

State variation in HIV/AIDS health outcomes: the effect of spending on social services and public health

Kristina M. Talbert-Slagle, Maureen E. Canavan, Erika M. Rogan,
Leslie A. Curry and Elizabeth H. Bradley

Objective: Despite considerable advances in the prevention and treatment of HIV/AIDS, the burden of new infections of HIV and AIDS varies substantially across the country. Previous studies have demonstrated associations between increased health-care spending and better HIV/AIDS outcomes; however, less is known about the association between spending on social services and public health spending and HIV/AIDS outcomes. We sought to examine the association between state-level spending on social services and public health and HIV/AIDS case rates and AIDS deaths across the United States.

Design: We conducted a retrospective, longitudinal study of the 50 U.S. states over 2000–2009 using a dataset of HIV/AIDS case rates and AIDS deaths per 100 000 people matched with a unique dataset of state-level spending on social services and public health per person in poverty.

Methods: We estimated multivariable regression models for each HIV/AIDS outcome as a function of the social service and public health spending 1 and 5 years earlier in the state, adjusted for the log of state GDP per capita, regional and time fixed effects, Medicaid spending as % of GDP, and socio-demographic, economic, and health resource factors.

Results: States with higher spending on social services and public health per person in poverty had significantly lower HIV and AIDS case rates and fewer AIDS deaths, both 1 and 5 years post expenditure ($P \leq 0.05$).

Conclusion: Our findings suggest that spending on social services and public health may provide a leverage point for state policymakers to reduce HIV/AIDS case rates and AIDS deaths in their state.

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Introduction

Despite considerable advances in the prevention and treatment of HIV/AIDS over the past 30 years, progress on halting the epidemic in the United States has stagnated. For nearly a decade, approximately 50 000 people have been diagnosed with HIV every year in the United States. Furthermore, the burden of new infections of HIV and AIDS varies substantially across the states. Across the southern United States, for example, rates of

HIV diagnoses are more than double those of the Midwestern states [1]. Such regional and state-by-state differences raise questions for federal and state policymakers about what factors influence this variation and how best to invest in various programs in order to halt the epidemic.

Extensive evidence indicates that spending on healthcare services for people at risk of HIV infection and people living with HIV/AIDS (PLWHA) can lead to improved

Department of Health Policy and Management, Yale School of Public Health, New Haven, Connecticut, USA.

Correspondence to Kristina M. Talbert-Slagle, 2 Whitney Avenue, Suite 401, New Haven, CT 06510, USA.

E-mail: kristina.talbert-slagle@yale.edu

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health outcomes [2–4]. Prompt and ongoing medical treatment for PLWHA has been shown to reduce viral loads, block progression to AIDS, and reduce transmission [5–8]. Studies have also demonstrated that increased spending on healthcare services, such as testing, antiretroviral treatment, and primary patient care also leads to reductions in HIV/AIDS diagnoses and mortality [9]. Yet less is known about the association between spending on nonmedical services, such as public health and social services, and HIV/AIDS diagnoses and AIDS deaths, or about how variation in social service and public health spending may explain state-level variation in these HIV/AIDS outcomes across the United States [10].

Accordingly, we sought to examine the association between social service and public health spending and HIV diagnoses, AIDS diagnoses, and AIDS deaths using state-level data over a 10-year period, 2000–2009. Previous research has indicated that social factors such as housing [11] and food insecurity [12] are associated with increased risk of HIV infection, and average HIV diagnosis rates across the United States have been shown to increase in areas with increasing percentages of people who have less than a high school education and who live below the federal poverty level [13]. In addition, for PLWHA, insufficient income, limited access to transportation, inadequate housing, food insecurity, and low literacy levels can negatively impact their ability to access care and treatment, afford co-pays or other costs associated with treatment, or adhere to antiretroviral medication regimens [14–26], which can result in progression to or even death from AIDS [27,28]. Together, these data indicate the importance of social factors in affecting individuals' risk of becoming infected with HIV as well as the risk of progression to AIDS or death from AIDS among PLWHA in the United States [29].

We hypothesized that states with higher social service and public health spending per person in poverty would have significantly lower rates of HIV/AIDS diagnoses and AIDS deaths, adjusted for the log of state GDP per capita, regional and time fixed effects, Medicaid spending as a percentage of GDP in poverty, and covariates measuring socio-demographic, economic, and health resource factors. To address this aim, we constructed a novel longitudinal dataset of state-level spending on healthcare services, public health, which includes services such as health inspections, nutritional supports, and community health initiatives, and social services in all 50 states over 2000–2009 using data from a variety of sources including the U.S. Census Bureau, the National Health Expenditures Data [Centers for Medicare & Medicaid Services (CMS), 2014]. Findings from this study can be used to more fully understand the potential benefits of state investments in social services and public health on the health outcomes of PLWHA in the United States.

Methods

Study design

We conducted a retrospective, longitudinal study of the 50 U.S. states over the decade 2000–2009 ($N = 500$ state-year observations), the most recent 10-year period for which consistent data on our target HIV/AIDS health outcomes, public health, and social services spending across states were available. We created a dataset that included information on HIV/AIDS case rates and AIDS deaths per 100 000 people as well as for spending on social services and public health services. The protocol was reviewed by the Institutional Review Board at Yale University School of Medicine and was deemed exempt from review because we used publicly available, de-identified data.

Data and measures

Our dependent variables were state-level HIV diagnoses or AIDS diagnoses, reported as cases per 100 000 people, and AIDS deaths, reported as deaths per 100 000 people (Table 1). Although new HIV cases (reported as diagnoses) are reported annually via Centers for Disease Control and Prevention (CDC) HIV Surveillance reports [30], data are missing for several states within several years during 2000–2009. New HIV diagnoses are also reported for individual U.S. states on the CDC Atlas website [31], but only for the years 2008–present. Because individual states actively de-duplicate HIV diagnoses at regular intervals, we contacted each individual state public health department to obtain their most recent data on annual HIV diagnoses for the years 2000–2009. We obtained data on AIDS diagnoses and deaths from CDC Atlas [31] for all states during the years 2000–2009.

Our independent variable of interest for each state and year was total spending on social services and public health per person in poverty. We combined spending on social services and public health to create our independent variable because both types of spending address social and environmental determinants of health at the population level, rather than focusing on medical determinants of health for individuals. Social services included primary, secondary, and higher education; income supports [e.g. Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI),

Table 1. Means and standard deviations of annual HIV/AIDS outcomes and median annual state-level spending, 2000–2009.

Annual outcome (per 100 000 population)	Mean (SD)
HIV case rate	10.94 (9.40)
AIDS case rate	8.07 (6.77)
AIDS death rate	4.37 (3.70)
Spending variable	Median
(\$S+PH)/person in poverty	\$54.98 (19.08)

social security, other cash assistance, general relief for low-income or needs-tests beneficiaries of public welfare programs]; transportation (e.g. airports, public mass transit systems); environment (e.g. sanitation and recreational programming, conservation of natural resources); public safety (e.g. law enforcement and fire protection); and housing (e.g. aid for public or private housing and community development), and were obtained from the U.S. Census Bureau Annual Survey of State and Local Government Finances (U.S. Census Bureau, 2014), the Social Security Administration, Administration for Children and Families, and the U.S. Department of Agriculture for years 2000–2009. Public health spending, available through the U.S. Census Bureau, included provision of services for the conservation and improvement of public health, other than hospital care, and financial support of other governments' health programs, such as Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), protective inspection services, health-related inspections, community healthcare programs, and ambulance and emergency medical services (unless operated by local fire department).

Candidate covariates included state GDP per capita (obtained from the U.S. Department of Commerce, Bureau of Economic Analysis) for 2000–2009, Census region, as well as state socio-demographic and economic factors (from the U.S. Census Bureau) for 2000–2009 including percentage of the population aged 65 years and older, percentage white, percentage female, percentage of adults aged 25-years or older with a high school diploma, percentage of population living in urban area, percentage of children living in a single-parent household, primary care provider rate per 100 000 population, hospital bed rate per 100 000 population, mean house price, and percentage of adults who are unemployed. We collected unemployment rate data from the U.S. Department of Labor, mean housing price from the U.S. Federal Housing Finance Agency, and percentage of children living in single-parent household from National KIDS COUNT [32]. We obtained data on health resources (hospital beds, primary care providers, and dentists each per 100 000 population) from the American Medical Association, American Hospital Association, and American Dental Association. In addition, we sought data on state-level funding provided through the Ryan White Care Act (CARE), a federal funding programme initiated in 1990 that provides funds directly to U.S. states to support care for PLWHA who are un- or underinsured through what is known as part B [33]. Ryan White CARE expenditure data for part B were only available, however, for a portion of our total study period, 2006–2009 [34].

Data analysis

We used standard descriptive statistics to characterize state-level variation in HIV/AIDS outcomes as well as

spending on social services and public health. To estimate associations between social service and public health spending per person in poverty and HIV/AIDS case rates and AIDS death rate per 100 000 population, we estimated separate multivariable linear regression models for each HIV/AIDS outcome as a function of the social services and public health spending, using annual data for 2000–2009 with a 1-year time lag in the spending variables. We adjusted these models for the log of the state GDP per capita, Medicaid spending as a percentage of state GDP, time and region fixed effects [35,36], and state-level repeated measures because serial autocorrelation of the outcome variable was found to be significant based on the Wooldridge test [37,38]. Models were also run adjusting for the following covariates: percentage of the population aged 65 years and older, percentage white, percentage female, and percentage of population living in urban area, unemployment rate, percentage of children living in single-parent household, and primary care providers per 100 000 population. Although data on state-level expenditures through part B of the Ryan White Care Act were only available for years 2006–2009, we conducted sub-analysis using those 4 years of data and determined that inclusion of Ryan White data did not appreciably change the association between social service and public health spending and subsequent HIV/AIDS outcomes. We excluded several other variables that were found to be multicollinear (generally based on correlation or phi coefficient statistic greater than 0.50) [39]. We ran these models for total social service and public health spending per person in poverty as well as for each component (subgroup) of social services, which included education, income supports, transportation, environment, public safety, and housing. All estimates incorporated robust standard errors using the Huber–White sandwich estimators to address potential problems of normality, heteroscedasticity, or individual observations that have large residuals, leverage or influence [40,41]. Additionally, we used the post estimation technique of assessing the variance inflation factor on the final models to ensure they did not violate multicollinearity assumptions [42]. All models reported had variance inflation factors below 10, indicating that multicollinearity did not compromise model fit. We imputed missing data for social service and public health spending data in years 2001 and 2003 and for social security spending in 2000 using a Bayesian posterior predictive distribution of the missing data with an iterative Markov chain Monte Carlo method with 50 imputations per variable [43].

In secondary analysis, we re-estimated all models with 5-year time lags in the spending variables in order to address simultaneous causation concerns and to capture a time frame in which spending may potentially influence health outcomes. All statistical analyses were performed with STATA, version 12 (College Station, Texas, USA).

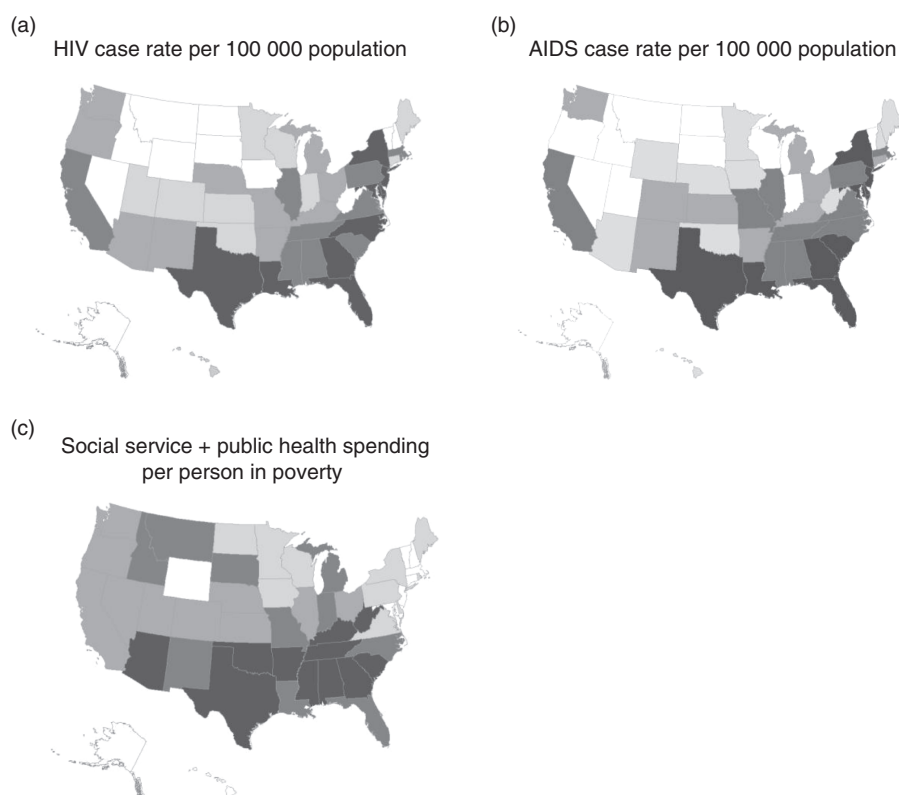


Fig. 1. U.S. maps of HIV/AIDS case rates and combined social service and public health spending per person in poverty, 2009. (a, b) Dark gray indicates highest quintile (i.e. poorest health outcomes) and white indicates lowest quintile (i.e. best health outcomes). (c) Dark gray indicates lowest social service + public health spending per person in poverty; white indicates highest social service + public health spending per person in poverty.

Results

State-level variation in spending and outcomes

Means and standard deviations for annual HIV/AIDS case rates and AIDS deaths as well as the median annual spending on social services and public health are shown in Table 1. Maps of the United States characterizing states by quintiles of HIV/AIDS case rates and spending per person in poverty on social services and public health are shown in Fig. 1.

Associations between HIV/AIDS outcomes and spending

We found that higher spending on social services and public health was associated with reduced HIV/AIDS case rates and AIDS deaths 1 year later ($P < 0.05$) in models adjusted for the log of state-level GDP per capita, regional and time fixed effects, Medicaid spending as a percentage of state GDP, and state-level serial correlation (Table 2). These effects remained significant when models were further adjusted by percentage of the population

Table 2. Associations between social services + public health spending per person in poverty and HIV/AIDS outcomes across 50 U.S. states, 2000–2009.

	One year lag in spending (N = 450)				Five year lag in spending (N = 250)			
	Model 1 ^a		Model 1A ^b		Model 2 ^a		Model 2A ^b	
	Estimate	P value	Estimate	P value	Estimate	P value	Estimate	P value
HIV case rate ^c	-0.529	0.002	-0.468	<0.001	-0.491	0.005	-0.247	0.013
AIDS case rate ^c	-0.287	0.002	-0.138	0.006	-0.252	0.006	-0.123	0.050
AIDS death rate ^c	-0.188	0.002	-0.081	0.028	-0.166	0.007	-0.061	0.027

^aModel adjusted for the log of state-level GDP per capita, regional and fixed effects, Medicaid spending as a percentage of state GDP, and state-level serial autocorrelation.

^bModel fully adjusted for the log of state-level GDP per capita, regional and fixed effects, Medicaid spending as a percentage of state GDP, and state-level serial autocorrelation as well as significant covariates in best fit model: percentage of the population aged 65 years and older, percentage white, percentage female, percentage of population living in urban area, unemployment rate, percentage of children living in single-parent household, hospital beds and primary care providers per 100 000 population.

aged 65 years and older, percentage white, percentage female, percentage of population living in urban area, unemployment rate, percentage of children living in single-parent household, hospital beds and primary care providers per 100 000 population ($P < 0.05$). These effects were also significant when we replaced the 1-year lagged spending variables with 5-year lagged spending (Table 2).

Spending on social service and public health subcategories and HIV/AIDS outcomes

Significant associations were apparent between higher spending for several subcategories of social services and the HIV/AIDS outcomes studied. Specifically, higher spending 1 and 5 years earlier on education per person in poverty was significantly ($P < 0.01$) associated with lower HIV case rates, AIDS case rates, and AIDS deaths per 100 000 people. Greater spending on income support was also marginally associated with reductions in HIV case rates ($P < 0.1$), and higher spending on public health per person in poverty was significantly associated with reductions in AIDS case rates and AIDS deaths ($P < 0.05$) and marginally associated with reductions in HIV case rates ($P < 0.1$). We did not find significant associations between spending in other subcategories and HIV/AIDS outcomes.

Discussion

We found that U.S. states with higher spending per person in poverty on social services and public health had subsequently lower rates of HIV diagnoses, AIDS diagnoses, and AIDS deaths per 100 000 people. This effect was observed not only for social service and public health spending from the previous year, but also when we incorporated spending from 5 years earlier and persisted even after adjusting for healthcare spending and socio-economic factors that vary across the states. To our knowledge, this is the first study that explicitly establishes a significant association between key state-level social services investments and clinical health outcomes for people at risk of HIV infection or for those living with HIV/AIDS. This work highlights a potentially critical element, often missing from health policy discussions, in improving outcomes for this important population.

It is important to note that the measure we used in our analysis, HIV diagnoses per 100 000 people, is not a perfect measure of new HIV infections, or HIV incidence [44]; changes in this value could reflect not only changes in the number of people who become infected with HIV in a given year, but also changes in HIV testing in different states. Calculation of true HIV incidence requires more extensive analysis of diagnostic samples and is beyond the scope of this study [45]. Despite the limitations of HIV diagnosis in reflecting true incidence of HIV in the

United States, our study results consistently indicated that increased spending on social services and public health was associated with decreased HIV case rates, with important implications for the potential role of increasing social services and public health spending in preventing HIV infection in the United States.

The findings from our study were subject to a few additional limitations. First, our data are observational rather than experimental and thus limited in terms of producing claims of causal inference. Nonetheless, we employed strong statistical methods to estimate the association between previous spending and subsequent health outcomes at the state level, adjusted for an array of potentially confounding variables as well as regional and time fixed effects. Second, the data are somewhat dated; however, these were the most contemporary data we could locate that had a decade of consistent measurement in spending across all states. Third, we lacked data on state-level healthcare spending from the Ryan White Comprehensive AIDS Resources Emergency Act (CARE) program for the full study period; however, in a sub-analysis with 2006–2009 data, for which we could attain Ryan White spending data, its inclusion in the multivariable models did not materially affect our results. Fourth, due to limited temporal changes in annual state-level social service spending we were not able to find a significant relationship between annual changes in spending and changes in HIV/AIDS outcomes. However, we did address how spending from 1 year might be associated with health outcomes 1 and 5 years later at the state level using a lagged spending variable. Last, although we analyzed sub-categories of social service spending, future studies are needed to identify specific social service programmes that are most impactful on HIV/AIDS health outcomes.

Of the approximately 1.2 million people in the United States who are living with HIV, [1] only an estimated 25% achieve viral suppression through antiretroviral therapy, with the remainder either unaware that they are infected (20%) or not fully engaged in medical care (>50%). These breaks in the care continuum for PLWHA, known as the treatment cascade, represent a serious medical and public health challenge [46] and have contributed to treatment guidelines for physicians that specifically recommend exploring social factors such as housing, food insecurity, and transportation that may affect a patient's likelihood of receiving care or adhering to an antiretroviral medication regimen [46,47]. Many scholars have called, however, for broader action on HIV prevention than discussion and decision-making that can occur between medical care provider and patient, [29] advocating social and structural approaches to prevent HIV transmission and improve outcomes for PLWHA [48–50]. Our findings suggest an association between increased spending on social services and public health and reduced HIV diagnoses as well as reduced AIDS diagnoses and deaths. Spending on social

services and public health may thus provide a key, previously overlooked leverage point both to improve treatment outcomes for PLWHA and also to prevent new HIV infections in the United States.

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Conflicts of interest

There are no conflicts of interest.

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