Disparities among states in hiv-related mortality in persons with hiv infection, 37 U.S. STATES, 2001–2007

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Objective: To examine interstate variation in US HIV case-fatality rates, and compare them with corresponding conventional HIV death rates.

Design: Cross-sectional analysis using data on deaths due to HIV infection from the National Vital Statistics System and data on persons 15 years or older living with HIV infection in 2001—–2007 in 37 U.S. states from the national HIV/AIDS Reporting System.

Methods: State rankings by age-adjusted HIV case-fatality rates (with HIV-infected population denominators) were compared with rankings by conventional death rates (with general population denominators). Negative binomial regression determined case-fatality rate ratios (RRs) among states, adjusted for age, sex, race/ethnicity, year, and state-level markers of late HIV diagnosis.

Results: Based on 3,096,729 HIV-infected person-years, the overall HIV case-fatality rate was 20.6/1,000 person-years (95% confidence interval [CI], 20.3–20.9). Age-adjusted rates by state ranged from 9.6 (95% CI 6.8–12.4) in Idaho to 32.9 (95% CI 29.8–36.0) in Mississippi, demonstrating significant differences across states, even after adjusting for race/ethnicity ($p < 0.0001$). Many states with low conventional death rates had high case-fatality rates. Nine of the ten states with the highest case-fatality rates were located in the U.S. South.

Conclusions: Case-fatality rates complement and are not entirely concordant with conventional death rates. Interstate differences in these rates may reflect differences in secondary and tertiary prevention of HIV-related mortality among infected persons. These data suggest that state-specific contextual barriers to care may impede improvements in quality and disparities of health-care without targeted interventions.

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Introduction

In the United States (US), human immunodeficiency virus (HIV) infection remains a major public health concern. About 50,000 new infections continue to occur annually[1], and while deaths due to HIV infection declined dramatically after the introduction of highly active antiretroviral therapy (HAART) in the late 1990s[2], continued mortality reductions have been small in recent years[3]. The *National HIV/AIDS Strategy for the United State*s has prioritized the reduction of health disparities among demographic groups[4]. Examining disparities by geography is important, since they may suggest reducible contextual barriers to health care for

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HIV-infected persons[5–7]. Interstate disparities may be particularly informative, because health care access varies with state policies regarding insurance for healthcare and prescription drugs. Yet few studies have examined interstate disparities in HIV-related outcomes in the HAART era. Two cross-sectional studies from the late 1990 s found substantial state-level variation in the use of services, length of stay, and inpatient mortality among hospitalized HIV-infected patients in 10 states[8,9]. Annual national vital statistics also report wide differences in rates of death due to HIV disease by state (range: 0.8—8.3 per 100,000 in 2007)[10].

The choice of the measure used to describe state-based disparities is underappreciated. "Conventional" death rates include both HIV-infected and uninfected individuals in the denominator to quantify HIV mortality in a population overall. However, these rates may obscure important distinctions by reflecting the underlying prevalence and, indirectly, the incidence, of HIV infection in the general population. Thus, higher death rates may be due, in part, to failures of primary prevention of HIV infection, which can confound the analysis of factors important for secondary or tertiary prevention of death among people already infected with HIV. In contrast, case-fatality rates assess mortality in only the HIV-infected population, and thus are more useful for identifying determinants of the availability, utilization, timeliness, and quality of care for that population.

Using national population-based data, we compared HIV case-fatality rates in 37 US states in 2001—2007 to conventional HIV death rates based on general population denominators. We also compared case-fatality rates among states, controlling for age, sex, race/ethnicity, year, and state-level markers of late HIV diagnosis. Lastly, to explore the potential consequences that interventions could have if they lowered state case-fatality rates enough to eliminate the interstate differences, we calculated the number of excess deaths associated with living in states with higher case-fatality rates.

Methods

Study population and data sources

HIV case-fatality rate denominators (reported per 1,000 HIV-infected person-years) were computed using data from all persons aged 15 years and older alive during 2001—2007 who were reported to the national HIV/AIDS Reporting System (HARS) by December 31, 2009[11] and met the surveillance case definition of HIV infection[12]. Analysis was restricted to persons who at diagnosis were residents of the 37 states that had confidential name-based reporting of HIV infection for at least four years by 2010, because four years has been found long enough for reliable determination of trends after such reporting has been implemented in a state[13]. State surveillance programs ascertained deaths by linking cases with death registries (state vital statistics, National Death Index, or Social Security Death Master File). Persons were presumed alive if not found to be dead. Numbers in each state were adjusted for reporting delays[13].

Case-fatality numerators used HIV deaths from death certificate data files of the National Vital Statistics System for 2001—2007[14]. These files contain individual-level information on all deaths reported to state or local health departments. HIV deaths were defined as those for which the underlying cause was determined to be HIV disease, as indicated by ICD-10 codes B20 through B24[15].

For comparison, we calculated conventional HIV death rates (per 100,000 population person-years) for each state using the same numerator data but denominators derived using data from the annual US Census Bureau population estimates[16]. For this measure, we included all persons aged 15 and older who lived in the same states in 2001—2007.

Statistical analysis

Direct standardization was used for age-adjustment based on the 2000 US Standard Population[17]. States were ranked based on each of the age-adjusted rates calculated for the full study period. Five states contributed data only in later years due to newly implemented confidential name-based HIV reporting: New York (2002—2007); Georgia (2005—2007); and Connecticut, Kentucky, and New Hampshire (2006—2007).

We compared HIV case-fatality rates among states using negative binomial regression. We used the state with the lowest overall case-fatality rate as the reference group and controlled for age, sex, race/ethnicity, and year. We explored the possibility that late HIV diagnosis at the state level could account for differences in HIV case-fatality rates by further controlling for two markers of late HIV diagnosis in each state: the median CD4+ T-lymphocyte count at HIV diagnosis in 2005—2007 and the percent of all HIV diagnoses considered to be late (i.e., diagnosed within 12 months of initial HIV diagnosis) in 2007[18]. These measures of late HIV diagnosis were included as random effects, in order to properly account for clustering within states, in models that also controlled for the previously mentioned characteristics.

To assess potential mortality reductions if interventions could reduce case-fatality rates in higher mortality states to those in lower mortality states, we calculated the population attributable fraction (PAF), i.e., the proportion of deaths hypothetically prevented by eliminating the causal effects of a given exposure[19]. We defined PAF as $1-\Sigma(pd_i/RR_i)$, where pd_i represents the proportion of HIV deaths in each quartile i of state case-fatality rates and

RR_i represents the adjusted relative case-fatality rate for *i* compared with the lowest quartile[19]. We calculated excess HIV deaths that could be prevented by multiplying the PAF in each quartile by the number of observed deaths and then summing[20]. 95% CIs were constructed based on 1,000 parametric bootstrap samples. Sensitivity analyses examined how the PAF and excess deaths would change if alternate reference groups were chosen.

Results

The analysis included 3,096,729 HIV-infected person-years during 2001—2007 from 37 states. Overall, the age-adjusted HIV case-fatality rate was 20.6/1,000 HIV-infected person-years (95% CI 20.3—20.9). The corresponding conventional HIV death rate (using the general population denominator) was 5.8/100,000 person-years (95% CI 5.7—5.8). Figure 1 displays maps of the two rates in each state, showing generally higher values for both in the South.

Table 1 provides HIV case-fatality rates and conventional death rates, with corresponding rankings for each state, highlighting those with more discordant rankings. The ranks of certain states changed substantially when moving from the conventional death rate to the case-fatality rate. For example, Wyoming's rank moved up 27 places (from 36 to 9) and Iowa's 17 places (from 34 to 17). Similarly, the ranks of New York and Connecticut moved down 27 places (from 3 to 30) and 23 places (from 12 to 35), respectively. In contrast, other states demonstrated no major change in ranks. For example, Louisiana had the second highest rate regardless of the denominator used.

Table 2 shows results from regression models examining characteristics associated with HIV case-fatality rate ratios (RRs). Overall, differences by state were statistically significant when initially adjusting for age only and after adjusting for sex, race/ethnicity, and calendar year also (both $p < 0.0001$). Compared with Colorado, which had the lowest rate in the fully adjusted model, 12 of the 14 states representing the South had case-fatality rates at least twice as high, illustrating substantial variation in rates by state (e.g., RR for Georgia: 2.53, 95% CI 2.27—2.80). Other characteristics significantly associated with increases in case-fatality rates included older age and non-Hispanic black race/ethnicity. In addition, case-fatality rates declined over time (RR 0.91 per year, 95% CI 0.90—0.91). Including state-level measures of late HIV diagnosis in models did not change the rate ratios or overall rankings of state case-fatality rates appreciably (data not shown).

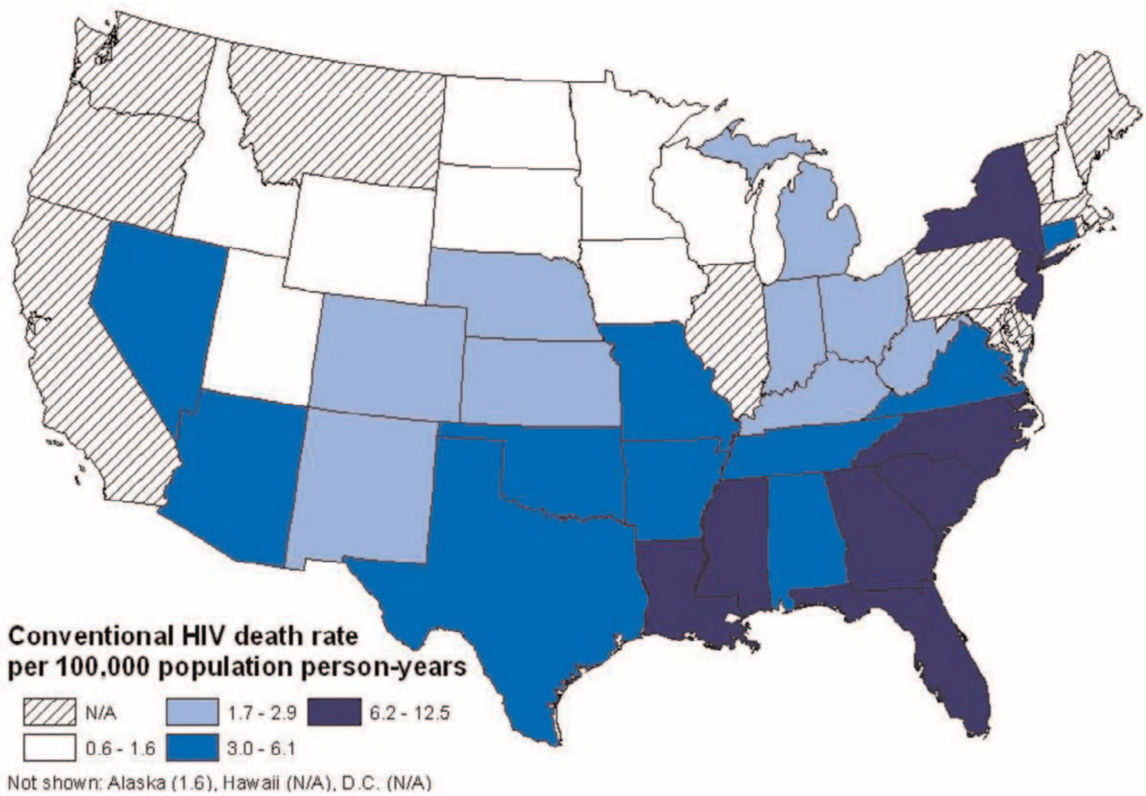
The PAF attributable to living in states with case-fatality rates higher than those in the lowest quartile was 0.269 (95% CI 0.253—0.286) (Table 3). This translates to 5,669 excess deaths (95% CI 5,331—6,076) that hypothetically could have been eliminated if an intervention reduced case-fatality rates in states with higher rates to rates of states in the lowest quartile, or 809 deaths annually. Sensitivity analyses using alternate reference groups to target mortality reduction goals resulted in the hypothetical elimination of 291—913 excess deaths annually (Appendix Table 1).

Discussion

We identified significant interstate differences in US HIV case-fatality rates, with rates in many southern states being more than twice as great as those in other states even after adjusting for differences in racial/ethnic and age distributions. Substantial rank differences between case-fatality rates and conventional death rates in some states imply important differences in primary versus secondary and tertiary HIV prevention in these areas. For example, New York's conventional HIV death rate was the third highest among the states examined, attributable in part to its high HIV prevalence[21]. Its comparatively low case-fatality rate rank (30^{th} out of the 37 states) suggests good secondary and tertiary prevention of HIV disease, which could be due in part to earlier screening or entry into care, better adherence to medical instructions, or better care, compared to many other states. In contrast, Wyoming has a relatively low conventional HIV death rate, ranking 36^{th}, owing to its low HIV prevalence. However, its high HIV case-fatality rate rank (9^{th}) suggests that services to those with HIV may be inadequate.

The elimination of HIV-related health disparities is a national priority[4]. Our study shows that state of residence should be considered as a geographic unit of analysis when assessing disparities, in addition to categorizations like sex, race/ethnicity, and transmission category. Our findings also support earlier work identifying disparities in the southern US for earlier consequences of HIV infection, namely AIDS diagnosis[22]. Examination of these rate disparities is a crucial step in addressing their causes, and can guide policy-makers to consider area-level factors as well as individual factors when choosing interventions[23].

Why do HIV case-fatality rates vary among states? Delayed diagnosis of HIV infection, which has been found to differ by state of residence[18], may be attributed to geographic differences in the patient perception of risk for HIV and the benefits of testing, in how screening is done[24], or both. However, our analyses found that case-fatality rate rankings did not change substantively after controlling for available measures of late diagnosis, suggesting that the role of late diagnosis may be less important at the state level than other factors. However, future work with more complete data on late diagnosis



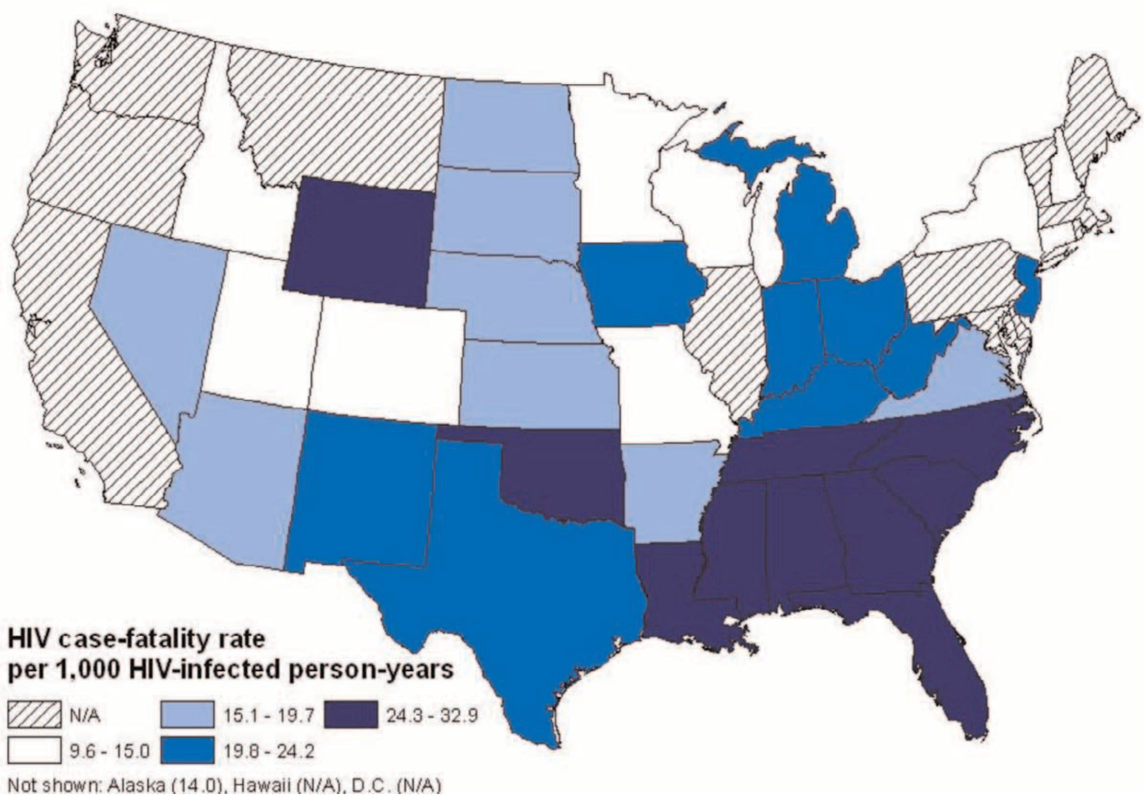


Fig. 1. Maps of conventional HIV death rate per 100,000 population person-years and HIV case-fatality rate per 1,000 HIV-infected person-years, 37 US states, 2001–2007.

Table 1. HIV mortality rates and associated rankings by state of residence, 37 US states, 2001–2007.

State	HIV deaths	Conventional HIV death rate: Person-years	Conventional HIV death rate: Rate per 100,000 p-y (95% CI)	Ranking	HIV case-fatality rate: Person-years	HIV case-fatality rate: Rate per 1,000 p-y (95% CI)	Ranking	Difference in ranking
Wyoming	19	2,829,013	0.7 (0.4, 1.0)	36	1,064	24.3 (0.8, 47.8)	9	+27
Iowa	144	16,527,812	0.9 (0.8, 1.1)	34	8,083	20.1 (13.9, 26.3)	17	+17
Oklahoma	627	19,532,857	3.4 (3.1, 3.7)	17	26,502	29.8 (25.0, 34.6)	3	+14
Kentucky[a]	135	6,779,940	2.0 (1.6, 2.3)	24	7,811	23.3 (15.5, 31.0)	13	+11
West Virginia	175	10,383,505	1.8 (1.5, 2.1)	25	8,294	23.2 (16.8, 29.6)	14	+11
South Dakota	39	4,293,592	1.0 (0.7, 1.3)	33	2,055	19.3 (10.6, 28.1)	22	+11
North Dakota	19	3,609,298	0.6 (0.3, 0.8)	37	897	15.2 (8.1, 22.4)	27	+10
New Mexico	247	10,372,810	2.5 (2.2, 2.8)	20	12,798	24.1 (18.2, 30.1)	11	+9
Mississippi	1,279	15,752,311	8.5 (8.1, 9.0)	7	46,914	32.9 (29.8, 36.0)	1	+6
Nebraska	160	9,628,516	1.8 (1.5, 2.1)	26	8,312	19.6 (13.8, 25.4)	20	+6
North Carolina	3,033	47,766,115	6.4 (6.1, 6.6)	8	123,187	28.8 (26.9, 30.6)	4	+4
Tennessee	1,988	33,184,818	6.1 (5.8, 6.4)	9	80,323	27.0 (24.7, 29.3)	5	+4
Indiana	800	34,381,740	2.4 (2.2, 2.5)	23	47,183	19.7 (16.8, 22.5)	19	+4
New Hampshire[a]	22	2,136,165	1.0 (0.6, 1.4)	32	2,101	15.0 (1.6, 28.4)	28	+4
Alabama	1,345	25,237,736	5.5 (5.2, 5.8)	11	58,116	25.0 (22.6, 27.4)	8	+3
Michigan	1,540	55,867,002	2.8 (2.6, 2.9)	19	76,226	20.9 (18.9, 22.8)	16	+3
Ohio	1,514	63,829,345	2.4 (2.3, 2.5)	21	87,552	19.8 (17.8, 21.9)	18	+3
Kansas	235	15,093,032	1.6 (1.4, 1.8)	27	14,294	15.3 (11.6, 18.9)	26	+1
Louisiana	2,626	24,358,737	11.2 (10.8, 11.6)	2	93,984	32.5 (30.1, 34.9)	2	0
South Carolina	1,971	23,520,693	8.6 (8.2, 9.0)	6	83,839	25.2 (23.3, 27.1)	7	−1
Georgia[a]	2,034	21,777,350	9.2 (8.8, 9.6)	4	81,333	25.6 (23.9, 27.4)	6	−2
Texas	7,183	120,840,116	6.0 (5.9, 6.2)	10	338,818	23.5 (22.5, 24.5)	12	−2
Idaho	58	7,560,110	0.8 (0.6, 1.0)	35	4,149	9.6 (6.8, 12.4)	37	−2
Alaska	61	3,547,757	1.6 (1.2, 2.0)	28	3,567	14.0 (8.3, 19.7)	31	−3
Wisconsin	427	30,868,031	1.4 (1.3, 1.5)	29	27,861	13.9 (11.4, 16.5)	32	−3
Minnesota	364	28,253,963	1.3 (1.2, 1.4)	30	33,475	13.5 (10.5, 16.6)	33	−3
Utah	141	12,692,988	1.3 (1.1, 1.5)	31	12,638	12.8 (7.7, 17.9)	34	−3
Arkansas	542	15,289,098	3.8 (3.5, 4.1)	15	27,966	19.6 (16.6, 22.5)	21	−6
Arizona	1,037	31,575,121	3.5 (3.2, 3.7)	16	64,371	16.4 (14.6, 18.2)	24	−8
Florida	11,814	98,709,697	12.5 (12.3, 12.7)	1	515,228	24.2 (23.5, 24.9)	10	−9
Virginia	1,761	41,737,691	4.2 (4.0, 4.4)	14	114,858	16.8 (15.5, 18.2)	23	−9
New Jersey	4,505	48,003,059	9.1 (8.8, 9.3)	5	216,067	21.1 (20.0, 22.2)	15	−10
Missouri	918	32,069,892	2.9 (2.8, 3.1)	18	65,114	15.0 (13.2, 16.8)	29	−11
Nevada	547	12,736,382	4.3 (3.9, 4.6)	13	38,137	15.5 (13.1, 18.0)	25	−12
Colorado	625	25,617,008	2.4 (2.2, 2.6)	22	64,147	9.8 (8.4, 11.3)	36	−14
Connecticut[a]	264	5,634,702	4.4 (3.9, 4.9)	12	21,223	12.2 (9.8, 14.5)	35	−23
New York[a]	10,024	93,312,262	10.7 (10.5, 10.9)	3	678,242	14.7 (14.2, 15.2)	30	−27

CI, confidence interval; HIV, human immunodeficiency virus; p-y, person-years. Rates restricted to persons age 15 and older and age-adjusted to the 2000 US Standard Population.
[a]Fewer than seven years of data used to calculate rates.

should explore this relationship further. Following diagnosis, differences in the receipt of HAART could play a role, given known regional disparities in medical care among those with HIV infection[25]. Potential drivers for these differences include socioeconomic status[26], the prevalence of drug abuse or other psychopathologic impediments to utilization of available care[27], and state health programs such as Medicaid and AIDS Drug Assistance Programs (ADAPs)[28,29].

Because public health insurance programs vary among US states, geographic disparities in morbidity and mortality may be more pronounced in the US than in resource-rich countries with geographically uniform national health insurance programs. We could not easily find information on population-based case-fatality rates in the literature or on government websites at similar jurisdictional levels for other countries such as Canada, Australia, or the United Kingdom. We speculate that this is because of limited data availability at this level or a perception that such jurisdictional boundaries may not be relevant in these countries. Such data are even scarcer in resource-poor countries. In the absence of these data, HIV case-fatality rates based on cohort studies in other resource-rich countries during a similar time period fall in the lower quartiles of the US rates calculated in our study. For example, crude rates reported based on cohorts in Australia and in Europe were 5.9 and 15 per 1,000 person-years, respectively[30,31], compared with our overall rate of 20.6/1,000 person-years. It is likely that differences in the characteristics of patients participating in cohort studies versus those assessed through surveillance contribute to these disparities, but other factors such as differences in health care systems may also play a role.

There are some limitations to our analysis. First, data from 13 US states and the District of Columbia were not

Table 2. Factors associated with HIV case-fatality rate, 37 US states, 2001–2007.

Variable	Age-adjusted rate ratio (95% CI)	P-value	Fully-adjusted[a] rate ratio (95% CI)	P-value
Age, per 10 years	1.35 (1.33, 1.37)	<0.001	1.36 (1.35, 1.37)	<0.001
Calendar year	0.91 (0.90, 0.92)	<0.001	0.91 (0.90, 0.91)	<0.001
Race/ethnicity (ref. = non-Hispanic other)				
Non-Hispanic black	1.47 (1.42, 1.52)	<0.001	1.43 (1.40, 1.47)	<0.001
Hispanic	0.95 (0.90, 0.99)	0.03	1.00 (0.97, 1.04)	0.86
Female sex (ref. = male)	1.06 (1.02, 1.10)	<0.01	1.03 (1.00, 1.05)	0.02
State of residence (ref. = Colorado[†])				
Alaska	1.54 (1.16, 2.05)	<0.01	1.65 (1.27, 2.16)	<0.001
Alabama	2.32 (2.03, 2.64)	<0.001	2.09 (1.88, 2.32)	<0.001
Arkansas	2.06 (1.78, 2.39)	<0.001	1.92 (1.70, 2.17)	<0.001
Arizona	1.66 (1.44, 1.90)	<0.001	1.72 (1.54, 1.92)	<0.001
Connecticut	1.11 (0.92, 1.34)	0.26	1.39 (1.19, 1.62)	<0.001
Florida	2.13 (1.90, 2.40)	<0.001	2.03 (1.86, 2.23)	<0.001
Georgia	2.31 (2.01, 2.65)	<0.001	2.53 (2.27, 2.80)	<0.001
Iowa	1.74 (1.41, 2.14)	<0.001	1.83 (1.52, 2.21)	<0.001
Idaho	1.33 (0.99, 1.77)	0.06	1.44 (1.10, 1.90)	0.01
Indiana	1.75 (1.52, 2.02)	<0.001	1.72 (1.53, 1.92)	<0.001
Kansas	1.66 (1.38, 1.98)	<0.001	1.69 (1.45, 1.98)	<0.001
Kentucky	1.84 (1.46, 2.33)	<0.001	2.17 (1.78, 2.64)	<0.001
Louisiana	2.80 (2.47, 3.17)	<0.001	2.52 (2.28, 2.78)	<0.001
Michigan	1.99 (1.74, 2.26)	<0.001	1.79 (1.62, 1.99)	<0.001
Minnesota	1.12 (0.95, 1.32)	0.17	1.09 (0.95, 1.26)	0.19
Missouri	1.49 (1.30, 1.72)	<0.001	1.38 (1.23, 1.54)	<0.001
Mississippi	2.76 (2.41, 3.15)	<0.001	2.42 (2.18, 2.69)	<0.001
North Carolina	2.42 (2.14, 2.74)	<0.001	2.17 (1.97, 2.39)	<0.001
North Dakota	1.60 (1.00, 2.55)	0.05	1.67 (1.06, 2.65)	0.03
Nebraska	1.95 (1.60, 2.38)	<0.001	1.99 (1.67, 2.38)	<0.001
New Hampshire	0.97 (0.61, 1.53)	0.89	1.30 (0.84, 2.00)	0.24
New Jersey	1.89 (1.67, 2.13)	<0.001	1.76 (1.60, 1.93)	<0.001
New Mexico	1.90 (1.59, 2.27)	<0.001	2.06 (1.76, 2.40)	<0.001
Nevada	1.46 (1.25, 1.69)	<0.001	1.45 (1.28, 1.64)	<0.001
New York	1.37 (1.22, 1.54)	<0.001	1.35 (1.23, 1.48)	<0.001
Ohio	1.74 (1.52, 1.98)	<0.001	1.66 (1.50, 1.84)	<0.001
Oklahoma	2.47 (2.13, 2.87)	<0.001	2.48 (2.20, 2.79)	<0.001
South Carolina	2.29 (2.01, 2.60)	<0.001	2.00 (1.81, 2.21)	<0.001
South Dakota	1.68 (1.19, 2.36)	<0.01	1.77 (1.28, 2.46)	<0.001
Tennessee	2.63 (2.31, 2.99)	<0.001	2.35 (2.13, 2.60)	<0.001
Texas	2.26 (2.01, 2.54)	<0.001	2.14 (1.95, 2.34)	<0.001
Utah	1.09 (0.88, 1.35)	0.41	1.21 (1.00, 1.46)	0.05
Virginia	1.50 (1.32, 1.71)	<0.001	1.35 (1.22, 1.49)	<0.001
Wisconsin	1.50 (1.28, 1.75)	<0.001	1.46 (1.28, 1.67)	<0.001
West Virginia	2.00 (1.64, 2.43)	<0.001	2.02 (1.70, 2.40)	<0.001
Wyoming	1.41 (0.89, 2.26)	0.15	1.50 (0.95, 2.38)	0.08

CI, confidence interval; HIV, human immunodeficiency virus.
[a]Adjusted for age, calendar year, race/ethnicity, and sex.
[†]Colorado was chosen as the reference group because it was the state of residence with the lowest case-fatality rate after adjusting for all other characteristics.

included because confidential name-based reporting of HIV infection had not yet been fully established in these areas. However, the analysis covers over two-thirds of the 50 states, representing 70% of the US population, to provide timely information for current efforts to prevent morbidity and mortality. Second, only limited data were available to assess potential contributors to the association between state of residence and HIV case-fatality rates.

Table 3. Population attributable fraction and excess HIV deaths associated with living in states with higher HIV case-fatality rates, 37 US states, 2001–2007.

Quartile of state HIV case-fatality rate	Rate ratio[a] (95% CI)	HIV deaths	Proportion of deaths	Population attributable fraction (95% CI)	Excess HIV deaths (95% CI)
Quartile 1	1.76 (1.70–1.82)	14,922	0.25	0.107 (0.101–0.114)	1,602 (1,508–1,670)
Quartile 2	1.49 (1.44–1.53)	27,257	0.45	0.146 (0.135–0.157)	3,987 (3,761–4,312)
Quartile 3	1.22 (1.17–1.27)	5,140	0.09	0.016 (0.012–0.019)	80 (62–94)
Quartile 4	Reference	12,904	0.21	Reference	Reference
Overall	–	60,223	1.00	0.269 (0.253–0.286)	5,669 (5,331–6,076)

CI, confidence interval; HIV, human immunodeficiency virus.
[a]Adjusted for age, calendar year, race/ethnicity, and sex.

Many known characteristics were adjusted for, but data on other characteristics associated with HIV-related mortality, such as socioeconomic status, type of health insurance, and risk behaviors (e.g., drug abuse), were unavailable. Third, like all PAF analyses, we make an assumption that interventions to reduce state homogeneity would have a causal impact on the case-fatality rate[32]. The conclusions from these analyses should be considered exploratory.

Another possible limitation is that the calculations may be inaccurate if our data on the numbers of HIV-related deaths or the numbers of persons living with HIV infection were inaccurate. For instance, rates could be overestimated if denominators were undercounted. Our method takes into account state differences in reporting delay[33], but not incomplete reporting. While reporting of HIV infection diagnoses in the US has been found to be reasonably complete[34], surveillance does not capture the estimated 20% of living HIV-infected persons who are undiagnosed[35], which could disproportionately include certain populations (e.g., foreign-born persons)[36]. Conversely, rates could be underestimated if the denominator were overcounted because some reported HIV-infected persons were erroneously assumed to be still living in a particular state when they had moved to another state, or their deaths were not reported to HARS. We believe such errors to be small, given existing knowledge about migration patterns among HIV-infected persons[37] and the comprehensiveness of death ascertainment procedures[38]. Finally, rates could be underestimated if the numerator were undercounted because HIV infection was wrongly not reported on some death certificates. Failure to report HIV on death certificates rarely happens, however, when they mention an AIDS-defining disease (e.g., pneumocystosis). Unpublished data on causes of death for HIV cases in HARS registries of two states found that 85% of case death certificates that mentioned an AIDS-defining disease also mentioned HIV.

Ultimately, monitoring state-specific HIV case-fatality rates could contribute to improved allocation of national and state resources for HIV-related care by focusing attention on states where better secondary and tertiary prevention of HIV disease is needed, such as those in the southern US. Effective interventions are needed to address these interstate disparities as part of a comprehensive approach to controlling the HIV epidemic[4,39].

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Quantile of state HIV case-fatality rate	Rate ratio* (95% CI)	HIV deaths	Proportion of deaths	Population attributable fraction (95% CI)	Excess HIV deaths (95% CI)
Scenario 1: Reduce rate in Quartiles 1–2 to rate in Quartile 3					
Quartile 1	1.44 (1.39–1.50)	14,922	0.25	0.077 (0.069–0.084)	1,143 (1,031–1,231)
Quartile 2	1.22 (1.18–1.27)	27,257	0.45	0.081 (0.067–0.095)	2,207 (1,870–2,609)
Quartile 3	Reference	5,140	0.09	Reference	Reference
Quartile 4	0.82 (0.79–0.86)	12,904	0.21	N/A	N/A
Overall		60,223	1.00	0.158 (0.138–0.177)	3,350 (2,901–3,840)
Scenario 2: Reduce rate in Quintiles 1–4 to rate in Quintile 5					
Quintile 1	1.94 (1.84–2.04)	13,558	0.23	0.109 (0.101–0.116)	1,473 (1,380–1,570)
Quintile 2	1.67 (1.59–1.76)	25,423	0.42	0.168 (0.154–0.182)	4,271 (3,964–4,636)
Quintile 3	1.47 (1.39–1.56)	4,739	0.08	0.025 (0.022–0.029)	119 (104–137)
Quintile 4	1.17 (1.11–1.24)	14,563	0.24	0.036 (0.025–0.048)	531 (352–673)
Quintile 5	Reference	1,940	0.03	Reference	Reference
Overall		60,223	1.00	0.338 (0.306–0.369)	6,394 (5,800–7,016)
Scenario 3: Reduce rate in Quintiles 1–3 to rate in Quintile 4					
Quintile 1	1.65 (1.60–1.70)	13,558	0.23	0.089 (0.083–0.094)	1,199 (1,134–1,273)
Quintile 2	1.43 (1.38–1.47)	25,423	0.42	0.125 (0.114–0.135)	3,170 (2,968–3,425)
Quintile 3	1.25 (1.20–1.30)	4,739	0.08	0.016 (0.013–0.019)	75 (104–137)
Quintile 4	Reference	14,563	0.24	Reference	Reference
Quintile 5	0.85 (0.81–0.90)	1,940	0.03	N/A	N/A
Overall		60,223	1.00	0.229 (0.214–0.244)	4,444 (4,206–4,835)
Scenario 3: Reduce rate in Quintiles 1–3 to rate in Quintile 4					
Quintile 1	1.32 (1.27–1.37)	13,558	0.23	0.054 (0.047–0.062)	736 (641–829)
Quintile 2	1.14 (1.10–1.18)	25,423	0.42	0.051 (0.037–0.065)	1,301 (942–1,646)
Quintile 3	Reference	4,739	0.08	Reference	Reference
Quintile 4	0.80 (0.77–0.83)	14,563	0.24	N/A	N/A
Quintile 5	0.68 (0.64–0.72)	1,940	0.03	N/A	N/A
Overall		60,223	1.00	0.105 (0.085–0.125)	2,037 (1,583–2,475)

CI, confidence interval; HIV, human immunodeficiency virus, N/A, not applicable.
*Adjusted for age, calendar year, race/ethnicity, and sex.

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D.B.H. conceived and designed the study, acquired the NVSS data, conducted the main analysis, and drafted the article. R.M.S. and S.J.G. provided advice on the study design. T.T. converted the individual-level HARS data to summary counts for the analyses. All authors contributed substantially to the interpretation of the data, revised the article critically for important intellectual content, and gave approval of the final version. D.B.H. had full access to all the data in the study, except for individual-level HARS data, and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Appendix Table 1. Sensitivity analysis showing differences in population attributable fraction and excess HIV deaths due to living in states with higher HIV case-fatality rates, based on different scenarios.

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