Title 1 status under the original rules for Title 1 eligibility. The 2006 Ryan White CARE Act reauthorization changed the eligibility rules to allow some cities on the worst HIV/AIDS trajectories to obtain Title 1 status. In this appendix, I first show that estimating a naive difference-in-differences model that uses variation in Title 1 status from the 2006 reauthorization to identify the impact of Title 1 status without accounting for pre-existing trends would wrongly attribute the worsening HIV/AIDS outcomes associated with these cities qualifying for Title 1 status in 2007 as being part of the effect of Title 1 status. I then show that estimating a specification that accounts for city-specific time trends provides further evidence that Title 1 status reduces HIV/AIDS deaths.

For this analysis, I focus on the five cities obtaining Title 1 status in 2007 after the eligibility rules were changed. These cities are Baton Rouge, Charlotte, Indianapolis, Memphis, and Nashville. I include as the control cities the 25 cities with the most AIDS cases reported by 1995 that did not achieve Title 1 status before the 2006 Ryan White reauthorization and focus on years 1998 to 2018.[2]

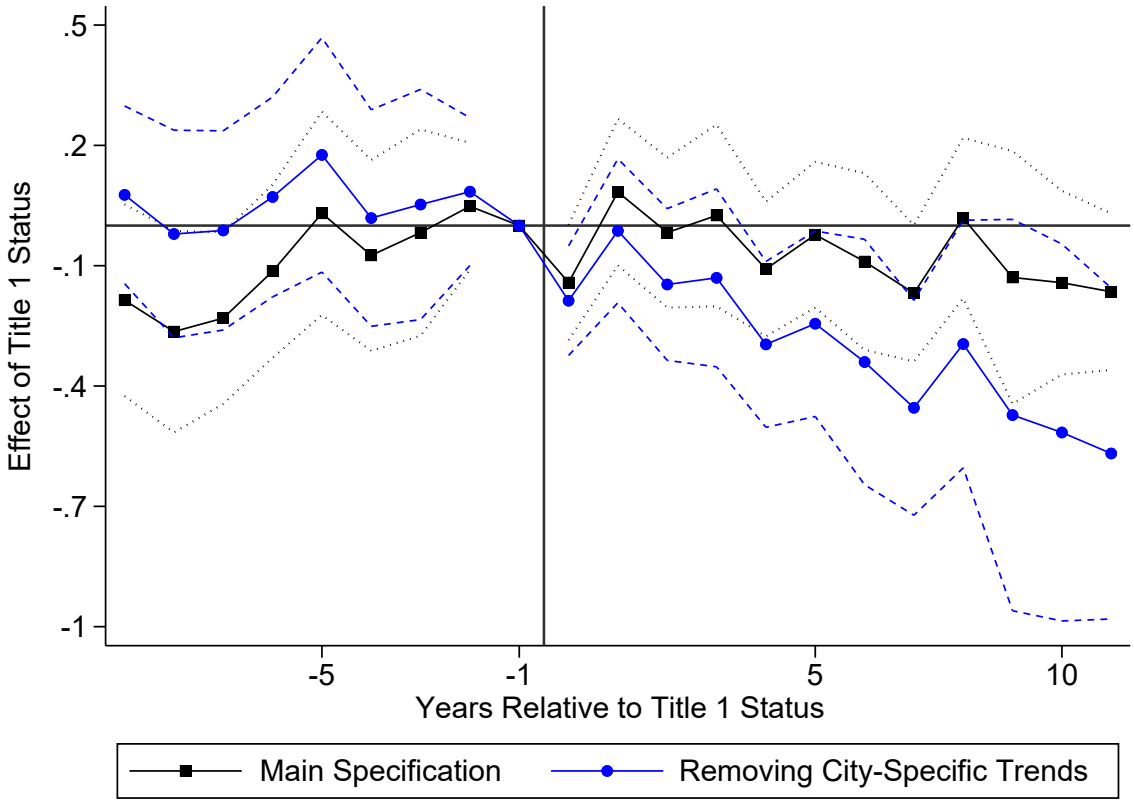
The black squares in Figure C.1 show estimates of duration-specific effects of Title 1 status from a single regression of Equation (1). The estimates indicate HIV/AIDS death rates for the cities that obtained Title 1 status in 2007 were increasing in the early 2000s relative to other cities. Within a few years of these cities obtaining Title 1 status in 2007, HIV/AIDS death rates begin to fall relative to non-Title-1 cities. This profile of estimates is consistent with the evidence in the main text that Title 1 status reduces HIV/AIDS deaths. However, the pre-existing trend towards more HIV/AIDS deaths for the 2007 Title 1 cities means that the parallel trends assumption required for difference-in-differences models is violated and that the baseline estimating equation will not yield valid estimates of the impact of Title 1 status. Table C.1 displays the estimated effect of Title 1 status from Equation (1). The point estimate is positive and statistically insignificant.

To account for the differential pre-trends, I remove the trends from the dependent variable and then estimate Equation (1) using the measure with the trends removed as the dependent variable. To remove the trends, I first estimate Equation (1) supplemented with 30 city-specific linear time trends using data from years 1998 to 2006. I then calculate the residuals for years 1998 to 2018, which is equivalent to removing the time trend from the logged HIV/AIDS death rates. Finally, I re-estimate Equation (1) with the residuals as the dependent variable.

[2] I exclude Columbus, which obtained Title 1 status in 2013, though a similar analysis could also be done to estimate the impact of Title 1 status on Columbus.

The blue series in Figure C.1 displays the coefficients on years relative to Title 1 status with the de-trended measure as the dependent variable. Column 2 of Table C.1 displays the estimate of the average impact of Title 1 on this de-trended variable. Once the differential trends that led to certain cities obtaining Title 1 status are accounted for, the estimates follow a similar pattern as the estimates of Title 1 status presented in the main text. The estimate in Table C.1 indicates that Title 1 status leads to a reduction in HIV/AIDS death rates of 0.318 log points, or approximately 27 percent.

Figure C.1: Relationship between Title 1 Status and HIV/AIDS Death Rates for Cities Obtaining Title 1 Status in 2007



Notes: Each marker is a coefficient on Title 1 status interacted with number of years from initial Title 1 status eligibility with the log of HIV/AIDS death rates as the dependent variable. The x-axis indicates the number of years from Title 1 status. The y-axis indicates the coefficient estimate. The sample contains 630 observations from 30 cities from 1998 to 2018. The regression for the blue circles accounts for city-specific linear time trends, while the regression for the black squares does not. Each regression includes city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. The dashed lines indicate 95% confidence intervals calculated using standard errors clustered by city.

Table C.1: Estimated Effect of Title 1 Status Using Variation in Title 1 Status from 2006 Ryan White CARE Act Reauthorization

	(1)	(2)
	0.019	-0.318
	(0.093)	(0.135)
	[0.841]	[0.025]
Years	1998-2018	1998-2018
Accounts for City-Specific Linear Trend		x
Number of Cities	30	30
n	630	630
Mean of D.V. in Levels	4.0	4.0

Notes: Each column displays the effect of Title 1 status from separate regressions of Equation (1). The unit of observation is a city and year combination. The dependent variable is the log of HIV/AIDS deaths per 100,000 people. Numbers of HIV/AIDS deaths each year come from the Vital Statistics Mortality data. All regressions include city fixed effects, year fixed effects, and controls for the share of cities' residents who are Black, Hispanic, younger than 18, 65 and older, and male. Standard errors are clustered by city and are shown in parentheses. P-values are shown in brackets.