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ORIGINAL PAPER

Factors Associated with State Variation in Mortality Among Persons Living with Diagnosed HIV Infection

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Abstract

In the United States, the all-cause mortality rate among persons living with diagnosed HIV infection (PLWH) is almost twice as high as among the general population. We aimed to identify amendable factors that state public health programs can influence to reduce mortality among PLWH. Using generalized estimating equations (GEE), we estimated age–group-specific models (24–34, 35–54, ≥ 55 years) to assess the association between state-level mortality rates among PLWH during 2010–2014 (National HIV Surveillance System) and amendable factors (percentage of Ryan White HIV/AIDS Program (RWHAP) clients with viral suppression, percentage of residents with healthcare coverage, state-enacted anti-discrimination laws index) while controlling for sociodemographic nonamendable factors. Controlling for nonamendable factors, states with 5% higher viral suppression among RWHAP clients had a 3–5% lower mortality rates across all age groups [adjusted Risk Ratio (aRR): 0.95, 95% Confidence Interval (CI): 0.92–0.99 for 24–34 years, aRR: 0.97, 95%CI: 0.94–0.99 for 35–54 years, aRR: 0.96, 95%CI: 0.94–0.99 for ≥ 55 years]; states with 5% higher health care coverage had 4–11% lower mortality rate among older age groups (aRR: 0.96, 95%CI: 0.93–0.99 for 34–54 years; aRR: 0.89, 95%CI: 0.81–0.97 for ≥ 55 years); and having laws that address one additional area of anti-discrimination was associated with a 2–3% lower mortality rate among older age groups (aRR: 0.98, 95%CI: 0.95–1.00 for 34–54 years; aRR: 0.97, 95%CI: 0.94–0.99 for ≥ 55 years). The mortality rate among PLWH was lower in states with higher levels of residents with healthcare coverage, anti-discrimination laws, and viral suppression among RWHAP clients. States can influence these factors through programs and policies.

Keywords HIV/AIDS · HIV testing · Viral suppression · Healthcare coverage · Stigma

Disclaimer The findings and conclusions in this article are those of the authors' and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Health Resources and Services Administration.

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Introduction

Advances in the treatment of HIV infection make it possible for a 20-year-old individual on antiretroviral therapy (ART) to have a life expectancy similar to a 20-year-old in the general population [1]. As a result, deaths due to HIV infection (as reported on death certificates) in the United States declined from 16.0 per 100,000 population in 1994 to 2.0 per 100,000 population in 2015 [2, 3]. These death rates are based on information recorded on death certificates that indicate an HIV-related condition was the cause of death. However, deaths among persons living with diagnosed HIV infection (PLWH) are not always accurately attributed to the HIV infection [4]. Therefore, examining all deaths among all PLWH allow for a more comprehensive assessment. Substantial state variation in all-cause mortality rates among persons living with diagnosed HIV infection (PLWH) exist. The 2014 state age-adjusted mortality rate among PLWH ranged from 0.5 per 100 PLWH in

Vermont to 3.6 per 100 PLWH in Idaho [5]. Although states receive federal support to implement programs that promote early diagnosis of HIV infection, link PLWH to medical care, fund HIV medical care and treatment, and provide a system of care that supports engagement in healthcare and improved health, additional action may be needed to address the state-level factors affecting mortality among PLWH [6].

Factors that impact access to, and use of, medical care may contribute to the variation in state mortality rates. Previous studies identified rural residence, black or Hispanic race/ethnicity, lower income, history of injection drug use, and living in the Southern region of the United States as factors associated with higher mortality rates [1, 7–11].

The reason for higher mortality rates among PLWH in the South [12] are unclear but may be related to higher rates of poverty and lower rates of health care coverage [13]. Other factors that are difficult to measure, such as racism, HIV-related stigma, or discrimination associated with sexual orientation and gender identity, may also affect mortality rates among PLWH in the South. Laws that protect the rights of all individuals regardless of sexual orientation and gender identity (anti-discrimination laws) could be associated with lower mortality among PLWH. A community-level study found that for a sexual minority living in high-prejudice area were more likely to have a shorter life span [14].

The purpose of our study was to identify factors associated with state mortality rates among PLWH that state public health programs can influence (amendable factors), such as health care coverage, viral suppression rates, and anti-discrimination laws. We considered these factors amendable because states can directly affect them by changing policies or providing services. For example, states can expand healthcare coverage through changes in health insurance or Medicaid policies that would increase access to health care, or pass laws that would protect the rights of all individuals regardless of sexual orientation or gender identity. States also provide direct services to people living with HIV through the Health Resources and Services Administration's Ryan White HIV/AIDS Program that can be evaluated and improved to increase viral suppression among persons served by this program. We also assessed if living in a southern state was associated with higher mortality after adjusting for other amendable and nonamendable (race/ethnicity among PLWH, poverty, region, education) factors to assess whether there continued to be unmeasured factors resulting in higher mortality rates among PLWH in the South compared with other regions.

Methods

We created an analytic data set of state-level aggregate data on state-enacted anti-discrimination laws (Human Rights Campaign), data from the National HIV Surveillance System (NHSS), Ryan White HIV/AIDS Program Services Report (RSR), and American Community Survey for years 2010–2014 [5, 15–18]. State all-cause mortality rates among PLWH (National Vital Statistics), state all-cause mortality rates among the overall population [19], and state-level clinical, socioeconomic, and demographic amendable and nonamendable variables are described in Table 1. Amendable factors are those that state public health programs can influence.

The Ryan White HIV/AIDS Program (RWHAP) provides primary medical care and essential support services to over half a million low-income PLWH who have no healthcare coverage, are underserved, or lack financial resources to access the HIV care and treatment they need [16]. We used RWHAP viral suppression data as a proxy for viral suppression among all PLWH in care living in a state because not all states have complete reporting of laboratory data from which NHSS viral suppression rates are calculated for all PLWH [5]. A comparison of viral suppression rates among RWHAP clients and among all PLWH in care for the states where both rates were available found the average difference was 2.8 percentage points (pp) higher among RWHAP Clients, ranging from − 17.1 to 39.8 pp (Supplemental Data Table 1). The percentage of states with absolute differences greater than 10 pp decreased from 2010 (32%) to 2014 (16%) indicating the differences may decrease as reporting of laboratory results to NHSS becomes more complete.

Cause of death varies by age in the general population; the leading cause of death in 2015 among 25 to 34 year olds was accidents (38.4%), while the leading cause of death among those aged 55–64 years was malignant neoplasms (32.5%) [19]. Therefore, mortality rates and covariates were stratified by age group when available (25–34 years, 35–54 years, and ≥ 55 years, typically used by NHSS and ACS) [5, 17]. Rural residence was not available by age group, and age group is not applicable for the anti-discrimination laws index and South region variables; therefore, the same values for rural residence, anti-discrimination laws index and South region were used for each age group. The education variable was available only for age groups 25–34 years, 35–64 years, and ≥ 65 years; these values were applied to the 25–34 year, 35–54 year, and ≥ 55 year age groups, respectively.

We conducted descriptive analyses to inspect possible associations between both amendable and nonamendable factors, and state mortality rates. States were divided into quartiles based upon the average mortality rate among PLWH from 2010–2014, and average state-level amendable and nonamendable factors for the same time period are presented. We also present state-level mortality rates among the general population and among PLWH to examine similarities between the two outcomes, and to consider the implications the similarites may have on interpreting this analysis.

Table 1 Definition and data source for all variables included in analysis

Variable	Data source	Definition
Mortality rates		
State mortality among people living with diagnosed HIV (PLWH)	NHSS, extracted from National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP) AtlasPlus in April 2017	The number of deaths, regardless of cause of death, divided by [the number of] PLWH aged 25 years and older during 2010–2014
State mortality rates among the general population	National Vital Statistics	The number of deaths, regardless of cause of death, divided by the overall state population, 2014
Amendable factors		
ADAP waiting list	National Alliance of state and Territorial Directors (NASTAD)	The presence of a waitlist in the state
Percentage RWHAP viral suppression: Percentage of Ryan White HIV/AIDS Program (RWHAP) clients with suppressed viral load	Health Resources and Services Administration's (HRSA), HIV/AIDS Bureau: RWHAP Services Report (RSR)	The number of persons with an HIV viral load < 200 copies per mL at last HIV viral load test during the measurement year, divided by [the number of] RWHAP clients with a diagnosis of HIV, at least one outpatient ambulatory medical care visit during the measurement year, and at least one viral load test.
Health care coverage: Percentage of population with health care coverage	American Community Survey (ACS)	The number of persons with health care divided by total civilian noninstitutionalized population. Health care coverage was coded based on yes/no response to: a plan purchased by an individual from a private company, TRICARE, other military health care, Medicare, Medicaid, VA Health Care, the Children's Health Insurance Program, and local medical programs for indigents (this program is included only for the Pacific Islands). ACS defines health care coverage to include plans and programs that provide comprehensive health coverage.
Anti-discrimination law index: Composite index of laws that protect the rights of all individuals regardless of sexual orientation and gender identity	Human Rights Campaign Equality from State to State Reports, 2012–2015	The sum of the number of state-enacted laws that protect the rights of all individuals regardless of sexual orientation and gender identity: (1) employment laws and policies prohibiting discrimination based on sexual orientation or gender identity; (2) law(s) that address discrimination, harassment and/or bullying of students based on sexual orientation and gender identity; (3) law(s) that address hate and/or bias crimes based on sexual orientation and gender identity; and (4) law(s) recognizing same sex marriage or spousal rights. Values ranged from 0 (no laws enacted) to four (all laws enacted).
Nonamendable factors		
Education: Percentage of the population with less than a high school education	American Community Survey	The number of persons aged 25 years and older with less than a 12th grade education (including individuals with 12 grades but no diploma) divided by the estimated state population age 25 years and older.
Rural residence: Percentage of the population living in a rural area	American Community Survey	The number of people living in an area with less than 50,000 people divided by the state population

Table 1 (continued)

Variable	Data source	Definition
Poverty: Percentage of the population living below the federal poverty level	American Community Survey	Poverty levels were defined by the Census Bureau, which uses a set of income thresholds that vary by family size and composition to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual in it is considered in poverty. The number of persons in poverty was divided by the estimated total state population.
South	US Census Bureau	Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia are categorized into the southern region by the US Census Bureau and assigned a 1, all other states assigned 0.
MSM PLWH: Percentage of PLWH who are men who have sex with men	NHSS, extracted from NCHHSTP AtlasPlus in April 2017	The number of PLWH who are MSM divided by the number of all PLWH
Black PLWH: Percentage of PLWH who are black/African American	NHSS, extracted from NCHHSTP AtlasPlus in April 2017	The number of PLWH who are black/African American divided by the number of all PLWH
Hispanic/Latino PLWH: Percentage of PLWH who are Hispanic/Latino	NHSS, extracted from NCHHSTP AtlasPlus in April 2017	The number of PLWH who are Hispanic/Latino divided by the number of all PLWH

To identify state-level factors associated with mortality among PLWH, we applied GEE models, (SAS, version 9.3, GENMOD procedure) with a robust Poisson distribution and exchangeable correlation structure. Number of people living with HIV was included as an offset to account for the variation in prevalence between states. All years, for each state, were included in the model. Separate models were run for each age group. Empirical (robust) standard errors/confidence intervals were applied, accounting for the lack of independence between multiple observations for each state over time. Model 1 included the following nonamendable variables: year, rural residence, poverty, education, percentage of PLWH who are men who have sex with men (MSM), percentage of PLWH who are black/African American, and percentage of PLWH who are Hispanic/Latino. Model 2 included the variables from Model 1 and added the amendable variables: health care coverage, RWHAP clients with viral suppression, and anti-discrimination law index. We also assessed whether viral suppression mediated the relationship between health insurance and mortality. Model 3 included the variables from Model 2 and added the South variable to account for unmeasurable factors (e.g., population and social inequities) that may be associated with higher mortality rates among PLWH in the South compared with other regions. All independent variables that represented a percentage were modeled to estimate the rate ratio for 5% change in the covariate.

Results

The all-cause mortality rate per 100,000 people in the general population for 2014 varied by region and state (Fig. 1). States in the South accounted for 7 of 12 states (58%) in the highest quartile. The mortality rate per 100,000 PLWH also varied by region and state (Fig. 2). States in the South accounted for 8 of 12 states (67%) in the highest quartile. Five states, Alabama, Arkansas, Mississippi, Oklahoma, and West Virginia, in the South were in the top quartile for mortality rates in both the general population and among PLWH.

During 2010–2014, the mortality rate among PLWH varied by age group. Among PLWH aged 25–34 years, the average within-quartile mortality rate per 100 PLWH ranged from 0.5 to 1.4; among PLWH aged 35–54 years, the average within-quartile mortality rate per 100 PLWH ranged from 1.2 to 2.1; and among PLWH aged ≥ 55 years, the average within-quartile mortality rate per 100 PLWH ranged from 2.4 to 4.2 (Table 2a–c).

The nonamendable factors that were associated with mortality rates among PLWH (Model 1) varied by age group (Table 3a–c). Year was significantly associated with mortality rates among PLWH indicating decreasing mortality

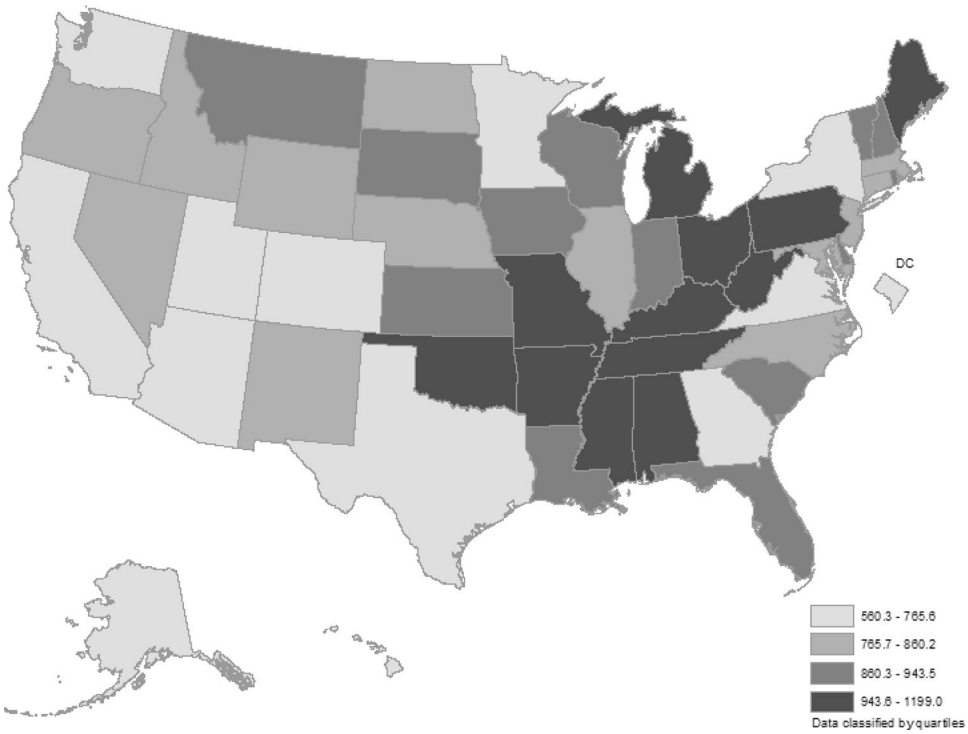

Fig. 1 Rates of death from any cause per 100,000 persons, by state (n = 51), National Vital Statistics, 2014

rates over time for all age groups. Higher poverty was significantly associated with higher mortality, and a higher percentage of PLWH who are MSM was significantly associated with lower mortality rates for the 25–34 and 35–54 year age groups. Other nonamendable factors were significant for only one age group: states with higher percentage of residents with less than a high school education had higher mortality for the 25–34 year age group; states with higher percentage of PLWH who are Hispanic/Latino had lower mortality for the 35–54 year age group. Other than year, no other nonamendable factors were associated with state mortality rates for the ≥ 55 years age group (Model 1).

Amendable factors tested for their association with mortality rate among PLWH (Model 2) were the percentage of RWHAP clients with viral suppression, health care coverage, and the anti-discrimination laws index. No other amendable factors were tested. When amendable factors were added to the model, the percentage of RWHAP clients with viral suppression was significantly associated with mortality for all age groups. States with 5% higher percentage of RWHAP clients with viral suppression were associated with 5, 3, and 4% lower mortality rates in the 25–34 year age group (aRR: 0.95, 95% CI: 0.92–0.99), 35–54 year age group (aRR: 0.97, 95% CI: 0.94–0.99), and ≥ 55 year age group (aRR: 0.96, 95% CI: 0.94–0.99), respectively. States with 5% higher health care coverage were associated with 4% and 11% lower mortality rates in the 35–54 year age group (aRR: 0.96, 95% CI: 0.93–0.99) and ≥ 55 year age group (aRR: 0.89, 95% CI: 0.81–0.97), respectively. The association between health insurance and mortality was not mediated by viral suppression for any age group. When viral suppression was removed from model 2 the effect size for health insurance was similar (< 0.05% change) and still non-significant for 25–34 year and remained significant for 35–54 year and ≥ 55 year age groups. Having laws that address one additional area of anti-discrimination was associated with a 2% and 3% lower mortality rates in the 35–54 year age group (aRR: 0.98, 95% CI: 0.95–0.99) and ≥ 55 year age group (aRR: 0.97, 95% CI: 0.94–0.99), respectively.

When the South was added to the model (Model 3), there was no statistically significant association between the South and the mortality rate among PLWH for any age group (aRR: 0.93, 95% CI: 0.82–1.06 for 25–34 years; 1.02, 95% CI: 0.88–1.18 for 35–54 years; 1.07, 95% CI: 0.96–1.20 for > 55 years).

Discussion

This analysis documents associations between lower state-level mortality rates among PLWH and health care coverage, enacted laws that protect against discrimination associated with sexual orientation and gender identity, and viral suppression among RWHAP clients. However, some findings varied by age group, indicating that some strategies to lower all-cause mortality may affect age groups differently. Lastly, being a Southern state was not associated with state-level mortality rate for any age group.

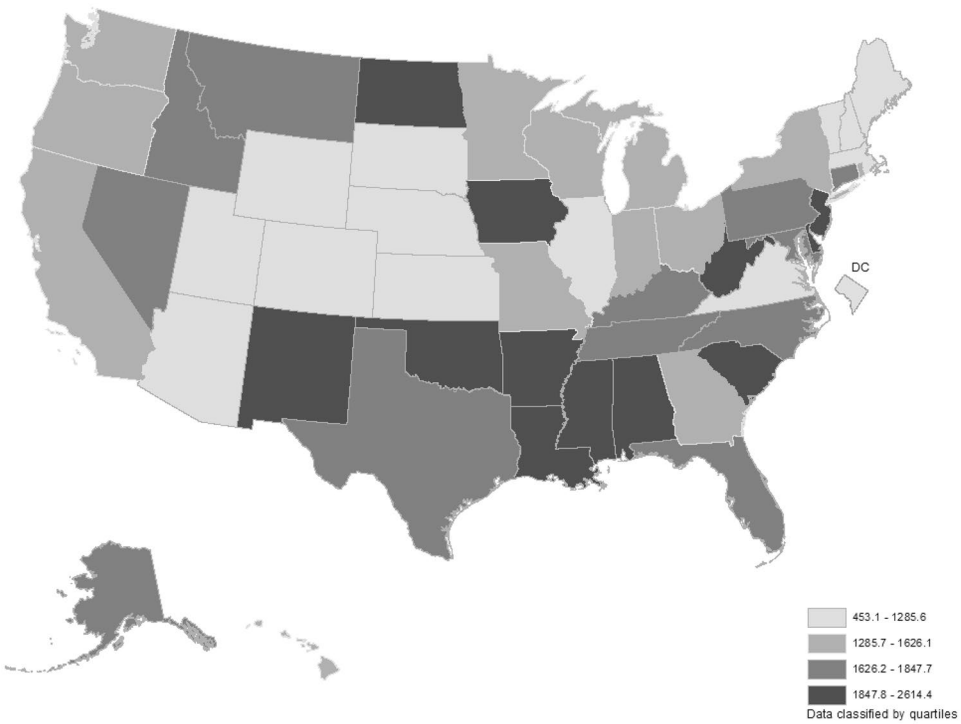

Fig. 2 Rates of death from any cause per 100,000 persons living with diagnosed HIV infection, by state (n = 51), NHSS, 2014

Higher levels of health care coverage in a state were associated with significantly lower mortality rates among PLWH aged 35–54 and ≥ 55 years. These findings emphasize the importance of healthcare coverage and support programs to increase access to HIV care and treatment and reduce mortality, particularly among people aged ≥ 55 years, where mortality was 11% lower with a 5% increase in state-level health care coverage. The lack of a statistically significant association between health care coverage and mortality for the younger age group (25–34 years) may suggest that healthcare coverage alone is insufficient to help young PLWH achieve optimal health outcomes. A previous study found that viral suppression was lower among younger compared with older PLWH who died in 2012 but that a higher percentage of young persons who died received HIV care; this suggests that HIV care alone may not be enough among the young [20]. Another possible explanation is the low variability in mortality in this age-group. Viral suppression did not mediate the relationship between health care coverage and mortality, which may be due to the inclusion of non-HIV-related mortality among PLWH. Lower mortality rates among MSM living with diagnosed HIV who are aged < 55 years may be due to a higher portion of MSM being virally suppressed [5]. Health outcomes among young PLWH may be improved through better medication adherence and access to other types of supportive services such as mental health and substance use treatment and peer support. The comprehensive system of care provided by the RWHAP is an important source of access to these essential support services. Additional investigations are needed to better understand how to reduce all-cause mortality among this young age group, in addition to HIV care.

A higher number of state-enacted laws that protect against discrimination related to sexual orientation and gender identity was associated with significantly lower mortality rates among PLWH aged 35–54 and ≥ 55 years. Our findings are consistent with a previous study that found sexual minorities living in communities with high levels of anti-gay prejudice experienced a higher mortality than those living in low-prejudice communities [14]. The lack of significant association among PLWH aged 25–34 years may be an artifact due to less state variation in mortality in this age group or it could be that discrimination affects persons differently depending upon their age. Older adults may experience more discrimination associated with sexual orientation and gender identity than younger adults, either currently or accumulated over their lives, which included periods of time wherein widely held social attitudes were highly stigmatizing. Compared with adults aged < 30 years, those aged 30–54 years were 16 times as likely to conceal their sexual orientation and those aged ≥ 55 years were 83 times as likely to do so in the 2008 General Social Survey [21]. Older persons' unwillingness to disclose their sexual orientation and gender identity may reflect higher experienced lifetime discrimination and more internalized stigma. Other laws that may increase discrimination, such as HIV criminalization laws, were not included in this study and may have a differential impact on discrimination and mortality by age groups. State Medicaid

Table 2 State-level clinical, socioeconomic, and demographic characteristics for quartiles based on average age-group specific mortality rate per 100 PLWH, 2010–2014

A. PLWH aged 25-34 years	Q1 (n = 15)			Q2 (n = 12)			Q3 (n = 12)			Q4 (n = 12)		
Average mortality rate per 100 PLWH (range)	0.5 (0.0–0.6)			0.8 (0.7–0.8)			0.9 (0.8–1.0)			1.4 (1.0–2.4)		
	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max
Percentage of population living in rural area[a]	24.8	0	61.3	23.7	9.3	51.3	21.4	5.3	33.9	33.6	8.8	50.7
Percentage of population living below federal poverty level[b]	14.4	9.7	20.8	13.7	9.8	21.9	17.2	10.8	20	18.3	9.3	26.2
Percentage of population with ≤ high school education[c]	8.6	4.1	17.1	8.8	4.2	13.6	12.3	8.2	17.4	12	5.7	17.1
Percentage of HIV-diagnosed pop. MSM[b]	60.9	44.1	77.7	56	41.1	70.8	63.2	43.2	73.9	55	27	68.4
Percentage of HIV-diagnosed pop. Black/AA[b]	22.2	0	74.1	38.9	8.5	75.9	50.5	13.5	77.2	46.1	0	80.3
Percentage of HIV-diagnosed pop. Hispanic/Latino[b]	19.5	0	49.1	18.7	5.9	41.5	17.6	5.7	41.5	14.6	3.2	59.4
Percentage of population with health care coverage[b]	79.6	66.6	93.7	79.3	68.7	87.5	72.6	60.7	84.8	70.8	61.6	82.5
Percentage RWHAP viral suppression[b]	72.2	45.7	89.2	70.8	54.4	100	64.6	50.3	84.6	64.7	43.7	84.9
Anti-discrimination laws index (0–4)	2.8	0	4	1.8	0	4	1.2	0	4	0.5	0	3
South	1/15			3/12			6/12			7/12		
B. PLWH aged 35–54 years	Q1 (n = 14)			Q2 (n = 14)			Q3 (n = 12)			Q4 (n = 11)		
Average mortality rate per 100 PLWH (range)	1.2 (1.0–1.3)			1.5 (1.4–1.7)			1.8 (1.7–1.9)			2.1 (1.9–2.6)		
	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max
Percentage of population living in rural area[a]	24.7	0	61.3	21.2	8.1	36	23.5	5.3	51.3	35.5	16.7	50.7
Percentage of population living below federal poverty level[b]	10	6.6	16.3	11	8	14.7	12.7	7	19.2	13.3	7.3	18.2
Percentage of population with ≤ high school education[c]	9	4.4	18.9	9.6	6.1	13.5	11.7	5.5	18.1	11.6	5.6	16.6
Percentage of HIV-diagnosed pop. MSM[b]	58.1	40.8	70.7	54.6	27	70.6	49.4	28.9	65.6	49.8	32.4	60.3
Percentage of HIV-diagnosed pop. Black/AA[b]	21.4	0	72.3	28.3	4.1	66	38.1	3.2	74.1	43.9	11.6	72.2
Percentage of HIV-diagnosed pop. Hispanic/Latino[b]	15	0	37.9	16.6	5.2	37.1	17	3.4	50.3	6.1	2.6	11.8
Percentage of population with health care coverage[b]	85.8	76.8	95.9	84.9	75.3	94.2	79.4	71.3	89.7	80.9	74.8	90.2
Percentage RWHAP viral suppression[b]	83.3	61.1	100	79.7	63	93.1	78.3	60.5	93.9	74.8	56	88.1
Anti-discrimination laws index (0–4)	2.3	0	4	2.1	0	4	1.3	0	4	0.5	0	3
South	2/14			1/14			6/12			8/11		
C. PLWH aged 55 years and older	Q1 (n = 14)			Q2 (n = 13)			Q3 (n = 12)			Q4 (n = 12)		
Average mortality rate per 100 PLWH (range)	2.4 (1.1–2.7)			3.0 (2.7–3.2)			3.5(3.3–3.6)			4.2(3.7–6.4)		
	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max
Percentage of population living in rural area[a]	20.6	0	61.1	25.2	5.8	61.3	28.5	5.3	51.3	29.8	9.3	50.7
Percentage of population living below federal poverty level[b]	9.2	5.4	16.8	9.1	6.7	13	9	5.6	11.8	10.7	6.8	16.1
Percentage of population with ≤ high school education[c]	16.7	8.9	23.7	17.7	11.2	32.7	18.8	9.9	30.3	22.8	13.8	30.3
Percentage of HIV-diagnosed pop. MSM[b]	60.4	40.2	76.4	55.5	23.8	72.2	50.8	24.4	69.3	41.4	24.8	61
Percentage of HIV-diagnosed pop. Black/AA[b]	20.3	0	74	25.6	3.9	47.5	29.3	0.7	53.8	52.2	5	75
Percentage of HIV-diagnosed pop. Hispanic/Latino[b]	10.7	0	35.6	11.6	3	31.6	10.5	0	23.7	4.9	1.2	22.4

Table 2 (continued)

C. PLWH aged 55 years and older	Q1 (n = 14)			Q2 (n = 13)			Q3 (n = 12)			Q4 (n = 12)		
Average mortality rate per 100 PLWH (range)	2.4 (1.1–2.7)			3.0 (2.7–3.2)			3.5(3.3–3.6)			4.2(3.7–6.4)		
	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max	Mean %	Min	Max
Percentage of population with health care coverage[b]	94.7	90.5	98.5	94.3	89.3	96.8	93.2	87.6	97.5	93.7	90.8	97
Percentage RWHAP viral suppression[b]	89.1	75	97.8	87.2	72.9	100	85.5	66.7	97.1	83.5	62.2	100
Anti-discrimination laws index (0–4)	2.4	0	4	2.2	0	4	0.9	0	4	1	0	4
South	2/14			1/13			3/12			10/12		

PLWH Persons living with HIV infection, *RWHAP* Ryan White HIV/AIDS Program

[a]2010 only

[b]Age groups—25–34; 35–54; 55 + years

[c]Age groups—25–34; 35–64; 65 + years

coverage was not included in the analysis due to collinearity with percentage of RWHAP clients virally suppressed and state ADAP waiting lists did not provide additional information to the model.

States with higher levels of viral suppression among clients who receive RWHAP services were significantly and consistently associated with lower mortality rates, regardless of age, among PLWH. This finding is not surprising given the increase in life expectancy from the use of ART [22]. The RWHAP provides HIV primary medical care, treatment, and support services to more than 50% of PLWH in the United States, particularly those who are uninsured or underserved [23]. The RWHAP comprehensive system of care and treatment has an impact on reducing mortality among PLWH, but does not reach all PLWH.

Lastly, states in the South account for a higher percentage of states in the highest quartile for all-cause mortality and mortality among PLWH than other regions. Being a southern state was not associated with higher mortality rates among PLWH after adjustment for other amendable and nonamendable variables. This finding indicates that the variables included in this analysis accounted for the regional variation in mortality rates among PLWH. More analyses examining unmeasured factors unique to the south may be needed.

Limitations

We were not able to analyze factors associated with mortality rates among PLWH aged 13–24 years due to a small number of deaths in this age group. Therefore, the interpretation of our results is limited to adult PLWH aged 25 years and older. Additionally, the RWHAP provides services to approximately half of PLWH each year, and only to low income people; therefore, our viral suppression variable may not be representative of viral suppression for all PLWH in care in the United States. However, we compared state-level viral suppression rates for RWHAP clients and all PLWH in care when available and found the RWHAP viral suppression rates were a good proxy for the majority of states and the only source of viral suppression information for all states across the analysis time period. This ecological analysis only addresses associations between state-level mortality and amendable characteristics and does not infer causality. In addition, the mortality rates include all deaths to persons living with HIV infection regardless of whether the HIV infection caused the death. Higher rates of substance abuse, domestic violence and suicide among persons living with HIV compared with the general population [24–26] may contribute to higher all-cause mortality and were not accounted for in this analysis. The most common causes of death also vary by age (e.g. deaths related to chronic disease

Table 3 Multivariable models of the effects of state-level demographic, insurance, stigma and HIV care characteristics on mortality, by age group, 2010–2014

Independent variables	Model 1 Nonamendable		Model 2 Amendable		Model 3 Region	
	Rate ratio	95% CI	Rate ratio	95% CI	Rate ratio	95% CI
A. 25–34 years (n = 51)						
Year	**0.97**	**0.94–0.99**	1.00	0.96–1.03	1.00	0.96–1.04
% Of population living in rural area[a, d]	1.00	0.98–1.03	1.02	0.99–1.05	1.02	0.99–1.05
% Of population living below federal poverty level[b, d]	**1.21**	**1.10–1.33**	**1.12**	**1.01–1.24**	1.10	0.98–1.24
% Of population with ≤ high school education[c, d]	**1.20**	**1.04–1.38**	1.06	0.89–1.27	1.09	0.92–1.29
% Of HIV-diagnosed pop. MSM[b, d]	**0.93**	**0.92–0.95**	**0.95**	**0.93–0.98**	**0.95**	**0.92–0.97**
% Of HIV-diagnosed pop. Black/AA[b, d]	1.00	0.98–1.03	1.00	0.98–1.02	1.00	0.98–1.03
% Of HIV-diagnosed pop. Hispanic/Latino[b, d]	0.97	0.92–1.02	0.97	0.93–1.02	0.97	0.93–1.02
% Of population with health care coverage[b, d]			0.95	0.89–1.01	0.94	0.88–1.00
% RWHAP viral suppression[b, d]			**0.95**	**0.92–0.99**	**0.96**	**0.93–0.99**
Number of anti-discrimination laws (0–4)			0.99	0.95–1.02	0.99	0.95–1.02
South					0.93	0.82–1.06
B. 35–54 years (n = 51)						
Year	**0.94**	**0.92–0.95**	**0.96**	**0.94–0.98**	**0.96**	**0.94–0.98**
% Of population living in rural area[a, d]	1.00	1.00–1.01	1.00	1.00–1.00	1.00	1.00–1.00
% Of population living below federal poverty level[b, d]	**1.12**	**1.01–1.24**	1.04	0.96–1.14	1.05	0.96–1.14
% Of population with ≤ high school education[c, d]	1.12	0.99–1.27	**1.10**	**1.01–1.20**	**1.09**	**1.004–1.19**
% Of HIV-diagnosed pop. MSM[b, d]	**0.93**	**0.91–0.96**	**0.94**	**0.91–0.96**	**0.94**	**0.91–0.96**
% Of HIV-diagnosed pop. Black/AA[b, d]	0.99	0.97–1.01	0.98	0.96–1.00	0.98	0.96–1.00
% Of HIV-diagnosed pop. Hispanic/Latino[b, d]	**0.95**	**0.90–0.99**	**0.94**	**0.91–0.98**	**0.95**	**0.91–0.98**
% Of population with health care coverage[b, d]			**0.96**	**0.93–0.99**	0.97	0.92–1.01
% RWHAP viral suppression[b, d]			**0.97**	**0.94–0.99**	**0.97**	**0.94–0.99**
Number of anti-discrimination laws (0–4)			**0.98**	**0.95–0.999**	**0.98**	**0.96–0.998**
South					1.02	0.88–1.18
C. 55 years and older (n = 51)						
Year	**0.94**	**0.92–0.97**	**0.98**	**0.95–0.997**	**0.97**	**0.95–0.99**
% Of population living in rural area[a, d]	1.00	1.00–1.01	1.00	1.00–1.01	1.00	1.00–1.01
% Of population living below federal poverty level[b, d]	1.02	0.80–1.29	0.98	0.82–1.16	0.96	0.80–1.15
% Of population with ≤ high school education[c, d]	1.05	0.94–1.17	1.05	0.98–1.12	1.05	0.99–1.12
% Of HIV-diagnosed pop. MSM[b, d]	0.98	0.94–1.02	**0.96**	**0.93–0.99**	**0.96**	**0.92–0.99**
% Of HIV-diagnosed pop. Black/AA[b, d]	1.01	0.97–1.05	0.99	0.96–1.02	0.99	0.95–1.02
% Of HIV-diagnosed pop. Hispanic/Latino[b, d]	0.98	0.92–1.05	0.96	0.92–1.01	0.97	0.93–1.02
% Of population with health care coverage[b, d]			**0.89**	**0.81–0.97**	0.91	0.83–1.01
% RWHAP viral suppression[b, d]			**0.96**	**0.94–0.99**	**0.96**	**0.94–0.99**
Number of anti-discrimination laws (0–4)			**0.97**	**0.94–0.99**	**0.97**	**0.95–0.99**
South					1.07	0.96–1.20

Bold text is significant at $p < 0.05$

CI Confidence interval, *RWHAP* Ryan White HIV/AIDS Program

[a]2010 only

[b]Age groups—25–34; 35–54; 55 + years

[c]Age groups—25–34; 35–64; 65 + years

[d]In increments of 5%

are more likely in the older population while deaths related to injury may be more likely in the younger population); [27] this could explain the different findings by age group. Lastly, some associations found might be affected by residual confounding that could not be accounted for.

Conclusion

States with higher levels of viral suppression among RWHAP clients, health care coverage, and laws that protect against discrimination associated with sexual orientation and gender identity were associated with lower mortality rates among PLWH. These factors are amendable should states wish to explore how to reduce mortality among PLWH in their jurisdictions. Future analyses could explore if changes in amendable factors over time are associated with change in mortality among PLWH.

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References

1. Samji, H., Cescon, A., Hogg, R. S., et al. (2013). Closing the gap: Increases in life expectancy among treated hiv-positive individuals in the United States and Canada. *PLoS ONE, 8*(12), e81355. https://doi.org/10.1371/journal.pone.0081355.
2. Underlying Cause of Death 1999-2015 on CDC WONDER Online Database, released 2015. Data are from the multiple cause of death files, 1999-2015, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program [database on the Internet]. CDC WONDER Online database. [cited July 5, 2017]. Available from: http://wonder.cdc.gov/ucd-icd10.html.
3. Underlying Cause of Death 1979-1998 on CDC WONDER online database. Data are from the underlying cause of death files, 1979-1998, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program [database on the internet]. CDC WONDER Online database. [cited July 5, 2017]. Retrieved from: https://wonder.cdc.gov/cmf-icd9.html.
4. Trepka, M. J., Sheehan, D. M., Fennie, K. P., Niyonsenga, T., Lieb, S., & Maddox, L. M. (2016). Completeness of HIV reporting on death certificates for Floridians reported with HIV infection, 2000–2011. *AIDS Care, 28*(1), 98–103. https://doi.org/10.1080/09540121.2015.1069786.
5. Centers for Disease Control and Prevention. Monitoring Selected National HIV Prevention and Care Objectives by Using HIV Surveillance Data—United States and 6 Dependent Areas—2015. July 2017; 22(2).
6. Centers for Disease Control and Prevention. Division of HIV/AIDS Prevention Strategic Plan, 2016–2020. July 2015.
7. Centers for Disease Control and Prevention. Monitoring Selected National HIV Prevention and Care Objectives by Using HIV Surveillance Data—United States and 6 Dependent Areas—2014. July 2016; 21(4).
8. Hanna, D. B., Selik, R. M., Tang, T., & Gange, S. J. (2012). Disparities among US states in HIV-related mortality in persons with HIV infection, 2001–2007. *AIDS, 26*(1), 95–103. https://doi.org/10.1097/QAD.0b013e32834dcf87.
9. Lemly, D. C., Shepherd, B. E., Hulgan, T., et al. (2009). Race and sex differences in antiretroviral therapy use and mortality among HIV-infected persons in care. *Journal of Infectious Diseases, 199*(7), 991–998. https://doi.org/10.1086/597124.
10. Sorlie, P. D., Backlund, E., & Keller, J. B. (1995). US mortality by economic, demographic, and social characteristics: the National Longitudinal Mortality Study. *American Journal of Public Health, 85*(7), 949–956.
11. Wilper, A., Woolhandler, S., Lasser, K., McCormick, D., Bor, D., & Himmelstein, D. (2009). Health insurance and mortality in US adults. *American Journal of Public Health, 99*(12), 2289–2295.
12. U.S. Department of Commerce. Economics and Statistics Administration U.S. Census Bureau. Census regions and divisions of the United States. U.S. Census Bureau. https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf. Accessed July 1, 2014.
13. U.S. Census Bureau: State and County QuickFacts. QuickFacts. U.S. Census Bureau. 2016. https://www.census.gov/quickfacts/fact/map/US/IPE120215#viewtop. Accessed August 29, 2017.
14. Hatzenbuehler, M. L., Bellatorre, A., Lee, Y., Finch, B. K., Muennig, P., & Fiscella, K. (2014). Structural stigma and all-cause mortality in sexual minority populations. *Social Science and Medicine, 103,* 33–41. https://doi.org/10.1016/j.socscimed.2013.06.005.
15. NCHHSTP AtlasPlus. [database on the Internet] [cited April 17, 2017]. Retrived from: https://www.cdc.gov/nchhstp/atlas/.
16. Health Resources and Services Administration. Ryan White HIV/AIDS Program Annual Client-Level Data Report 2016. http://hab.hrsa.gov/data/data-reports.November.
17. U. S. Census Bureau. American Community Survey. Accessed December 16, 2015, http://factfinder.census.gov/faces/nav/jsf/pages/programs.xhtml?program=acs.
18. Human Rights Campaign. State equality index. 2015. Accessed Septebmer 23, 2015, http://www.hrc.org/campaigns/state-equality-index.
19. National Center for Health Statistics. (2017). *National vital statistics reports deaths: Leading causes for 2015*. Hyattsville: National Center for Health Statistics.
20. Hall, H. I., Espinoza, L., Harris, S., & Shi, J. (2016). Care and viral suppression during the last year of life among persons with HIV who died in 2012, 18 US jurisdictions. *AIDS Care, 28*(5), 574–578. https://doi.org/10.1080/09540121.2015.1118428.
21. Gates GJ. Sexual Minorities in the 2008 General Social Survey: Coming out and demographic characteristics. Los Angeles, CA: The Williams Institute, UCLA2010.
22. Marcus, J. L., Chao, C. R., Leyden, W. A., et al. (2016). Narrowing the gap in life expectancy between hiv-infected and hiv-uninfected individuals with access to care. *Journal of Acquired Immune Deficiency Syndromes, 73*(1), 39–46. https://doi.org/10.1097/QAI.0000000000001014.

23. Health Resources and Services Administration. About the Ryan White HIV/AIDS Program. 2016. https://hab.hrsa.gov/about-ryan-white-hivaids-program/about-ryan-white-hivaids-program.
24. Ferlatte, O., Salway, T., Oliffe, J. L., & Trussler, T. (2017). Stigma and suicide among gay and bisexual men living with HIV. *AIDS Care, 29*(11), 1346–1350. https://doi.org/10.1080/09540121.2017.1290762.
25. Green, T. C., McGowan, S. K., Yokell, M. A., Pouget, E. R., & Rich, J. D. (2012). HIV infection and risk of overdose: a systematic review and meta-analysis. *AIDS, 26*(4), 403–417. https://doi.org/10.1097/QAD.0b013e32834f19b6.
26. Whitehorn L, Domestic violence doubles risk of death for HIV-positive women. AIDS 2012; 2012; Washington DC. https://www.poz.com/article/hiv-women-violence-22757-8706.
27. Centers for Disease Control and Prevention. 10 Leading causes of death by age group, United States—2016. 2018. https://www.cdc.gov/injury/wisqars/pdf/leading_causes_of_death_by_age_group_2016-508.pdf.