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JEL Classification: I18, J18, N32

Keywords: AIDS, HIV, surveillance, United States

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Disease Surveillance, Mortality and Race: The Case of HIV/AIDS in the United States*

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1 Introduction

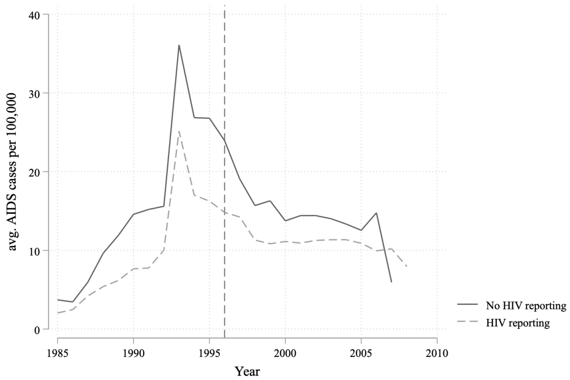
When the World Health Organization's Director-General, Dr. Tedros Adhanom Ghebreyesus, encouraged countries to "test, test, test" on March 16, 2020, during the worsening COVID-19 pandemic, he brought to the forefront what public health experts had long argued: that in the absence of an effective treatment or vaccine, surveillance is one of the most powerful weapons against disease mankind has at its disposal. It is therefore surprising that there is a lack of quantitative evidence on the effectiveness of surveillance, something which we aim in the following to address through the example of HIV/AIDS. This pandemic killed millions and had a disproportionate impact on black communities in the United States (Aburto et al., 2021), and continues to ravage the world, although to a lesser extent since an effective treatment, HAART, was discovered in 1996. HIV surveillance was rolled out at different times for different states in the United States between 1985 and 2008, and it is this variation which we exploit to consider the effectiveness of testing and reporting both before and after the availability of an effective medical treatment (HAART).

Public health surveillance is the "ongoing, systematic collection, analysis, and interpretation of health-related data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those responsible for prevention and control" (Thacker and Berkelman, 1988). It can be divided into two categories: case surveillance, which focuses on individuals or groups to identify diseases and guide public health action; and statistical surveillance, which focuses on populations to inform public health policy-making, although the term "surveillance" for statistics was not applied until the mid-twentieth century. According to the Centers for Disease Control and Prevention (CDC), the purposes of surveillance are to assess public health status, to define public health priorities, to evaluate programs, and to stimulate research. It is well-known that the worldwide eradication of smallpox became possible in the 1970s only because of a surveillance-vaccination approach, and surveillance from its origins in the fourteenth century was focused on detecting individual cases and taking action based on these through monitoring, treatment, quarantine, and contact tracing.

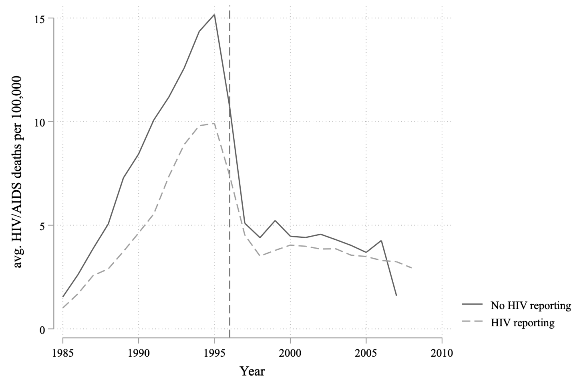
HIV/AIDS, like COVID-19, appears to have its origins in the contact between people and wild animals, specifically through contact with infected blood from wild chimpanzees in Africa (Sharp and Hahn, 2011; Faria et al., 2014). The first official case of AIDS and death from HIV/AIDS was registered in the United States in 1981, and in 1985 the first blood test for HIV became available, making it possible to detect the virus before it developed into AIDS. As a result, US states introduced HIV reporting alongside that which was already mandatory for AIDS, but for a number of reasons which we return to below, not least the considerable stigma attached to the diagnosis, did so at different points in time. In 1996 the first effective medical treatment for HIV was introduced, HAART, and although this significantly reduced mortality, we consider the impact of testing and reporting prior to this effective medical treatment, and the relative impact of this and the differential roll-out of surveillance across US states between 1985 and 2008 as a case to investigate the relative importance of surveillance and treatment. We use this variation to investigate if testing and reporting had a direct impact on AIDS cases and mortality from HIV/AIDS. Then, inspired by the work of Aburto et al. (2021) and others, who demonstrate that blacks were hit harder by HIV/AIDS than whites in terms of life expectancy and lifespan disparity (a measure of variance), we also consider whether there was a differential effect of surveillance by race.

Figure 1 presents the average AIDS case rate and HIV/AIDS deaths per 100,000 between 1985 and 2008, where we differentiate between those states which had introduced HIV reporting, as defined below, and those which had not. It is clear that both were lower in those states which had HIV surveillance compared to those which did not, although this difference narrows after the introduction of HAART in 1996. Inspired by this, we use a difference-in-differences strategy to investigate whether surveillance had an impact on cases and mortality, both before and after 1996, prior to which 22 states had introduced HIV reporting in a gradual roll-out between 1985 and 1995[1]. Thus, by exploiting this differential roll-out, we find that surveillance helped reduce both AIDS cases and mortality from HIV/AIDS before 1996. However, with the introduction of HAART, only the effect on cases remains, except in the case of blacks: for them, the effect on mortality is apparent even after 1996. This finding provides the first empirical support for the effectiveness of surveillance in the absence of a treatment or cure, or when this treatment is not equally accessible for all, as might well have been the case for the black population as we discuss more below. It also lends support to the idea that this might be through the impact on risky behavior (see for example Baird et al., 2014), beyond that which has been demonstrated at the level of individual testing and education in for example the use of condoms (Moran et al., 1990; Sonenstein et al., 1998; Anderson, 2003). In fact, to our knowledge, there is little previous quantitative work on the direct impact surveillance can have on case rates and mortality, despite the general acceptance about its importance as outlined above, although see Di Chiara and Vanuzzo (2009) on cardiovascular prevention. However, in more general terms we contribute to an expanding literature within economics on the use of public health interventions, for example Egedesø et al. (2020) on the roll-out of tuberculosis dispensaries in Denmark, Cutler and Miller (2005) on clean water technologies in the United States, and Coffey et al. (2018) on the impact of community sanitation on anemia in Nepal.

[1] Our sample is limited to 42 states, due to suppressed mortality data from CDC wonder. The first year CDC provides mortality from HIV/AIDS as an individual cause is in 1987. Prior to that HIV/AIDS death are constructed manually. See more in section 3.



(a) AIDS case rate



(b) HIV/AIDS death rate

Figure 1: (a) AIDS case rate and (b) HIV/AIDS death rate in the United States, differentiating between those states with surveillance and others

Note: Own calculations. Average number of cases and deaths per 100,000 across states divided by whether they have introduced HIV reporting or not. Data is available from 1982-2015, but figure 1 only shows the period 1985-2008, where states introduced HIV reporting. The sharp drop in both cases and deaths in 2007 for non reporting states is because Hawaii (in our sample) was the only state left that had no reporting in that year. The spike in panel (a) in the year 1993 is due to a change in the case definition.

The remainder of this paper proceeds as follows. The following section presents the historical background to the epidemic. Section 3 presents the data used in the empirical analysis, the empirical strategies are presented in Section 4, and the main results are in Section 5. Finally, Section 6 concludes.

2 The History of HIV and Surveillance

In 1893, the US Congress enacted a law providing for the collection of information on infectious diseases each week from state and municipal authorities, and by 1901 all states required "notification" for diseases including smallpox, tuberculosis and cholera. Although the list of notifiable diseases has changed, the basic strategy established in the nineteenth century – postcard reporting to local health departments, weekly summaries in the Morbidity and Mortality Weekly Report, etc. – are generally still in place today (Thacker, 2000). In the US, infectious disease surveillance is constitutionally viewed as a state responsibility, and the list of notifiable diseases varies by state. This surveillance infrastructure was presented with a serious challenge from 1981 when, by the end of the year, 270 cases of an as yet unknown illness was reported among gay men, 121 of whom passed away the same year. In an unfortunate precedent of the fear and stigma which was to surround the disease, and which was to prove a major hindrance to its successful surveillance and combat, some researchers began by calling it GRID, "Gay-Related Immune Deficiency". It was, however, soon discovered that it could also have long-term consequences for women, heterosexual men, hemophiliacs, people who inject drugs, and children. On September 24, 1982 the CDC used the term AIDS for the first time, and on January 7, 1983, the CDC reported the first cases of AIDS in women whose male sexual partners were infected. On May 18 of the same year, the US Congress passed the first bill which allocated funding specifically targeted at AIDS research and treatment.

From this point, medical knowledge progressed rapidly. On September 9 the CDC ruled out transmission by casual contact, food, water, air, or environmental surfaces, and on January 11, 1985 the CDC revised the AIDS case definition to note that it is caused by a newly identified virus and issued guidelines for blood screening. Certain notable individuals also assisted in spreading awareness of the nature of the disease, and an important milestone came on October 22, 1986, when the US Surgeon General Dr. C. Everett Koop issued the Surgeon General's Report on AIDS. This made it clear that it could not be spread casually and called for a nationwide education campaign, early sexual education, increased use of condoms, and voluntary HIV testing. It was however two major innovations which eventually turned the tide in the US. First, new tests allowed for surveillance of HIV, which was important due to the long lag between contraction and the onset of AIDS, often around a decade (CDC). Second, antiretroviral treatments became available, which eventually allowed those with HIV to die with the virus instead of from it. The first enzyme-linked immunosorbent assay (ELISA) kit to screen for antibodies to HIV was approved by the Federal Drug Administration (FDA) in 1985, and was soon followed in 1987 by approval of the "Western blot" blood test kit, which provided a more specific test for antibodies. Rapid diagnostic kits were developed from the 1990s and by 2012 the FDA had approved the first at-home HIV test kit which revealed HIV status immediately. As regards treatment, on March 19, 1987 the FDA approved the first antiretroviral drug, zidovudine (AZT) and the US Congress awarded $30 million in emergency funding to states for this, laying the groundwork for what would become the AIDS Drug Assistance Program (ADAP), authorized by the Ryan White CARE act in 1990. However, it was not until June 1995 that the FDA approved the first protease inhibitor which ushered in a new era of highly active antiretroviral therapy (HAART), and rapidly became the new standard of HIV care. In 1996 the number of new AIDS cases in the US declined for the first time, and the following year the CDC recorded the first substantial decline in HIV/AIDS deaths in the US, a result of the combination of first surveillance, made possible by testing, and then treatment.

AIDS case surveillance was in fact set up in 1982, before there was a test for HIV and even before the names HIV and AIDS were invented. Then, in June 1987 President Ronald Reagan directed the Department of Health and Human Services (DHHS) "to carry out a comprehensive program to determine the nationwide incidence of the human immunodeficiency virus (HIV) and to predict its future occurrence and to initiate epidemiological studies to determine the extent to which HIV has penetrated the various segments of our society." The CDC was directed to recommend the best methods, and concluded that information and educational programs were of prime importance. Since there was no vaccine, these were the only measures available to prevent AIDS and the transmission of HIV. From 1988 this program became fully operational (CDC and DPC 1987). The system evolved over time, mostly in terms of changing the case definition to reflect the growing clinical understanding. For example, in 1993 the CDC expanded the case definition of AIDS and added three new conditions – pulmonary tuberculosis, recurrent pneumonia, and invasive cervical cancer – to the list of clinical indicators of AIDS[2]. This meant that more women and intravenous drug users would be diagnosed with AIDS. Then again, in 1999 the CDC released a new HIV case definition to help state health departments expand their HIV surveillance efforts and more accurately track the changing course of the epidemic. Until the development of potent antiretroviral therapies, AIDS case reporting gave a relatively accurate picture of trends in infection. Back-calculation methods were used to estimate the incidence of HIV, but the new therapies altered the incubation period, making this unreliable, making new testing methods and earlier surveillance necessary to distinguish between recent and longstanding infections, which in turn was highly reliant on public trust (Sullivan et al., 2007).

Therefore, we will focus on HIV (not AIDS) surveillance. Along with the introduction of the blood test for HIV in 1985, which made it possible to discover the disease at an early stage, Colorado, Minnesota and Wisconsin were the three first states to implement HIV reporting alongside the already compulsory AIDS reporting. Over the next 23 years all states in the US implemented HIV reporting (CDC, table 19). In 2008, Vermont and Hawaii were the last two states to implement name-based HIV reporting (Stoto, 2003), and in early 2013 estimated data on diagnosed HIV infection were available for all 50 states, the District of Columbia, and six US dependent areas for the first time (Cohen et al., 2014). It is important to note that when we refer to HIV reporting, we refer to what is known as name-based HIV reporting, and we use the year of the implementation of the name-based reporting system as the treatment in our diff-in-diff, since this assures that we have the same treatment across states. In 2005 the CDC strengthened its official guidance, recommending that all states switched to the name-based surveillance system in order to ensure nationwide, standardized and high-quality surveillance data. Some states had introduced alternative more anonymous systems earlier before switching to the name-based system (see Table A1), but HIV cases at the state level were only reported in the annual HIV Surveillance Reports after the state implemented name-based reporting. Hence the name-based reporting system covers both dimensions of surveillance; case surveillance and statistical surveillance. Information was and is reported on a standard case report form, including data on patient demographics, HIV risk behaviors, laboratory and clinical events, and virologic and immunologic status. These data are then submitted to the state or local public health authority and entered into the HIV/AIDS Reporting System,

[2]The spike in figure 1a in the year 1993 is due to this change in the case definition.

a standard software data management system. The reports are then forwarded without personal identifiers to CDC, and through interstate communication procedures endorsed by the Council of State and Territorial Epidemiologists, case identification numbers are then sent back to state surveillance coordinators, who use the information to check for potential duplicates, and this is then reported back to the CDC via the case identification numbers, and any potential duplicates are removed from the national dataset. This is then used to develop the national epidemiological profile of HIV/AIDS in the United States (Lee and McKenna, 2007).

By 1996, 26 of the 50 US states had implemented name-based HIV reporting, but there were significant privacy concerns regarding contract tracing. Figure 2 shows the roll out of HIV reporting across states and time. States that adopted HIV reporting late, would often first introduce an alternative more anonymous system, and then later switched to the name-based system, once the CDC strengthened its official guidance in 2005. All states colored black in the figure show those who changed system after 2005. This tendency to postpone implementation in some states, and then implement more anonymous systems owed largely to the stigma surrounding the disease, in particular due to its association with homosexuals and drug users. A telephone survey conducted in 1999 (Herek et al., 2003) found that anonymous reporting was supported by a margin of 2-to-1, and name-based reporting was opposed 3-to-1. Those who supported name-based reporting were generally more negatively inclined towards people with AIDS, homosexuals, and injecting drug users. More than one third of survey participants stated that concerns about AIDS stigma would affect their decision to be tested in the future. The public health officials who were promoting name-based reporting in the late 1990s were not aiming to promote stigma, but stigma created barriers[3]. This was a particular issue in California, and other areas which housed a considerable (openly) gay community, which were largely confined to large cities, demonstrating a striking persistence over time (Black et al., 2000; Grey et al., 2016). Gates (2013) lists the top ten states ranked by number of same-sex couples per 1,000 households in 1990[4], excluding DC since it is not in our analysis, this leaves us with the following nine states; California, Washington, Massachusetts, New York, Oregon, Minnesota, Vermont, Maine and Maryland. There is a high overlap between states implementing HIV reporting later or implementing an alternative anonymous system, before switching to the name-based HIV reporting system, and those which have larger openly gay communities. Of these nine states only Minnesota introduced name-based reporting early on in 1985, whereas the other eight states either introduced an alternative system or introduced name-based reporting late (see

[3]Another bone of contention was that HIV testing would identify a larger number of infected people and thus attract greater federal funding, and this point was raised in Congress during the debate on Ryan White Care Act reauthorization in 2000, although Shrestha et al. (2014) estimated the annual total HIV surveillance cost to the Michigan health department to be just $87 per case.

[4]See table 12.1 in Gates (2013).

Table A1)[5].

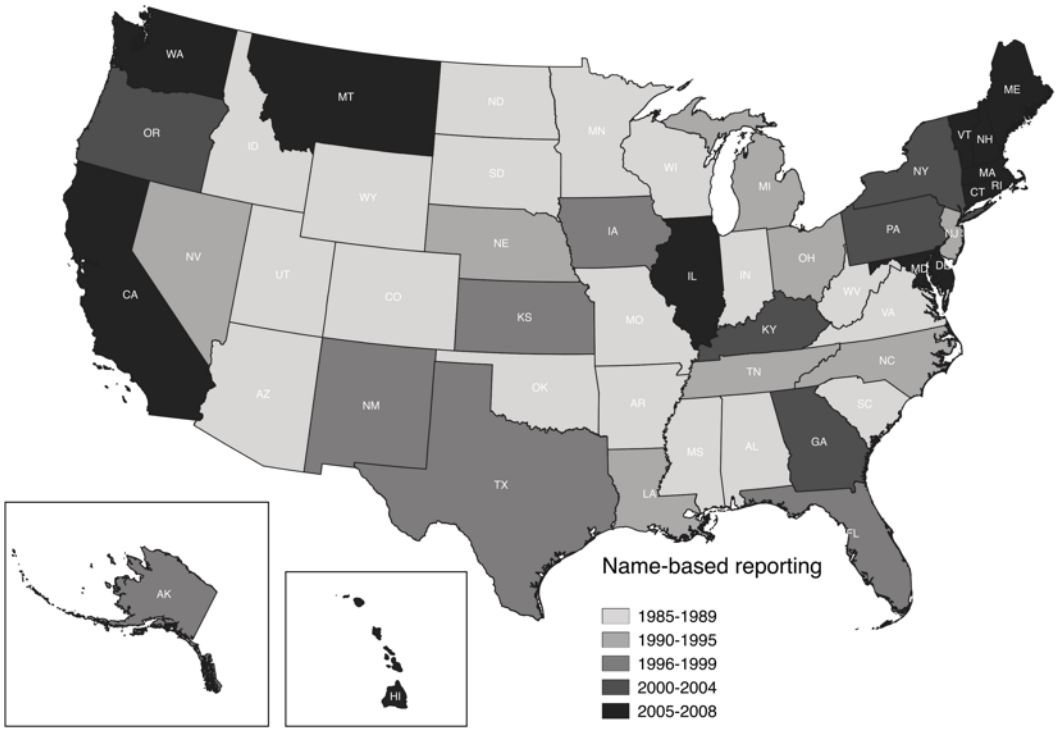


Figure 2: Roll-out map name-based HIV reporting
Note: The exact year of implementation of name-based HIV reporting can be seen in Table A1. The states shown in black indicate those who switched to a name-based system after the strengthened recommendation from CDC in 2005.

3 Data

In the first part of our analysis we focus on the period prior to 1996, to investigate the impact of surveillance on AIDS cases and mortality from HIV/AIDS in the absence of effective medical treatment. Then, we extend the period up until 2015, to determine if reporting also had an impact after the introduction of HAART. Our two main outcome variables are AIDS cases per 100,000 and deaths from HIV/AIDS per 100,000. AIDS cases are obtained and digitized at the state level from CDC's annual HIV/AIDS surveillance reports (end year) starting in 1982 up until 2015. Mortality from HIV is first presented as an individual cause of death in 1987[6]. In order to follow the mortality pattern from the beginning and to have a comparable sample for AIDS cases and mortality, we manually constructed HIV/AIDS deaths for the years 1982-1986 following

[5] Recently, Brodeur and Haddad (2018) have demonstrated a correlation with gold rush counties, which led to a large temporary increase in the male-to-female ratio, and which have more favorable attitudes towards homosexuality today.

[6] From 1987-1998 death from HIV had the ICD-9 codes 042-044, whereas from 1999-2016 deaths from HIV had the ICD-10 codes B20-B24.

the description in the technical appendix to the 1988 Multiple Cause of Death file, which describes the ICD codes that contained most HIV/AIDS deaths prior to 1987 (National Center for Health Statistics, 1991)[7]. All mortality data is downloaded from CDC WONDER, and is obtained both as total number of deaths at the state level, but is also divided by race at the state level[8]. Population data is also obtained from CDC WONDER along with the mortality data. Since data from CDC WONDER is suppressed in the case of fewer than 10 deaths within an age group, it is not possible to construct reliable age-adjusted death rates, so we instead use simple mortality rates (number of deaths per 100,000). The disease affected mainly those in the age group 25-44 years, so we always control for the initial population share aged 25 to 44. When referring to the initial level, this is always in 1980, which is the year before the first cases of AIDS were officially reported in 1981. When analyzing HIV/AIDS mortality for the total population 13 states have suppressed data for at least one or more years. We exclude states where HIV/AIDS mortality data are suppressed for more than 5 years. Eight states were dropped, leaving us with a sample of 42 states. For the five states where data is suppressed for less than six years, we allocate nine deaths to these years, which is the maximum possible number due to HIV/AIDS that could have occurred given that data is suppressed[9]. When performing the analysis for blacks and whites separately our sample drops to 33 states[10].

As a robustness check, we control for the initial share of the black population. We also control for initial income per capita and initial income inequality. Income data are obtained from Sommeiller and Price (2018). They provide annual income data for all states, but also average income for the top 10 percent and bottom 90 percent of the population. As a measure of income inequality, we use the ratio of income for the top 10 percentile to the bottom 90 percentile. As a control for direct poverty we use poverty rates by state from the U.S. Census Current Population Survey, 1960 to 2020 Annual Social and Economic Supplements .

Summary statistics for the main variables are presented in table 1, with panel A showing the summary statistics for the period 1982-1995 and panel B for the full period 1982-2015. Finally, table 2 reports a balancing test, comparing the initial five-year average between 1980-84 of the main variables for the states that adopted name-based HIV reporting before 1996 compared to those that did not. When it comes to initial mortality from HIV/AIDS and AIDS cases we only have data for the initial three-year average 1982-1984. One might expect that states having more AIDS cases or a higher death rate would implement HIV reporting earlier, but this seems not to have been the case. What is apparent, however, is that states that implemented

[7]Deficiency of cell-mediated immunity (ICD No. 279.1), Pneumocystosis (ICD- 9 No. 136.3), and Site unspecified (ICD-9 No. 173.9), under other malignant neoplasms of skin.

[8]CDC WONDER (Compressed Mortality) [Retrieved: April 8 2020]. From 1987-1998 race is divide as White, Black or African American and Other. From 1999-2016 race in divided into White, Black or African American, Asian or Pacific Islander and American Indian or Alaska Native.

[9]A full list of states and years where HIV/AIDS death are suppressed can be seen in Table A2 in the Appendix.

[10]A full list of states and years where HIV/AIDS death are suppressed for blacks and whites can be seen in Table A3 in the Appendix.

HIV reporting prior to 1996 had a significantly lower rate of AIDS cases and mortality from HIV/AIDS. These early adopters also had a significantly lower population size, a larger black share of the population, lower average income per capita and a higher poverty rate.

Table 1: Summary Statistics

	Panel A: 1982-1995					
	Period	No. obs	Mean	SD	Min	Max
Crude death rate	1982-1995	588	867.9	118.8	520.9	1,122
HIV/AIDS death rate	1982-1995	588	5.702	6.540	0.0628	43.82
AIDS case rate	1982-1995	588	10.32	13.07	0	95.02
Population	1982-1995	588	5.735e+06	5.448e+06	599,565	3.172e+07
Black pop share	1982-1995	588	0.113	0.0917	0.00315	0.365
White pop share	1982-1995	588	0.846	0.117	0.318	0.989
Age 25-44 share	1982-1995	588	0.312	0.0193	0.259	0.358
Top bottom ratio 10/90	1982-1995	588	5.473	0.814	3.201	8.098
Poverty rate	1982-1995	588	13.95	4.349	2.900	27.20
Income per capita (1000s)	1982-1995	588	22.18	3.929	13.40	34.86
Life expectancy (e_0)	1982-1995	588	75.30	1.353	72.34	78.86
Lifespan variation (std_0)	1982-1995	588	17.41	0.640	15.97	19.06
Coef. of variation (std_0/e_0)	1982-1995	588	0.231	0.0120	0.206	0.262
	Panel B: 1982-2015					
	Period	No. obs	Mean	SD	Min	Max
Crude death rate	1982-2015	1,428	864.1	121.5	519.1	1,236
HIV/AIDS death rate	1982-2015	1,428	4.398	4.938	0.0628	43.82
AIDS case rate	1982-2015	1,428	10.28	10.50	0	95.02
Population	1982-2015	1,428	6.409e+06	6.234e+06	599,565	3.899e+07
Black pop share	1982-2015	1,428	0.121	0.0935	0.00315	0.381
White pop share	1982-2015	1,428	0.826	0.120	0.297	0.989
Age 25-44 share	1982-2015	1,428	0.292	0.0265	0.231	0.358
Top bottom ratio 10/90	1982-2015	1,428	6.527	1.562	3.201	13.97
Poverty rate	1982-2015	1,428	13.33	3.857	2.900	27.20
Income per capita	1982-2015	1,428	25.73	5.752	13.40	50.22
Life expectancy (e_0)	1982-2015	1,428	76.62	1.966	72.34	81.70
Lifespan variation (std_0)	1982-2015	1,428	16.95	0.798	15.14	19.06
Coef. of variation (std_0/e_0)	1982-2015	1,428	0.222	0.0155	0.187	0.262

Note: This table reports summary statistics for the main variables used in the empirical analysis. Panel A covers the period 1982-1995, while panel B shows the summary statistics for the whole period 1982-2015.

Table 2: Balance Test

	Period	Pre-1996 adopters Mean	Pre-1996 adopters SD	Pre-1996 non-adopters Mean	Pre-1996 non-adopters SD	Mean-comparison test
		Comparing adopters versus non-adopters before 1996				
No. observations		22		20		
Crude death rate	1982-1984	845.405	110.185	855.263	122.205	0.6365
HIV/AIDS death rate	1982-1984	0.405	0.352	0.627	0.781	0.0462
AIDS cases rate	1982-1984	0.356	0.904	1.116	2.574	0.0335
Population	1980-1984	4,281,107	2,414,750	6,564,832	6,485,131	0.0012
Black pop share	1980-1984	0.128	0.101	0.088	0.074	0.0014
White pop share	1980-1984	0.854	0.096	0.859	0.136	0.7619
Age 25-44 share	1980-1984	0.286	0.019	0.291	0.018	0.0769
Top bottom ratio 10/90	1980-1984	4.682	.487	4.677	.526	0.9411
Poverty rate	1980-1984	15.523	4.913	13.426	3.414	0.0004
Income per capita	1980-1984	18.833	2.998	20.981	2.745	0.0000
Life expectancy (e_0)	1980-1984	74.193	1.268	74.782	1.143	0.0005
Lifespan variation (std_0)	1980-1984	17.836	0.659	17.629	0.600	0.0181
Coef. of variation (std_0/e_0)	1980-1984	0.241	0.013	0.236	0.011	0.0033

Note: This table reports the balancing test, comparing the initial five-year average between 1980-84 of the main variables for the states that adopted name-based HIV reporting before 1996 compared to those that did not. Data is only available for the initial three-year average (1982-1984) for the HIV/AIDS death rates and AIDS cases.

4 Empirical strategies

The key empirical challenge is to estimate the effect of the implementation of HIV reporting on the AIDS case rate and HIV/AIDS death rate. By using the variation in the implementation year of HIV reporting by states, this can be investigated using a staggered difference-in-difference (DiD) framework. However, numerous papers have over the last years documented that the resulting estimated coefficient on the treatment variable might be misleading in a staggered DiD setting, since the estimated coefficient on the treatment is in fact a weighted average of many different treatment effects, and these weights can be negative and non-intuitive (De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2020; Callaway and SantâAnna, 2020; Borusyak and Jaravel, 2017; Sun and Abraham, 2020; Baker et al., 2021). In order to try to overcome some of the pitfalls a first step suggested in the literature is to focus on event-study estimates, however we will also calculate the 'standard' DiD estimates. We also implement the suggested decomposition method by Goodman-Bacon (2020) and the solution using only 'clean' controls by Cengiz et al. (2019).

4.1 Event-study

The event-study will both help us identify if treatment effects are increasing over time, and provide evidence of whether the common trend assumption is satisfied. Common trend for the treated and untreated group prior to treatment is the main identifying assumption in the DiD framework, meaning that states that adopted HIV reporting would have followed the same path as those that did not in the absence of the introduction of the HIV reporting system.

$$y_{it} = \sum_{j \in T} \alpha_j \times Reporting_{it}^{\tau+j} + \delta_i + \lambda_t + \mathbf{X'_{it}}\beta + \varepsilon_{it} \tag{1}$$

For the analyses prior to 1996 $T = -10, \dots, -1, 0, \dots, 10$, where for the full period $T = -10, ..., -1, 0, ..., 20$. $Reporting_{it}^{\tau+j}$ is an indicator equal to one when $t = \tau + j$, where τ is the year in which state i implemented name-based HIV reporting. If there is a common pre-trend, the estimated coefficients, $\hat{\alpha_j}$, which outline the dynamic effects of the introduction of HIV reporting relative to the omitted base year just before the intervention, $t = \tau - 1$, should be $\hat{\alpha_j} \approx 0 \forall j < 0$.

4.2 Pre-1996 analysis

For the first analysis, which is limited to the period prior to the introduction of HAART in 1996, we use the following DiD approach to identify the effect of HIV reporting on the rate of AIDS cases and mortality from HIV/AIDS:

$$y_{it} = \alpha Reporting_{it} + \delta_i + \lambda_t + \mathbf{X'_{it}}\beta + \varepsilon_{it} \tag{2}$$

where y_{it} is the outcome of interest: AIDS cases per 100,000 and deaths due to HIV/AIDS per 100,000 in state i in year t. $Reporting_{it}$ is an indicator equal to one if the state has a HIV reporting system in year t. δ_i controls for state fixed effects, while λ_t indicates year fixed effects. In the main specification we also include initial share of population aged 25-44 interacted with year fixed effects, X_{it}. For robustness checks we also include additional state-specific controls, such as initial share of the black population, initial income per capita, initial income inequality, and initial poverty rate, all interacted with year fixed effects, where the initial level refers to the year 1980. Standard errors, ε_{it}, are clustered at the state level. If HIV reporting has an impact on AIDS cases and mortality from HIV/AIDS, we expect $\hat{\alpha} < 0$. Prior to 1996, 22 states in our sample had implemented name-based reporting but at different points in time between 1985 and 1995. This implies that before a state introduced name-based reporting it functions as a control, together with the 20 states that did not introduce name-based HIV reporting until after 1996. We show the Goodman-Bacon decomposition in order to see where the main effect is coming from. Here we have the comparison of both treated versus never treated, early treated states versus later treated states as control, and late treated states using earlier treated states as control.

In an additional approach we focus on years since adoption, in order to capture the anticipated dynamic effect on the rate of AIDS cases and mortality from HIV/AIDS, simply because the development of the disease by its nature is lagged. Prior to the introduction of HAART, it took on average a decade from being infected with HIV until AIDS developed. Then, a person with AIDS could expect to live around three more years (CDC)[11]. Hence, we exploit years since the introduction of name-based reporting in the following way:

$$y_{it} = \alpha Reporting_{it} \times (t + 1 - j_i) + \delta_i + \lambda_t + \mathbf{X'_{it}}\beta + \varepsilon_{it} \tag{3}$$

The estimated coefficient, $\hat{\alpha}$ is now a measure of the annual effect on the rate of AIDS cases and mortality after the introduction of HIV reporting. The additional term $(t+1-j_i)$ indicates years since the introduction of name-based reporting, where j_i is the year of the introduction of name-based HIV reporting, and t is the year. The interpretation of the other variables is as before.

4.3 Full period analysis

In order to consider whether HIV reporting still had an impact on AIDS cases and mortality after the introduction of HAART, which had a direct effect on the development of new AIDS cases and mortality from HIV/AIDS, we extend the study period to cover 1982-2015. Here we consider the impact of HIV reporting in combination with HAART, motivating the introduction of an interaction term as follows:

$$y_{it} = \alpha Reporting_{it} + \gamma_1 Reporting_{it} \times priorHAART_t + \gamma_2 priorHAART_t + \delta_i + \lambda_t + \mathbf{X'_{it}}\beta + \varepsilon_{it} \tag{4}$$

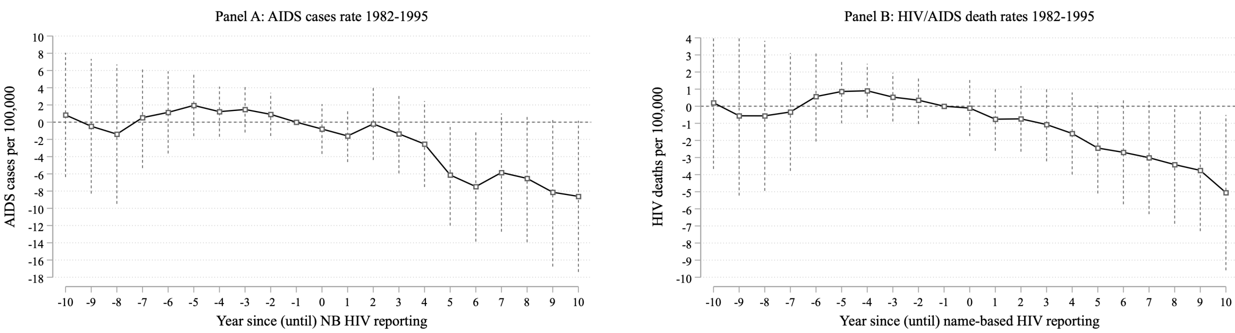
where $priorHAART_t$ is an indicator equal to one prior to 1996. The advantage of the interaction with $priorHAART_t$ is that the average effect of name-based reporting and the significance level, in the presence of medical treatment, HAART, can directly be obtained from the coefficient $\hat{\alpha}$. Alternatively, one could interact with $HAART_t$, being an indicator after 1996, and then calculate the effect that was left due to HIV reporting. It is implicitly assumed that all states had equal access to this new medical treatment.

[11]CDC, About HIV: https://www.cdc.gov/hiv/basics/whatishiv.html

5 Results

5.1 Pre-1996 analysis

As a first step we provide evidence supporting the main identifying assumption of a common trend in the rate of AIDS cases and HIV/AIDS mortality prior to the introduction of HIV reporting. Also we can identify the dynamic effect of HIV reporting, having in increasing effect over time.



(a) AIDS case rate

(b) HIV/AIDS death rate

Figure 3: Event-study prior to 1996

Note: The event-study graphs show the estimated $\hat{\alpha_j}$ and the 95% confidence intervals from estimating equation (1). Panel (a) graphs the estimated differences in AIDS cases per 100,000 and panel (b) graphs the estimated differences in HIV/AIDS deaths per 100,000. Estimations include state and year fixed effects and initial share of population aged 25-44 interacted by year.

Figure 3 plots the estimated coefficients, $\hat{\alpha_j}$, and their 95% confidence interval obtained by estimating equation (1). For both AIDS cases and HIV/AIDS mortality, the coefficients fluctuate around zero with no systematic trend prior to the introduction of name-based HIV reporting, supporting the common pre-trend assumption. After three years the coefficients for AIDS cases turns permanently negative and becomes statistically significant after five years. The magnitude seems to stabilize five to ten years after the implementation of HIV reporting, although with somewhat increasing confidence intervals. Panel B shows the corresponding graphs with mortality from HIV/AIDS as the outcome variable. One year after the introduction of name-based reporting the coefficients turn permanently negative and increase in magnitude as time passes since the introduction of HIV reporting. This supports our belief that there would be no immediate effect, but that it should be observed with some delay due to the time between acquiring HIV and the development of AIDS, and also the time before death due to HIV/AIDS.

Table 3 columns (1) and (2) report the results from estimating equation (2), while columns (3) and (4) report the annual effects from estimating equation (3). From equation (2) we find a negative effect for both AIDS cases and mortality, but both are only statistically significant at the 10% level. When estimating equation

(3) the precision of our estimate increases and both are now significant at the 5% level. We see this as a reflection of the fact that it takes some years for the effect of HIV reporting to materialize as also shown in the event-study (Figure 3). The annual effect estimated in column (3) suggests that introducing name-based HIV reporting reduced AIDS cases per 100,000 by 1.223 (95% CI: -2.17 to -0.28). Compared with the average AIDS case rate which was 10.32 this represents an annual reduction of 11.95%. The corresponding annual reduction in mortality due to implementing name-based HIV reporting was 10.51%.

Table 3: Effect of HIV reporting on AIDS cases and HIV/AIDS mortality, pre-1996 analysis

Dep. variable	AIDS case rate (1)	HIV/AIDS death rate (2)	AIDS case rate (3)	HIV/AIDS death rate (4)
$Reporting_{it}$	-4.032*	-2.169*		
	(2.175)	(1.092)		
$Reporting_{it} \times (t + 1 - j_i)$			-1.223**	-0.599**
			(0.468)	(0.231)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Time period	1982-1995	1982-1995	1982-1995	1982-1995
Observations	588	588	588	588
R^2	0.706	0.717	0.722	0.731
States	42	42	42	42

*Note: Outcome variables are AIDS cases per 100,000 and HIV/AIDS death per 100,000. All regressions include year, and state fixed effects and initial share of population aged 25-44 years interacted with year fixed effects. $Reporting_{it}$ is an indicator variable equal to one after the introduction of name-based HIV reporting, and j_i is the year of the introduction of HIV reporting. Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively.*

5.1.1 Robustness analysis pre-1996

We start with the concerns raised about staggered DiD, and the fact that the estimates given above are a weighted average of multiple DiDs. We can divide these into three overall groups: those treated early, those treated late and those never treated. The estimates above are a weighted average of all possible 2x2 DiD from these groups. Often we are interested in the effect when comparing treated states to 'clean' controls, in this case the 20 states that were never treated within our study period. The Goodman-Bacon decomposition summarizes these, and from table 4 we can see that the main effect, both in terms of weight and the average DiD estimate comes from the comparison of states treated within our time window, 1985-1995, using untreated states as the control. This goes for both AIDS cases and HIV/AIDS mortality. The corresponding figures showing all possible 2x2 DiD estimates and their weights can be seen in figure A1 in the appendix.

Table 4: Goodman-Bacon decomposition

Dep. variable	AIDS case rate		HIV/AIDS death rate	
$Reporting_{it}$	-4.286**		-2.361**	
	(2.038)		(1.052)	
DD Comparison	Weight	Avg. DD est	Weight	Avg. DD est
Earlier T vs. Later C	0.142	-1.126	0.142	-1.075
Later T vs. Earlier C	0.126	2.160	0.126	0.746
T vs. Never treated	0.732	-6.009	0.732	-3.146
State FE	Yes		Yes	
Year FE	Yes		Yes	
Time period	1982-1995		1982-1995	
Observations	588		588	
R^2	0.6938		0.7042	
States	42		42	

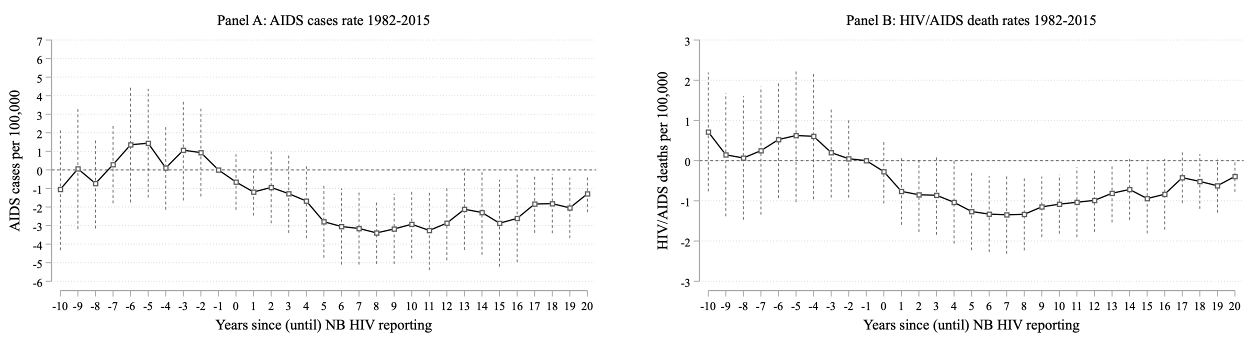
Note: T = Treatment, C=Control. The estimates reported in the first column, for both the AIDS case rate and the HIV/AIDS death rate, are slightly higher than the comparable estimates in columns (1) and (2) in table 3, because it is not possible to include interacted controls in the GB decomposition, and hence not possible to control for the initial share of population age 25-44 interacted by time. However, the decomposition still help us identify where the main effect is coming from.

Now that we have seen that the main effect actually comes from the comparison between treated states and 'clean' controls, and that our estimated effect is lower then if we only compared treated states to never treated states, we are comfortable using the simple DiD estimate. In the following we control for pre-intervention state characteristics interacted with year fixed effects. Table A4 in the appendix reports the results, using AIDS cases as the outcome. When adding the initial share of the black population (columns (1) and (6)), the coefficient increases slightly both when looking at the total effect, and the annual effect, and the significance level increases in both cases. Including initial income per capita (columns (2) and (7)) lowers the coefficients substantially and both the total effect and and annual effect becomes insignificant. Adding instead income inequality (columns (3) and (8)) or the poverty rate (columns (4) and (9)), the coefficients and significance levels for both the total and annual effect is similar to the baseline results in table 3. Lastly, columns (5) and (10) include all controls together and we see that the coefficient drops to about 2/3 for the total effect, while the annual estimates drop to about half of the baseline estimate, but the significance stays at the same levels as in the baseline result.

Table A5 shows the same robustness analysis, with the HIV/AIDS death rate as the outcome variable. The changes are all similar to those for AIDS cases, with one exception: the annual effect on HIV/AIDS death rate when including initial income is significant at the 10% level and does not drop as much as it did for AIDS cases.

5.2 Full period analysis

Again, we begin by providing evidence in favor of the common pre-trend assumption. Figure 4 shows the event study 10 years prior to the introduction of name-based reporting and up to 20 years after, which is now possible due to the extended time period of the study. For both AIDS cases and HIV/AIDS mortality the coefficients before the introduction of name-based HIV reporting fluctuate around zero and are all insignificant. After the introduction of name-based reporting the coefficients become negative. Panel A uses the AIDS case rate as the outcome, showing that the coefficients are significantly lower after five years and stay stable for the next 6-7 years, before we see an slight increase, but still an overall significantly negative effect. Panel B has the HIV/AIDS death rate as outcome, and here the pattern is very similar, although the coefficient drops after just one year, it does not become significant before after five years. The long-run effect is however less clear, and 14 years after implementation the effect does not seem significant anymore.



(a) AIDS case rate

(b) HIV/AIDS death rate

Figure 4: Event-study full period

Note: The event-study graphs show the estimated $\hat{\alpha_j}$ and the 95% confidence intervals from estimating equation (1). Panel (a) graphs the dynamic estimated differences in AIDS cases per 100,000 and panel (b) graphs the estimated dynamic differences in HIV/AIDS deaths per 100,000. Estimations include state and year fixed effects and initial share of population aged 25-44 interacted by year.

Table 5 shows the results from estimating equation (2) and equation (4) using all data up until 2015. The impact of HIV reporting on AIDS cases (column (1)) and mortality from HIV/AIDS (column (3)) are both negative and slightly smaller in magnitude compared to the baseline result prior to 1996, however the average treatment effect of HIV reporting on the HIV/AIDS death rate is similar to the effect prior to 1996, while the average treatment effects on AIDS cases drops from 39.1% before 1996 to 33.7% when including the full period. Both estimates are now statistically significant at the 5% level. However, the main results of interest from table 5 are those in column (2) and (4) which show the effects of HIV reporting taking into account the introduction of medical treatment, HAART. This effect and significance level of reporting after the introduction of HAART can be obtained directly from the coefficient on $Reporting_{it}$, because the included interaction $priorHAART_t$ takes the value one for the years prior to 1996. The effect on AIDS cases decreases slightly in magnitude and significance, but is still significant at the 10% level. The effect on mortality, on the other hand, seems to disappear after the introduction of effective medical treatment, with the coefficient decreasing to -0.738 and becoming insignificant. We interpret this in the following way: the introduction of HAART reduced mortality from HIV/AIDS, which is also clearly evident from figure 1, and HIV reporting does not give any additional effects. However, when it comes to reducing AIDS cases, having an HIV reporting system is crucial. People are still infected with HIV and in order to make sure the disease does not develop into AIDS, medical treatment is important, but the first step is to be aware that a person is infected. Thus, we believe that the effect we see from having an HIV reporting system on reducing AIDS cases is because this provides the first important step of identifying the disease at an early stage.

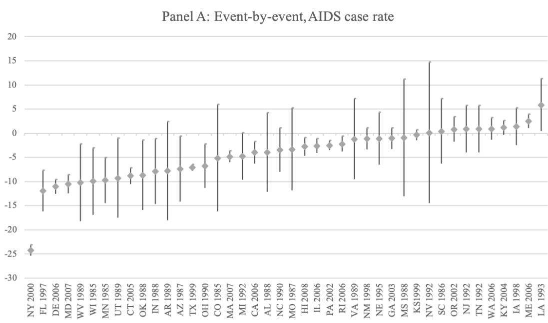
Table 5: Effect of HIV reporting on AIDS cases and HIV/AIDS mortality, full period analysis

Dep. variable	AIDS case rate (1)	AIDS case rate (2)	HIV/AIDS death rate (3)	HIV/AIDS death rate (4)
$Reporting_{it}$	-3.466**	-2.885*	-1.649**	-0.738
	(1.511)	(1.495)	(0.803)	(0.591)
$Reporting_{it} \times priorHAART_t$		-1.145		-1.796**
		(1.398)		(0.810)
$priorHAART_t$		-6.244		-3.064
		(8.226)		(3.078)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Time period	1982-2015	1982-2015	1982-2015	1982-2015
Observations	1,428	1,428	1,428	1,428
R^2	0.632	0.633	0.659	0.665
States	42	42	42	42

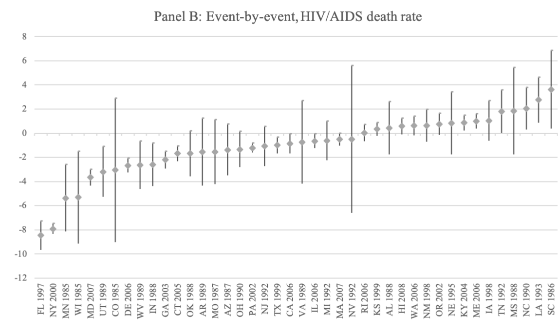
*Note: Outcome variables are AIDS cases per 100,000 and HIV/AIDS death per 100,000. All regressions include year and state fixed effects and initial share of population aged 25-44 years interacted with year fixed effects. $Reporting_{it}$ is an indicator variable equal to one after the introduction of name-based HIV reporting, and $priorHAART_t$ is an indicator variable equal to one prior to the introduction of HAART treatment (pre-1996). Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively.*

5.2.1 Robustness analysis full period

Again the coefficients presented in table 5 are a weighted average of multiple DiDs, but now there are no 'clean' controls, since all states are treated at some point over our study period, so there are only two groups: those treated early and those treated late, and the estimate is a weighted average of all possible 2x2 DiDs between these. In order to see the effect when comparing treated states with 'clean' controls, we instead follow Cengiz et al. (2019)and perform an event-by-event analysis for each of the 42 events. To do so we create 42 event specific annual state panel datasets. Each event specific dataset includes the treated state and all other clean control states for a -/+ 10 year period, ($t = -10, ..., 10$) with the introduction of HIV reporting at year $t = 0$. Clean controls are those without any change in HIV reporting within the event window of -/+ 10 years. Figure 5 shows the event-specific point estimates and confidence interval, for each event where 20/42 and 16/42 events yield statistically significant estimates for the AIDS case rate and the HIV/AIDS death rate, respectively. Also the simple average effect across all events is -4.34 for AIDS cases and -1.06 for HIV/AIDS mortality. Comparing these to the estimated effects in table 5 columns (2) and (4), we see that the effects of the standard DiDs are lower.



(a) AIDS case rate



(b) HIV/AIDS death rate

Figure 5: Event-study full period

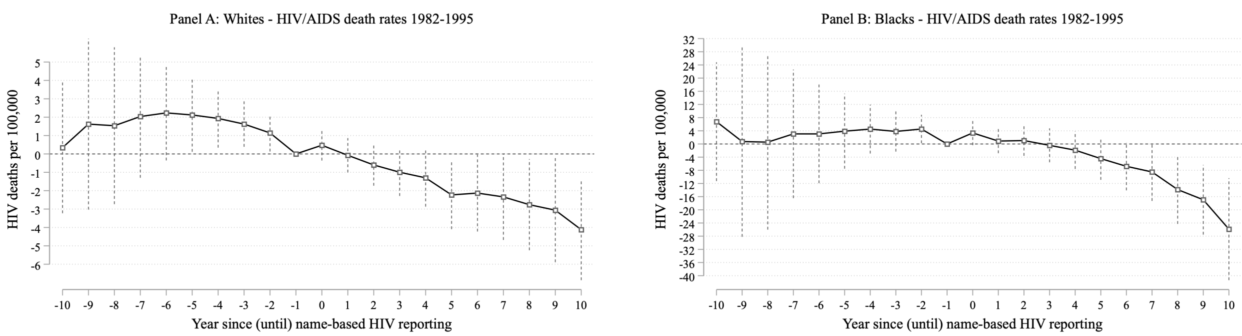
Note: The figure shows the event-specific point estimates (grey points) and corresponding 95% confidence interval (black vertical lines) for HIV reporting on (a) the AIDS case rate and (b) the HIV/AIDS death rate. The point estimates are calculated using equation (4). ordered according to the size of the estimated effect. Along the x-axis are the state and year of implementation reported for the given event. If the confidence interval does not contain 0, we can say that the effect is significant at the 5% level. 20/42 and 16/42 events yield statistically significant estimates for AIDS cases and HIV/AIDS mortality.

In the following we control for the same pre-intervention state characteristics interacted with year fixed effects as we did for the pre-1996 period. Results are presented in table A6 and table A7 in the appendix. Table A6 shows the results having the AIDS case rate as the outcome variable. We are mainly interested in the results of the even columns, since these include the interaction with the HAART treatment period. When including the initial share of the black population (column (2)) the coefficient increases and so does the significance level, so that the coefficient is significant at the 1% level. Otherwise, the coefficients and significance levels are very similar to the baseline results in table 5 column (2). Only when including initial income per capita (column (4)) does the coefficient drop and becomes insignificant.

Table A7 shows the results with the HIV/AIDS death rate as the outcome variable. Again, including the initial share of the black population (column (2)) increases the estimate and it becomes significant at the 5% level. Otherwise, the coefficients are stable and remain insignificant as in the baseline results (table 5, column (4))

5.3 Racial differences

As shown in several studies including Aburto et al. (2021) the HIV epidemic had a disproportionate impact on black communities in the US. Our robustness results in the appendix also indicate that once we include the initial share of the black population we see an increased effect of HIV reporting, so it is interesting to see if we will find differences of the effect of having HIV reporting, separately for whites and blacks. We are only able to focus on mortality from HIV/AIDS as the outcome variable, since it is not possible to obtain AIDS cases divided by race from the annual surveillance reports, except for the most recent years. We start with the period prior to 1996, with the results given in figure 6 and table 6. Our sample is reduced to 33 states, since the share of the black population in some states is very low, and hence also mortality from HIV/AIDS was too low to be reported by CDC and data for most years is therefore suppressed (see table A3 in the appendix for the list of states included)[12].



(a) HIV/AIDS death rate for whites

(b) HIV/AIDS death rate for blacks

Figure 6: Event-study prior to 1996 for blacks and whites

Note: The event-study graphs show the estimated $\hat{\alpha_j}$ and the 95% confidence intervals from estimating equation (1). Panel (a) graphs the estimated differences in HIV/AIDS deaths per 100,000 for whites, while panel (b) shows the corresponding graph for blacks. Both include state and year fixed effects. They also include the initial share of the white and black population aged 25-44 interacted by year fixed effects, respectively.

[12] If they have less than 10 deaths, the data are suppressed by CDC.

Table 6: Effect of HIV reporting on HIV/AIDS mortality for whites and blacks, pre-1996 analysis

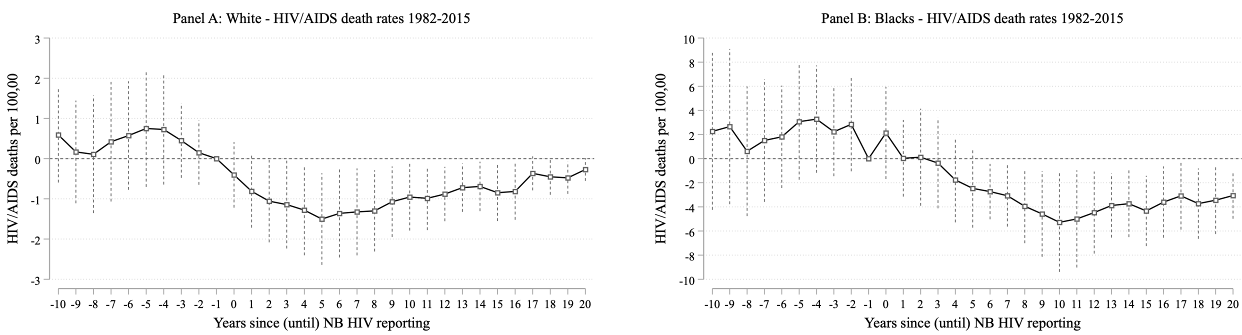
Dep. variable	HIV/AIDS death rate Whites (1)	HIV/AIDS death rate Blacks (2)	HIV/AIDS death rate Whites (3)	HIV/AIDS death rate Blacks (4)
$Reporting_{it}$	-2.323**	-6.466*		
	(0.879)	(3.402)		
$Reporting_{it} \times (t + 1 - j_i)$			-0.544***	-2.566***
			(0.182)	(0.692)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Time period	1982-1995	1982-1995	1982-1995	1982-1995
Observations	462	462	462	462
R^2	0.9473	0.9230	0.9512	0.9335
States	33	33	33	33

Note: The outcome variable is HIV/AIDS death per 100,000 for whites and blacks. All regressions include year and state fixed effects and initial share of white and black population age 25-44 years interacted with year fixed effects, respectively. $Reporting_{it}$ *is an indicator variable equal to one after the introduction of name-based HIV reporting, and* j_i *is the year of the introduction of HIV reporting. Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively. Wild cluster bootstrapping standard error are similar in significance level.*

We find an overall negative and significant effect on HIV/AIDS mortality for both whites and blacks. For the period before 1996 we are mainly interested in the annual effects shown in table 6 in column (3) for whites and in column (4) for blacks. Both are highly significant, and compared to the average death rate from HIV/AIDS, which for whites was 4.87 per 100,000 and 16.41 per 100,000 for blacks, the effect for whites was an annual reduction of 11.17% while it for blacks was 15.64%. The event graphs in figure 6 confirm that the effect increases over time, and it takes about 5 years before we see significant effects for both whites and blacks. From figure 6a, we also see some evidence that that the HIV/AIDS death rate for whites 4-5 years prior to the introduction of HIV reporting was significantly higher whereas for blacks there is no evidence of such a pre-trend, with all coefficients prior to the introduction of HIV reporting around zero and insignificant. This might seem to suggest that reporting was introduced earlier in areas where whites were more likely to die from HIV/AIDS, but that areas with high black mortality were not similarly prioritized.

Once we extend our study to the full period, the pre-trend for whites vanishes and we see a similar pattern as for the full population. For the black population, however, the effect seems more persistent over time and stays significantly negative over the full period (see figure 7). The results for the white population follow the baseline results for the total population (table 7). The effect of HIV reporting after controlling for the introduction of HAART drops and is only significant at the 10% level. On the other hand, the coefficients for the black population remain high and significant for HIV/AIDS mortality after the introduction of HAART. HIV reporting lowered mortality from HIV/AIDS among blacks by 4.4431 deaths per 100,000. If we compare this with the average number of deaths among blacks over the full period, which was 14.82 deaths per 100,000, this corresponds to an average reduction of 29.9%, which is considerable.

This difference indicates that blacks did not experience the same benefit from HAART as whites, perhaps due to social inequality and potentially difficulties accessing treatment, or even unwillingness to do so (see Alsan and Wanamaker (2018); Whetten et al. (2006); Gaston and Alleyne-Green (2013)).



(a) HIV/AIDS death rate for whites

(b) HIV/AIDS death rate for blacks

Figure 7: Event-study full period for blacks and whites

Note: The event-study graphs show the estimated $\hat{\alpha_j}$ *and the 95% confidence intervals from estimating equation (4). Panel (a) graphs the estimated differences in HIV/AIDS deaths per 100,000 for whites, while panel (b) shows the corresponding graph for blacks.*

Table 7: Effect of HIV reporting on HIV/AIDS mortality for whites and blacks, full period analysis

Dep. variable	HIV/AIDS death rate	HIV/AIDS death rate	HIV/AIDS death rate	HIV/AIDS death rate
	Whites	Whites	Blacks	Blacks
	(1)	(2)	(3)	(4)
$Reporting_{it}$	-1.805**	-0.667*	-5.611**	-4.431**
	(0.699)	(0.363)	(2.315)	(2.044)
$Reporting_{it} \times priorHAART_t$		-2.135**		-2.193
		(0.873)		(2.195)
$priorHAART_t$		-2.147		-11.516**
		(2.039)		(5.210)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Time period	1982-2015	1982-2015	1982-2015	1982-2015
Observations	1,122	1,122	1,122	1,122
R^2	0.7092	0.7222	0.7037	0.7046
States	33	33	33	33

Note: The outcome variable is HIV/AIDS death per 100,000 for whites and blacks. All regressions include year and state fixed effects and initial share of white and black population age 25-44 years interacted with year fixed effects, respectively. $Reporting_{it}$ *is an indicator variable equal to one after the introduction of name-based HIV reporting, and* $priorHAART_t$ *is an indicator variable equal to one prior to the introduction of HAART treatment (prior to 1996). Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively. Wild cluster bootstrapping standard error are similar in significance level.*

6 Conclusion

We have provided the first quantitative analysis of the impact of surveillance, testing and reporting on mortality and cases during a pandemic. We find that HIV reporting helped reduce AIDS cases and mortality from HIV/AIDS prior to the introduction of the effective treatment, HAART, and that this was more pronounced for the black population. With the introduction of an effective treatment, HAART, surveillance continued to have a significant effect on reducing new AIDS cases, but no impact on mortality for the general population. However, blacks continued to benefit.

Our results suggest that surveillance is an important tool for combating epidemics, even in the presence of effective treatments, especially if access to these is unequal, perhaps due to its impact on the avoidance of risky behavior. Moreover, our work supports earlier studies which have highlighted the importance of combating stigma associated with a disease (see Merson et al. (2008)). Many states delayed introducing name-based reporting due to concerns about privacy, which in turn reflected the deep-seated prejudices of society towards for example blacks and drug users, who were particularly, although by no means exclusively, impacted by HIV. Policymakers, community leaders, and others in a position to influence public opinion thus have an important role to play in combating novel viruses, and this can surely be generalized beyond the case presented here.

Appendix

Table A1: Implementation of HIV reporting

Year	Number of states	State names
1985	3	Colorado, Minnesota, Wisconsin
1986	1	South Carolina, Idaho
1987	2	Arizona, Missouri
1988	4	Alabama, Indiana, Mississippi, Oklahoma, North Dakota, South Dakota
1989	4	Arkansas, Utah, Virginia, West Virginia, Wyoming
1990	2	North Carolina, Ohio
1991	0	
1992	4	Michigan, Nevada, New Jersey, Tennessee
1993	1	Louisiana
1994	0	
1995	1	Nebraska
1996	0	
1997	1	Florida
1998	2	Iowa, New Mexico
1999	2	Kansas, Texas, Alaska
2000	1	New York
2001	0	
2002	2	Oregon*, Pennsylvania
2003	1	Georgia
2004	1	Kentucky*
2005	1	Connecticut*, New Hampshire*
2006	6	Illinois*, Maine*, Washington*, Rhode Island*, Delaware*, California*, Montana*
2007	2	Maryland*, Massachusetts*
2008	1	Hawaii*, Vermont*

*Notes: *These states had implemented an alternative (anonymous) system earlier before switching to the name-based system. The first date of implementation for the states are Oregon (1988), Kentucky (2000), Connecticut (2002), Illinois (1999), Maine (1999), Washington (1999), Rhode Island (2000), Delaware (2001), California (2002), Maryland (1994), Massachusetts (1998), Hawaii (2001). States in grey are dropped in the analysis due to suppressed mortality data from CDC.*

Table A2: Suppressed HIV death data

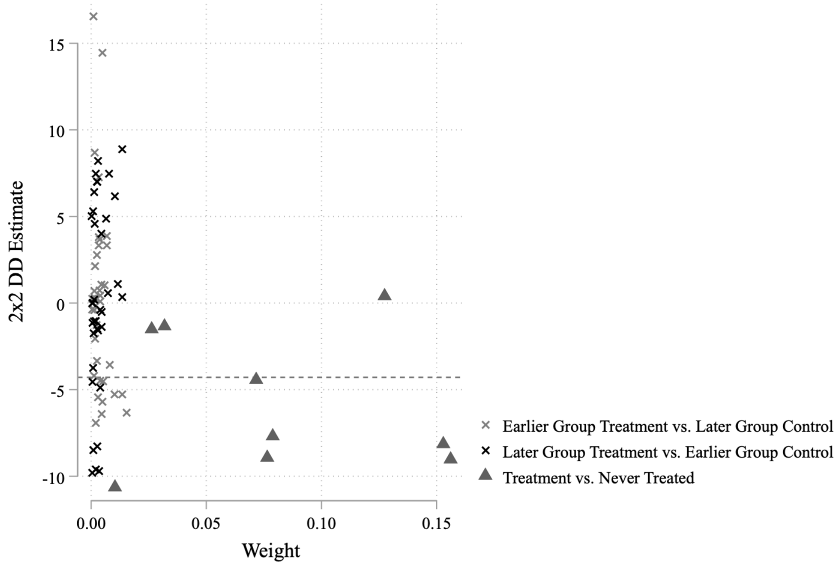
State	Year(s)
Alaska*	1989, 1998, 2001, 2003, 2004, 2005, 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015
Hawaii	2013
Idaho*	1989, 1999, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2015, 2016
Iowa	1998
Maine	2010, 2011, 2012, 2014, 2015,
Montana*	1990, 1996, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015
New Hampshire*	2001, 2008, 2009, 2010, 2012, 2013, 2014
North Dakota*	1989, 1990, 1991, 1992, 1993, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015
Rhode Island	2014
South Dakota*	1989, 1990, 1991, 1992, 1994, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2011, 2012, 2013, 2014, 2015
Utah	2014
Vermont*	1997, 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015
Wyoming*	1989, 1990, 1991, 1993, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015

*Notes: * States are drop in the analysis due to suppressed data for more than five years.*

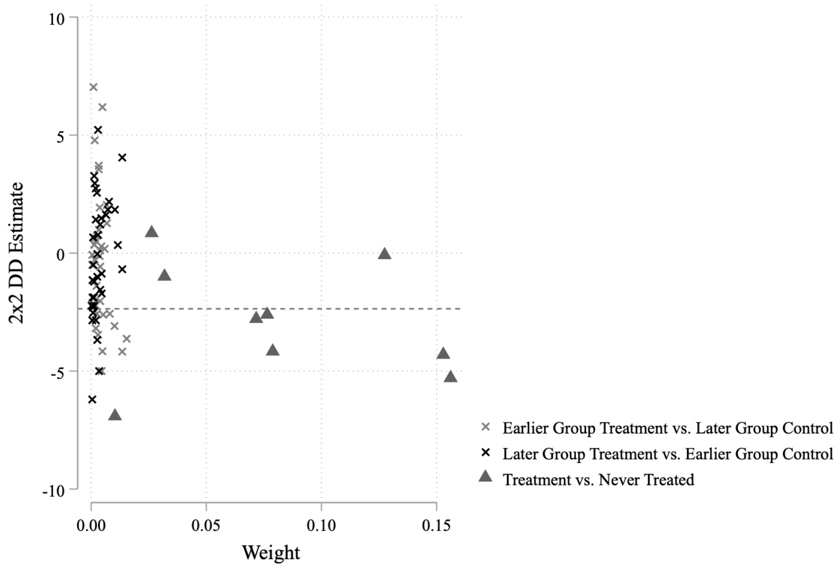
Table A3: Suppressed HIV death data (Blacks and whites)

State	Year(s) - Blacks	Year(s) - Whites
Alaska*	All years	
Arizona	1998,	
Colorado	1998, 2006, 2011, 2012, 2013, 2015	
Delaware		1998, 2009, 2011, 2012, 2013, 2014
Hawaii*	All years	
Idaho*	All years	
Iowa*	All years	
Kansas*	1990, 1998, 2000,2002, 2004, 2005, 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015	
Maine*	All years	
Minnesota	1989, 2012, 2014, 2015	
Montana*	All years	
Nebraska*	1989, 1990, 1991, 1992, 1993, 1995, 1998, 1999, 2000, 2002, 2004, 2005, 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015	
Nevada	1990	
New Hampshire*	All years	
New Mexico*	All years	
North Dakota*	All years	
Oklahoma	2015	
Oregon*	1989, 1990, 1991, 1992,1995, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015	
Rhode Island*	1989, 1998, 1999, 2000, 2001,2002, 2005, 2007, 2008, 2010, 2011, 2012, 2013, 2014, 2015	
South Dakota*	All years	
Utah*	All years	
Vermont*	All years	
Washington	2008, 2012, 2013,	
West Virginia*	1989, 1990, 1991, 1992, 1993, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2014, 2015	
Wyoming*	All years	

*Notes: * States are drop in the analysis due to suppressed data for more than six years.*



(a) AIDS case rate



(b) HIV/AIDS death rate

Figure A1: Goodman-Bacon decomposition pre-1996

Note: The figure show all possible 2x2 DiD estimates and the corresponding weights. Panel (a) AIDS cases per 100,000 and panel (b) HIV/AIDS deaths per 100,000

Table A4: Effect of HIV reporting on AIDS cases controlling for pre-intervention characteristics, pre-1996 analy-

sis

Dep. variable	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate	AIDS case rate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$Reporting_{it}$	-5.670**	-1.737	-4.151*	-4.036*	-2.788*					
	(2.153)	(1.790)	(2.082)	(2.368)	(1.454)					
$Reporting_{it} \times (t+1-j_i)$						-1.429***	-0.707	-1.099**	-1.220**	-0.609**
						(0.423)	(0.441)	(0.448)	(0.478)	(0.296)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
int. black pop share × Year FE	Yes	No	No	No	Yes	Yes	No	No	No	Yes
int. income per cap × Year FE	No	Yes	No	No	Yes	No	Yes	No	No	Yes
int. income inequality × Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes
int. poverty rate × Year FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995
Observations	588	588	588	588	588	588	588	588	588	588
R^2	0.748	0.764	0.739	0.708	0.855	0.764	0.770	0.749	0.724	0.856
States	42	42	42	42	42	42	42	42	42	42

Notes: The outcome variable is AIDS cases per 100,000. All regressions include year and state fixed effects, and initial share of population aged 25-44 years interacted with year fixed effects. $Reporting_{it}$ *is an indicator variable equal to one after the introduction of name-based HIV reporting, and* j_i *is the year of the introduction of HIV reporting. In columns (1) and (6) the initial black population share interacted with year fixed effects are included, in columns (2) and (7) the initial income per capita interacted with year fixed effects are included, and in columns (3) and (8) initial income inequality interacted with year fixed effects are included, in columns (4) and (9) the initial poverty rate interacted with year fixed effects are included, in columns (5) and (10) all controls are included. Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively.*

Table A5: Effect of HIV reporting on HIV/AIDS mortality controlling for pre-intervention characteristics, pre-1996 analysis

Dep. variable	HIV/AIDS death rate (1)	HIV/AIDS death rate (2)	HIV/AIDS death rate (3)	HIV/AIDS death rate (4)	HIV/AIDS death rate (5)	HIV/AIDS death rate (6)	HIV/AIDS death rate (7)	HIV/AIDS death rate (8)	HIV/AIDS death rate (9)	HIV/AIDS death rate (10)
$Reporting_{it}$	-3.073***	-1.145	-2.122**	-2.277*	-1.605*					
	(1.050)	(1.017)	(0.991)	(1.191)	(0.822)					
$Reporting_{it} \times (t+1-j_i)$						-0.712***	-0.414*	-0.524**	-0.609**	-0.368**
						(0.206)	(0.229)	(0.214)	(0.232)	(0.167)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
int. black pop share × Year FE	Yes	No	No	No	Yes	Yes	No	No	No	Yes
int. income per cap × Year FE	No	Yes	No	No	Yes	No	Yes	No	No	Yes
int. income inequality × Year FE	No	No	Yes	No	Yes	No	No	Yes	No	Yes
int. poverty rate × Year FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995	1982-1995
Observations	588	588	588	588	588	588	588	588	588	588
R^2	0.774	0.750	0.756	0.718	0.854	0.787	0.758	0.765	0.732	0.856
States	42	42	42	42	42	42	42	42	42	42

*Notes: The outcome variable is HIV/AIDS deaths per 100,000. All regressions include year and state fixed effects, and initial share of population aged 25-44 years interacted with year fixed effects. $Reporting_{it}$ is an indicator variable equal to one after the introduction of name-based HIV reporting, and j_i is the year of the introduction of HIV reporting. In columns (1) and (6) the initial black population share interacted with year fixed effects are included, in columns (2) and (7) the initial income per capita interacted with year fixed effects are included, and in columns (3) and (8) initial income inequality interacted with year fixed effects are included, in columns (4) and (9) the initial poverty rate interacted with year fixed effects are included, in columns (5) and (10) all controls are included. Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively.*

Table A6: Effect of HIV reporting on AIDS cases controlling for pre-intervention characteristics, full period analy- sis

Dep. variable	AIDS case rate (1)	AIDS case rate (2)	AIDS case rate (3)	AIDS case rate (4)	AIDS case rate (5)	AIDS case rate (6)	AIDS case rate (7)	AIDS case rate (8)	AIDS case rate (9)	AIDS case rate (10)
$Reporting_{it}$	-4.321***	-3.785***	-1.763	-2.015	-3.506**	-2.900**	-3.596**	-3.214**	-2.188**	-2.351**
	(1.490)	(1.336)	(1.224)	(1.310)	(1.384)	(1.411)	(1.631)	(1.584)	(0.979)	(0.880)
$Reporting_{it} \times priorHAART_t$		-1.066		0.506		-1.195		-0.748		0.338
		(1.223)		(1.306)		(1.409)		(1.371)		(1.160)
$priorHAART_t$		-0.979		-4.800		16.63		3.859		0.709
		(6.340)		(8.745)		(10.91)		(8.212)		(6.823)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
int. black pop share × Year FE	Yes	Yes	No	No	No	No	No	No	Yes	Yes
int. income per cap × Year FE	No	No	Yes	Yes	No	No	No	No	Yes	Yes
int. income inequality × Year FE	No	No	No	No	Yes	Yes	No	No	Yes	Yes
int. poverty rate × Year FE	No	No	No	No	No	No	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015
Observations	1,428	1,428	1,428	1,428	1,428	1,428	1,428	1,428	1,428	1,428
R^2	0.682	0.683	0.705	0.705	0.669	0.670	0.644	0.645	0.804	0.804
States	42	42	42	42	42	42	42	42	42	42

*Notes: The outcome variable is AIDS cases per 100,000 people. All regressions include year and state fixed effects, and initial share of population aged 25-44 years interacted with year fixed effects. $Reporting_{it}$ is an indicator variable equal to one after the introduction of HIV reporting, and $priorHAART_t$ is an indicator variable equal to one prior to the introduction of HAART treatment (pre-1996). In columns (1) and (6) the initial black population share interacted with year fixed effects are included, in columns (2) and (7) the initial income per capita interacted with year fixed effects are included, and in columns (3) and (8) initial income inequality interacted with year fixed effects are included, in columns (4) and (9) the initial poverty rate interacted with year fixed effects are included, in columns (5) and (10) all controls are included. Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively.*

Table A7: Effect of HIV reporting on HIV/AIDS mortality controlling for pre-intervention characteristics, full period analy-
sis

Dep. variable	HIV/AIDS death rate (1)	HIV/AIDS death rate (2)	HIV/AIDS death rate (3)	HIV/AIDS death rate (4)	HIV/AIDS death rate (5)	HIV/AIDS death rate (6)	HIV/AIDS death rate (7)	HIV/AIDS death rate (8)	HIV/AIDS death rate (9)	HIV/AIDS death rate (10)
$Reporting_{it}$	-2.125***	-1.151**	-0.985	-0.681	-1.560**	-0.683	-1.775**	-0.930	-1.117*	-0.816**
	(0.775)	(0.497)	(0.733)	(0.571)	(0.692)	(0.542)	(0.860)	(0.607)	(0.560)	(0.370)
$Reporting_{it} \times priorHAART_t$		-1.937**		-0.610		-1.728**		-1.656*		-0.624
		(0.831)		(0.700)		(0.749)		(0.831)		(0.730)
$priorHAART_t$		-0.994		-2.577		8.754**		2.380		2.386
		(2.163)		(3.355)		(3.965)		(2.757)		(2.424)
int. age 25-44 share × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
int. black pop share × Year FE	Yes	Yes	No	No	No	No	No	No	Yes	Yes
int. income per cap × Year FE	No	No	Yes	Yes	No	No	No	No	Yes	Yes
int. income inequality × Year FE	No	No	No	No	Yes	Yes	No	No	Yes	Yes
int. poverty rate × Year FE	No	No	No	No	No	No	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time period	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015	1982-2015
Observations	1,428	1,428	1,428	1,428	1,428	1,428	1,428	1,428	1,428	1,428
R^2	0.712	0.718	0.714	0.714	0.696	0.702	0.669	0.674	0.810	0.811
States	42	42	42	42	42	42	42	42	42	42

*Notes: The outcome variable is HIV/AIDS deaths per 100,000 people. All regressions include year and state fixed effects, and initial share of population aged 25-44 years interacted with year fixed effects. $Reporting_{it}$ is an indicator variable equal to one after the introduction of HIV reporting, and $priorHAART_t$ is an indicator variable equal to one prior to the introduction of HAART treatment (pre-1996). In columns (1) and (6) the initial black population share interacted with year fixed effects are included, in columns (2) and (7) the initial income per capita interacted with year fixed effects are included, and in columns (3) and (8) initial income inequality interacted with year fixed effects are included, in columns (4) and (9) the initial poverty rate interacted with year fixed effects are included, in columns (5) and (10) all controls are included. Robust standard errors clustered at the state level are in parentheses. *, ** and *** determine significance levels of 10%, 5% and 1%, respectively.*

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