

Individual, Community, and Structural Factors Associated With Linkage to HIV Care Among People Diagnosed with HIV in Tennessee

Aima A Ahonkhai (✉ aimalohi.a.ahonkhai@vumc.org)

Vanderbilt University Medical Center <https://orcid.org/0000-0003-0666-4767>

Peter Rebeiro

Vanderbilt University Medical Center

Cathy Jenkins

Vanderbilt University Medical Center

Michael Rickles

Tennessee Department of Health

Mekeila Cook

Meharry Medical College

Donaldson Conserve

University of South Carolina

Leslie Pierce

Vanderbilt University Medical Center

Bryan Shepherd

Vanderbilt University Medical Center

Meredith Brantley

Tennessee Department of Health

Carolyn Wester

Tennessee Department of Public Health

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Abstract

Background

We assessed trends and identified individual- and county-level factors associated with linkage to HIV care in Tennessee (TN).

Methods

TN residents diagnosed with HIV from 2012–2016 were included in the analysis ($n = 3,750$). Linkage was defined by the first CD4 or HIV RNA test date at or after HIV diagnosis. We used modified Poisson regression to estimate probability of 30-day linkage to care at the individual- and county-levels.

Results

Both MSM (aRR 1.16, 95%CI 1.01–1.32) and women who reported heterosexual sex risk factors (aRR 1.28, 95%CI 1.11–1.48) were more likely to link to care within 30-days than heterosexual males. Non-Hispanic Black individuals had poorer linkage than White individuals (aRR 0.77, 95%CI 0.72–0.83). County-level mentally unhealthy days were negatively associated with linkage (aRR 0.59, 95%CI 0.40–0.88).

Conclusions

Disparities persist at both individual and county levels and may warrant structural interventions to address racism and mental health needs.

Introduction

Since the first reported cases of HIV in 1981, the epicenter of the HIV epidemic has shifted from urban bi-coastal centers to the Southern United States (US) (1). In 2018, despite representing only 38% of the US population, Southern states accounted for an estimated 46% of persons living with HIV (PLWH) in the US, and 52% of new diagnoses (1). To gauge where the gaps in HIV care existed in the southeastern state of Tennessee (TN), the TN Department of Health (TDH) completed its first continuum of care analysis in 2010. The analysis revealed that TN under-performed relative to the general US population in both linking newly diagnosed patients to care within 90 days (66% vs. 80%) and retaining patients in HIV care over time (37% vs. 46%) (2, 3). Since then, TN has continued to lag in linkage to care indices. Only 46% of people diagnosed with HIV in TN in 2017 were linked to care within 30 days compared to 78% in the nation (4, 5). The importance of timely linkage to HIV care is emphasized as one of four pillars of the Department of Health and Human Services' recent Ending the HIV Epidemic (EtE) Initiative in the US, which are: 1) prompt diagnosis, 2) prompt engagement and treatment initiation, 3) prevention of new infections, and 4) early detection of new disease clusters (6). Further, pivotal research has shown that persons with undetectable HIV viral loads do not transmit the virus, thus, highlighting the importance of starting HIV treatment as soon as possible following diagnosis; an outcome now defined as linkage to an HIV provider within one month (6–8).

Despite widespread availability of potent antiretroviral therapy (ART) leading to drastic reductions in HIV incidence and mortality overall, several factors contribute to disparities in continuum of care outcomes. Individual and community-level factors like homelessness, unemployment, low education, food insecurity and substance use are all known predictors of poor linkage to HIV care following diagnosis (9, 10). Facility-level factors, such as location of testing site, have also been shown to have a negative impact on timely linkage in other Southern states (10). Importantly, disparities among racial/ethnic group have persisted in the US over decades, with non-Hispanic Blacks typically performing worse than other racial/ethnic groups across the entire continuum of care (11, 12). Racial disparities have been variably attributed to higher rates of poverty, unemployment, and stigma – inequities that are even more pronounced in the Southern US – and thus might drive some of

TN's poor performance on linkage to HIV care (11–15). There are limited data characterizing whether and to what extent significant racial disparities in HIV outcomes remain after accounting for both individual and county-level factors known to be associated with poor health outcomes, and disproportionately impacting racial minorities (14, 15). Such studies are important in the Southern US, home to both a higher rate of incident HIV and more pronounced racial disparities in HIV-related health outcomes than other regions in the US (16).

To improve performance along the continuum of HIV care, TDH launched a number of initiatives between 2010 and 2015. These included capacity building and infrastructure changes to improve the accuracy and efficiency of HIV testing and reporting such as instituting mandatory reporting of CD4 and HIV RNA tests to the state, and upgrading to fourth generation HIV antibody and antigen testing (17). In addition, CDC resources supported targeted programs to reduce racial disparities in HIV outcomes in the state including the implementation of a social networking program for non-Hispanic Black MSM for testing, allocating care navigation resources for released inmates, and the deployment of disease intervention specialists (DIS) using surveillance data to locate out of care patients living in the counties with the highest incidence of HIV (17). In the wake of these concerted efforts by TDH, the objective of this analysis was to integrate individual and county level data assessing important individual, community, and structural drivers of healthcare outcomes to understand 1) trends in linkage to HIV care in TN over time, 2) drivers of poor linkage to care outcomes and 3) drivers of ongoing racial disparities in these outcomes in the state, and in counties with the highest HIV burden.

Methods

Study Setting and Design

We conducted a retrospective cohort study of persons who resided in one of Tennessee's 95 counties and were newly diagnosed with HIV between January 1, 2012 and December 31, 2016. We assessed trends in rates of linkage to care over the study period and individual, community, and structural predictors of linkage to HIV care (measured at the county level). The outcome of interest was linkage to HIV care, which was defined as receipt of the first CD4 or HIV-1 RNA test result captured via TN's enhanced HIV/AIDS reporting system (eHARS) at or after diagnosis, and was assessed at 30, 60, and 90 days.

Data Collection and Analysis

Individual-Level Analysis

The individual-level variables obtained from eHARS and included: year of diagnosis, age at diagnosis, sex, race/ethnicity (White/non-Hispanic, Black/non-Hispanic, Hispanic/all races, other/unknown), HIV risk factor (heterosexual contact, men who have sex with men (MSM), injection drug use (IDU), MSM/IDU, other, unknown) and site of diagnosis (inpatient facility/ER, outpatient facility, health department or STD/family planning clinic, blood bank, correctional facility, other/unknown, missing). We combined sex and HIV risk factor into one variable with the following categories: male/heterosexual, male/MSM, male/IDU, male/other-unknown, female/heterosexual, female/IDU, and female/other-unknown.

Descriptive statistics for demographic and clinical characteristics (median, interquartile range [IQR] or percent, as appropriate) were calculated by linkage to care status within 30, 60 and 90 days of HIV diagnosis and overall. We used modified Poisson regression to assess risk ratios (RR) for linkage to care at each threshold adjusting for the *a priori* selected individual-level covariates in multivariable analysis. In primary analyses, year was modeled as a categorical variable. Age was included in models as a continuous variable and expanded using restricted cubic splines with 4 knots to avoid linearity assumptions. A secondary analysis modeled year as a continuous variable.

County-Level Analysis

We assessed community and structural factors at the county-level representing measures of healthcare access, socioeconomic status and burden of disease grounded in the social ecological model as a framework to consider barriers to linkage to HIV care (18, 19). The measures were drawn from several sources including a CDC-developed Vulnerability Index

(VI) which provided a means of identifying counties at high risk for incident cases of HIV/HCV (20, 21). The VI is comprised of measures such as percent of the population who have a car, are below the Federal Poverty Level, are non-Hispanic Whites, have poor or fair health, are with a disability, are smoking adults, as well as the per capita income, teen birth rate and HIV prevalence, which were felt to represent potential barriers to linkage to care for HIV [Table I] (20). We retained all 15 variables from the CDC study and included 63 additional variables collected from the 2010 US Census, TN state-specific indicators from the CDC and TDH HIV, STD, and viral hepatitis surveillance data [Table II].

Other county-level variables assessed as measures of healthcare access included: percent of the population without health insurance which was obtained from self-reported data collected in the American Community Survey administered by the US Census Bureau (22). The number of persons without health coverage was divided by the total civilian non-institutionalized population and the 2012 and 2013 five-year estimates were averaged, as were the rate of mental health providers and per capita urgent care facilities and per capita primary care physicians. Mental health providers were collected in the 2010 Census and included psychiatrists, psychologists and licensed clinical social workers specializing in mental health care (23, 24). The rate was calculated as the number of mental health providers per 100,000 population. Measures of community socioeconomic status included: percent of the population unemployed and without food security in addition to average numbers of vacant housing units, female-headed households, and drug-related or violent crimes. Finally, measures of community disease burden included: rates of STI diagnosis, percent of HIV cases due to IDU and average numbers of poor mental health days, a measure of community-level mental distress. Average number of mentally unhealthy days was determined using results from the Behavioral Risk Factor Surveillance System (BRFSS) that asked participants to answer the question “Now, thinking about your mental health, which includes stress, depression and problems with emotions, for how many days during the past 30 days was your mental health not good?” The survey is conducted annually in all states and uses a state-based random digit dial (RDD) telephone method (25).

Among the VI and additional variables, we hypothesized that county-level measures of healthcare access (percentage without healthcare insurance, rate of mental health providers, per capita urgent care facilities, and per capita primary care physicians, percentage of homes with cars), socioeconomic status (percentage below the federal poverty level, percentage unemployed, average vacant housing units, average number of female-headed households, percentage with food insecurity, violent crime rate), and disease burden (percentage of adults with poor or fair health, percentage of adult smokers, percentage with disability, HIV prevalence, rate of STD diagnosis) would be associated with linkage to HIV care.

To test our hypotheses, modified Poisson regression was used to obtain adjusted RR and marginal probabilities with 95% confidence intervals for the association between county-level characteristics and our outcomes. We fit multivariable models with the county-level variables described above along with our primary outcome of interest, linkage to HIV care. We adjusted for individual-level characteristics including age, sex, race/ethnicity, HIV transmission risk, site of diagnosis and time since HIV diagnosis. These covariates were modeled using restricted cubic splines for continuous measures and categorical indicators for all other measures. Robust standard errors for all models were calculated by clustering at the county level, assuming correlation in the primary outcomes between individuals residing in the same county at the time of HIV diagnosis.

IRB Approval

We obtained IRB approval from Vanderbilt University Medical Center (Protocol no. 17119, Nashville, TN, USA), and Tennessee Department of Health (protocol no. 1097644-4).

Results

Description of Cohort of TN Residents Newly Diagnosed with HIV

The data included 3,750 individuals newly diagnosed with HIV in TN between 2012 and 2016. The number of people newly diagnosed with HIV gradually decreased from 2012 to 2016 (2012: 842, 2013: 756, 2014: 729, 2015: 716, 2016: 707). Men comprised a greater proportion of the cohort (80%, n = 2987) than women; and non-Hispanic Black patients (59%, n = 2205)

comprised a greater proportion of the cohort than non-Hispanic White (33%, n = 1230) or Hispanic patients (5%, n = 200). The median age at diagnosis was 31 years [IQR 24, 43]. Over half (55%, n = 2079) of the population reported a transmission risk factor of MSM, while 24% (n = 883) reported heterosexual sex and 3% (n = 114) reported injection drug use. More patients were diagnosed from outpatient facilities (34%, n = 1291) than health department or STD clinics (28%, n = 1041), inpatient facilities or ERs (20%, n = 745), correctional facilities (5%, n = 195) or blood banks (4%, n = 134). [Table I]. Four counties in TN represented 71% of incident cases during the analysis period (Shelby County, county seat of Memphis (n = 1460, 39%); Davidson County, county seat of Nashville (n = 783, 21%); Hamilton County, county seat of Chattanooga (n = 232, 6%); and Knox County, county seat of Knoxville (n = 201, 5%)).

Trends in Establishing HIV Care Over Time

Over the entire study period, 49% (n = 1,841) of newly diagnosed PLWH were linked to care within 30 days, 66% (n = 2,472) within 60 days, and 73% (n = 2,747) within 90 days. The proportion of patients linked to care within 30 days of diagnosis increased from 47% (n = 398) in 2012 to 54% (n = 409) in 2013 and decreased to 46% (n = 325) in 2016. When modeled as a linear covariate, year of diagnosis was not a significant predictor of 30-day linkage to care (aRR 0.98 95%CI 0.93–1.03, data not shown). In addition, whether linkage to HIV care was defined at 30, 60, or 90 days after HIV diagnosis, linkage increased from 2012 to 2013 then declined to or below the 2012 value by the end of the study period in 2016, and the percentage of patients who were linked to an HIV provider increased as the time to linkage threshold was broadened. Adjusting for other patient-level factors (age, sex, transmission risk factor, site of diagnosis), 30-day linkage to care increased by 13% (aRR 1.13, 95%CI 1.03–1.24), and 60-day linkage to care increased by 9% (aRR 1.09, 95%CI 1.02–1.16) in 2013 compared to 2012. However, the adjusted rate of 30-, 60- and 90-day linkage to care did not significantly differ in 2014, 2015, or 2016 compared to 2012 (with the exception of the risk of 90-day linkage to care in 2016, which decreased by 7% compared to 2012 (aRR 0.93, 95% CI 0.87–0.99)) [Figure 1].

Individual-Level Predictors of Linkage to Care

Age was a significant, individual predictor of linkage to care (p = 0.002). Younger and older patients were more likely to establish care within 30 days (compared to 30 year-olds, aRR 1.09, 1.01, 1.04, 1.08, and 1.11, respectively for ages 20, 25, 35, 40, and 45 years). Race was also an independent predictor of linkage to care. Non-Hispanic Black patients had a significantly decreased rate of 30-day linkage to care compared to non-Hispanic Whites (aRR 0.77, 95% CI 0.72–0.83). Linkage to care did not differ significantly between non-Hispanic White patients and those who identified as Hispanic (aRR 0.99, 95%CI 0.86–1.13) or other/unknown (aRR 0.98, 95%CI 0.83–1.16). When we combined sex and HIV transmission risk factor categories, we found that MSM (aRR 1.16, 95%CI 1.01–1.32), male-IDU (aRR 1.22, 95% CI 1.01, 1.48), and heterosexual females (aRR 1.28, 95%CI 1.11–1.48) were more likely to link to HIV care than heterosexual males. Additionally, the location of HIV testing/diagnosis was also an important predictor of linkage to care. Compared to an inpatient facility or emergency room, patients diagnosed at outpatient facilities (aRR 0.84, 95%CI 0.78–0.90) and health departments or STD clinics (aRR 0.53, 95%CI 0.48–0.59) were less likely to establish HIV care [Table II]. While the data here are presented for 30-day linkage to care, the same patterns were seen for 60- and 90-day linkage to care as illustrated in Table II.

County-Level Factors Associated with Linkage to Care

Among the 23 county-level measures assessed, only four were both clinically and statistically significant in multivariable analysis. Average poor mental health was the strongest county-level predictor of poor linkage care at 30 days (aRR 0.59, 95%CI: 0.40–0.88 per 10-unit increase in poor mental health days). In addition, in counties with a higher percentage of HIV cases due to IDU, there was a nearly 2-fold increased likelihood of linking to care (aRR 1.71, 95%CI: 1.24, 2.36) and 25% increased likelihood in counties with higher numbers of methadone clinics (aRR 1.25, 95%CI: 1.06–1.47). Interestingly, increases in the disabled population (aRR 11.29, 95%CI: 1.32–96.54) were associated with a large increase in likelihood of linkage to care. Also, the percentage of White, non-Hispanic individuals within a county was associated with a higher likelihood of linkage to care, (HR 1.32, 95%CI: 1.23–1.42) [Table III].

Linkage to Care in the Highest Burden Counties in TN

We analyzed the marginal probabilities of linkage at 30-days in the four high-burden metropolitan counties, and found that non-Hispanic Black patients persistently had the lowest probability of 30-day linkage to care as compared to both White (non-Hispanic) and Hispanic individuals when adjusting for individual level factors, and when adjusting for both individual and county-level factors [Figure 2].

As in the entire cohort, more patients were diagnosed in outpatient facilities (n = 1291, 34%) than other sites assessed. Notably, 30-day linkage to care from outpatient facilities was poor across all of 4 highest burdened counties, and ranged from 54–64%. On the other hand, an analysis of 30-day linkage to HIV care from inpatient or emergency rooms in each of the four high-burden metropolitan counties showed that the proportion of patients linked to care was more variable, and ranged from 57% in Shelby County to 73% in Davidson and Knox counties, and 79% in Hamilton county [Table IV].

Discussion

Our analysis of patterns and predictors of linkage to HIV care in TN between 2012 and 2016 highlights unsettling trends. First, despite concerted efforts from TDH, CDC and local partners, timely linkage to HIV care among people newly diagnosed with HIV in TN has not only failed to improve over time, but TN now unfortunately trails the nation in linking PLWH to care. Second, unacceptable racial disparities in linkage to care persist, as non-Hispanic Blacks remain much less likely to link to care than non-Hispanic Whites – even after accounting for a range of individual and structural factors that often are drivers of poor healthcare access and engagement. Our analysis does, however, identify some potential systematic and programmatic opportunities that could be targets for intervention to begin to change this trend as well as areas for further research.

It is well-documented that HIV disproportionately affects the Black community in the US at large – a disparity that persisted decades beyond the start of the HIV epidemic (13–15). Unfortunately, our study findings add to the body of literature highlighting a critical need to adopt new strategies to address these persistent and pervasive racial disparities in HIV outcomes. Today, the life-changing pandemic caused by the novel SARS-coronavirus has shone a floodlight on the power of structural racism to undermine public health as whole (26). Astoundingly, non-Hispanic Blacks have accounted for more than 70% of all COVID-19 deaths in certain US counties (Milwaukee), cities (Chicago), and states (Louisiana) (26). These trends have incited important discussions about systemic racial disparities in the US healthcare system, and may afford a critical opportunity to seriously consider how to address the structural factors driving such disparities in our healthcare system.

Some, like former president of the American Public Health Association, Dr. Camara Jones, have called on us to recognize structural racism as “a system of structuring opportunity and assigning value based on the social interpretation of how one looks;” and the root cause of all differences in any health outcome associated with race (27). As such, racism itself is an important social determinant of health, that necessitates a structural intervention (27). Acknowledging these complex dynamics, one city, Milwaukee, declared racism as a public health crisis in the summer of 2019 (28). Following this declaration, County officials committed to putting racial equity at the core of all city procedures to advocate for policies that improve health in communities of color, and to train their employees on how racism impacts residents (28). Several other studies have taken adopted other strategies to counter structural racism (such as Racial Equity Here in Albuquerque, Austin, Grand Rapids, Louisville, and Philadelphia) (29). Cities and counties in TN and other regions across the countries contending with profound racial disparities may also need to consider these novel structural approaches to not only effectively reduce these disparities, but also to ultimately end the HIV epidemic.

In addition to race/ethnicity, site of diagnosis has also been identified as a significant predictor of linkage to HIV care in several studies. Most have highlighted that while HIV testing in non-healthcare settings may have a higher positivity rate; linkage to care is lower at testing sites without co-located medical facilities (30–32). As in other studies, individuals in our cohort who tested positive for HIV at sites without co-located medical facilities such as correctional facilities and blood banks, were the least likely to link to HIV care (31, 33). Surprisingly, while outpatient facilities yielded the greatest numbers of incident diagnoses in this cohort, diagnosis at these sites were also associated with a 30% reduced risk of linkage to care

compared to inpatient facilities. Higher likelihood of linkage to HIV care from inpatient facilities may also reflect the fact that patients diagnosed in these settings are more ill and in need of prompt ART, and thus more readily establish care after hospitalization. Linkage to care from both inpatient facilities and outpatient facilities was lowest in Shelby County, the County seat of Memphis, and TN's only county targeted for EtE activities. Such findings represent an opportunity for improvement via review and optimization of linkage referrals at such sites, and implementation of new care delivery models, such as rapid ART initiation to promote earlier linkage to care, especially in this county (34).

Our analysis of county-level drivers of linkage to HIV also yielded some intriguing findings. One of the strongest county-level predictor of linkage to HIV care in TN was the average monthly number of mentally unhealthy days. In adjusted analysis, living in a county with more mentally unhealthy days was associated with a 40% reduction in risk of linkage to care. A rich body of data supports an association between community factors and important health outcomes (35–37). Much of this research has focused on poor socioeconomic status (SES) and other characteristics of neighborhood deprivation (18, 35, 37, 38). One study set in TN found that individuals living in neighborhoods with the most adverse socioeconomic features were least likely to achieve virologic suppression (18). Some authors hypothesize that the relationship between SES and health outcomes are mediated by distribution of stressors, which may be more prevalent in poorer neighborhoods and among racial and ethnic minorities (35, 39–41). Others propose that maladaptive response to stressors may disproportionately impact those with low SES due to greater perceived stress and limited resources to cope with stress (39). Importantly, in our analysis, this finding was strong, and independent of race. Another notable finding was a nearly 2-fold increase in the likelihood of linkage to care for individuals living in counties with higher rates of HIV due to IDU. However, given the low prevalence of IDU as a risk factor for new HIV infections in TN (5%), this finding might reflect services for this population within these communities.

Surprisingly, access to health insurance at the county level was not significantly associated with a linkage to care. While TN has not accepted federal Medicaid expansion, through the federally-supported Ryan White (RW) program TN is still able to provide coverage for medical services directly or indirectly associated with HIV/AIDS and related illnesses, as well as general insurance assistance (42). The TN HIV Drug Assistance Program (HDAP), also funded through RW, provides assistance for the purchase of HIV treatment regimens (42, 43). Across the country, recipients of these funds are more likely to succeed along the continuum of care, as compared to uninsured PLWH or those with other forms of healthcare coverage (44, 45). As such, the promotion and utilization of RW services in TN may be an important mechanism to address unmet mental health needs as described earlier in the discussion. Interestingly, unlike access to health insurance directly, the proportion of individuals in a county living with a disability was associated with a tremendous increase in the likelihood of linkage to care for an individual living in that county. This variable may be an important proxy for health insurance given that Americans with disabilities are eligible for Medicare coverage (46).

Our analysis has notable strengths and weaknesses. Our integration of individual-level surveillance with county-level census and publicly reported data allowed us to identify important individual and county-level risk factors for poor linkage to care, while accounting for many of the socioeconomic drivers of racial disparities in health. However, our use of such data also posed some limitations, as we could not incorporate important factors that are not readily collected in these data systems like individual level mental health, experiences with stigma, racism, and other barriers to healthcare access and earlier linkage to HIV care for individuals living with HIV in TN. Additionally, despite the improvements in HIV surveillance and data quality since 2012, our measures of linkage to care were reliant on the completeness of the mandatory reporting system which varies by site and could have introduced some bias.

In conclusion, in order to meet critical EtE target of reducing the number of new HIV infections in the US by 90% and move towards ending the epidemic, statewide linkage to care in TN needs to improve. Despite targeted efforts both broadly and in minority communities, linkage to HIV care did not improve substantially from 2012 to 2016. The pervasiveness of racial disparities that persist at both individual and county levels suggests the need for exploring structural interventions to address racism as a public health threat. In addition, optimizing outreach for young heterosexual men who may be overlooked by interventions targeting MSM, and addressing linkage to care processes from outpatient and community-based testing

facilities through improved partnerships or co-location of testing and treatment services are potential areas for intervention. Further exploration of the role of poor community and individual mental health in this environment is needed to inform mental health interventions to improve engagement in HIV care.

Declarations

Ethics approval and consent to participate:

We obtained IRB approval from Vanderbilt University Medical Center (Protocol no. 17119, Nashville, TN, USA), and Tennessee Department of Health (protocol no. 1097644-4).

Consent for publication:

Not applicable.

Availability of data and materials:

The data that support the findings of this study are available from the Tennessee Department of Health but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Tennessee Department of Health.

Competing interests:

The authors declare that they have no competing interests" in this section.

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Authors' contributions:

AA/PFR/MR/BES/CW contributed to study design. MB/CW led data abstraction efforts. LP/CAJ/PFR/BES led data cleaning, coding, and analysis. AA/PFR/CAJ/MR/MC/DC/LP/BES/NB/CW contributed to data interpretation, drafting and editing the manuscript.

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Tables

Table I: Demographics of cohort of HIV-positive patients in Tennessee between 2010-2015

Demographic Value	Category	Total		30-Day		60-Day		90-Day	
		#	%	#	%	#	%	#	%
		(n=3750)		(n=1840)		(n=2472)		(n=2747)	
Sex	Male	2987	80%	1430	78%	1921	78%	2150	78%
	Female	763	20%	410	22%	551	22%	597	22%
Race/ Ethnicity	White (Non-Hispanic)	1230	33%	715	39%	903	37%	992	36%
	Black (Non-Hispanic)	2205	59%	950	52%	1338	54%	1505	55%
	Hispanic (All Races)	200	5%	109	6%	141	6%	155	6%
	Other/Unknown	115	3%	66	4%	90	4%	95	3%
Age at Diagnosis (years)	Median [IQR]	31	[24,43]	33	[25,45]	32	[24,45]	32	[24,45]
HIV Risk Factor	Heterosexual	883	24%	429	23%	595	24%	662	24%
	MSM	2079	55%	998	54%	1371	55%	1536	56%
	IDU	114	3%	60	3%	78	3%	84	3%
	MSM/IDU	75	2%	42	2%	52	2%	56	2%
	Other/Unknown	599	16%	312	17%	376	16%	409	15%
Year of Diagnosis	2012	842	22%	398	22%	545	22%	617	22%
	2013	756	20%	409	22%	542	22%	580	21%
	2014	729	19%	369	20%	500	20%	551	20%
	2015	716	19%	340	18%	462	19%	516	19%
	2016	707	19%	325	18%	423	17%	483	18%
Site of Diagnosis	Inpatient Facility or ER	745	20%	498	27%	575	23%	610	22%
	Outpatient Facility	1291	34%	717	39%	889	36%	989	36%
	Health Department or STD/Family Planning Clinic	1041	28%	360	20%	615	25%	712	26%
	Blood Bank	134	4%	16	1%	39	2%	48	2%
	Correctional Facility	195	5%	56	3%	94	4%	108	4%
	Other/Unknown	14	0%	2	0%	5	0%	6	0%

Missing	330	9%	191	10%	255	10%	274	10%
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Table II: Individual-level factors associated with linkage to HIV care

Variable	30-day			60-day			90-day		
	aRR*	95% Confidence Interval	P-Value	aRR*	95% Confidence Interval	P-Value	aRR*	95% Confidence Interval	P-Value
Year			0.05			<0.001			0.02
2012 (ref)	1.00			1.00			1.00		
2013	1.13	[1.03, 1.24]		1.09	[1.02, 1.16]		1.03	[0.98, 1.09]	
2014	1.06	[0.96, 1.17]		1.04	[0.97, 1.11]		1.01	[0.95, 1.07]	
2015	1.02	[0.92, 1.13]		1.00	[0.93, 1.08]		0.99	[0.93, 1.05]	
2016	1.00	[0.90, 1.11]		0.93	[0.86, 1.00]		0.93	[0.87, 0.99]	
Age at Diagnosis			0.002			<0.001			<0.001
20	1.09	[1.03, 1.16]		1.06	[1.01, 1.11]		1.06	[1.02, 1.10]	
25	1.01	[0.99, 1.04]		1.00	[0.98, 1.02]		1.00	[0.98, 1.01]	
30 (ref)	1.00			1.00			1.00		
35	1.04	[1.00, 1.07]		1.05	[1.02, 1.07]		1.05	[1.03, 1.07]	
40	1.08	[1.02, 1.15]		1.10	[1.05, 1.15]		1.10	[1.05, 1.14]	
45	1.11	[1.03, 1.20]		1.12	[1.06, 1.18]		1.12	[1.07, 1.17]	
Race/Ethnicity			<0.001			<0.001			<0.001
White, Non-Hispanic (ref)	1.00			1.00			1.00		
Black, Non-Hispanic	0.77	[0.72, 0.83]		0.85	[0.81, 0.90]		0.87	[0.83, 0.90]	
Hispanic, All Races	0.99	[0.86, 1.13]		1.00	[0.90, 1.10]		0.98	[0.91, 1.07]	
Other/Unknown	0.98	[0.83, 1.16]		1.06	[0.95, 1.18]		1.01	[0.92, 1.11]	
Sex/Risk Factor			0.01			<0.001			<0.001
Male/Heterosexual (ref)	1.00			1.00			1.00		
Male/MSM	1.16	[1.01, 1.32]		1.12	[1.02, 1.23]		1.06	[0.98, 1.15]	
Male/IDU	1.22	[1.01, 1.48]		1.10	[0.96, 1.27]		1.03	[0.91, 1.16]	
Male/Other-Unknown	1.12	[0.97, 1.30]		0.98	[0.88, 1.10]		0.90	[0.82, 1.00]	
Female/Heterosexual	1.28	[1.11, 1.48]		1.26	[1.14, 1.39]		1.15	[1.06, 1.25]	
Female/IDU	0.90	[0.66, 1.23]		0.99	[0.81, 1.22]		0.89	[0.74, 1.08]	
Female/Other-Unknown	1.13	[0.94, 1.35]		1.04	[0.91, 1.20]		1.00	[0.89, 1.12]	
Site of Diagnosis			<0.001			<0.001			<0.001
Inpatient Facility or Emergency Room (ref)	1.00			1.00			1.00		
Outpatient Facility	0.84	[0.78, 0.90]		0.90	[0.85, 0.95]		0.94	[0.90, 0.99]	

Health Department or STD/Family Planning Clinic	0.53	[0.48, 0.59]	0.78	[0.73, 0.83]	0.84	[0.80, 0.89]
Blood Bank	0.19	[0.12, 0.30]	0.40	[0.31, 0.52]	0.46	[0.37, 0.57]
Correctional Facility	0.47	[0.37, 0.59]	0.67	[0.57, 0.78]	0.72	[0.63, 0.82]
Other/Unknown	0.23	[0.07, 0.79]	0.50	[0.25, 1.00]	0.56	[0.31, 1.01]
Missing	0.85	[0.76, 0.94]	0.98	[0.92, 1.06]	1.00	[0.94, 1.06]

*Adjusted for year of diagnosis, sex/exposure category, race/ethnicity and site of diagnosis.

Table III: County level predictors of linking to HIV care within 30 days of diagnosis in Tennessee

Factor	RR [95% CI]
Avg. Monthly mental unhealthy days (per 10)	0.59** [0.40-0.88]
Avg. Morphine milligram equivalent	1.00 [1.00-1.00]
Avg. no. drug-related crimes (per 10)	1.00*** [1.00-1.00]
Avg. no. drug-related deaths (per 10)	0.98 [0.92-1.04]
Avg. no. female-headed households	21.88 [0.45-1,057.81]
Avg. no. violent crimes (per 10)	1.00* [1.00-1.00]
Avg. vacant housing units	1.00 [1.00-1.00]
Drug trafficking hot-zone	0.51 [0.16-1.59]
HIV prevalence (per 10%)	0.99 [0.99-1.00]
No. methadone clinics	1.25** [1.06-1.47]
Per capita income (log10)	4.77 [0.88-25.77]
Per capita primary care physicians (per 10%)	0.98* [0.96-1.00]
Per capita urgent care facilities (per 10%)	0.63 [0.17-2.43]
Percent below FPL	1.29 [0.06-28.86]
Percent experiencing food insecurity (per 10%)	4,707,596 [0.00-4e27]
Percent households with car	0.00 [0.00-141.27]
Percent non-Hispanic, White (per 10%)	1.14 [1.00-1.30]
Percent of adults smoking (per 10%)	0.90 [0.80-1.01]
Percent of HIV cases due to IDU (per 10%)	1.71*** [1.24-2.36]
Percent unemployed	1.02 [0.97-1.08]
Percent with disability	11.29* [1.32-96.54]
Percent with poor/fair health	1.00 [0.99-1.02]
Percent without health insurance	0.98 [0.94-1.02]
Proxy prevalence IDU	1.00** [1.00-1.00]
Rate mental health providers (per 10%)	1.01 [1.00-1.02]
Rate STD diagnoses (per 10%)	1.00 [0.99-1.00]
Segregation index (White / Non-White)	1.01 [1.00-1.01]
Teen birth rate (per 10%)	1.00 [1.00-1.00]
Violent crime rate (per 10%)	1.00 [1.00-1.00]
* p<0.05, ** p<0.01, *** p<0.001	

*Risk Ratio adjusted for age, sex, race/ethnicity, transmission risk factor, and site of diagnosis.

Avg = Average

No = Number

FPL = Federal poverty line

IDU = Intravenous drug use

STD = Sexually Transmitted Diseases

Table IV: County level 30-day linkage to HIV care rates by county and facility type in Tennessee

Facility Type of HIV Diagnosis	Combined		Shelby		Knox		Hamilton		Davidson	
	N	%	N	%	N	%	N	%	N	%
Inpatient Facility or Emergency Room	478	64.02%	276	56.88%	33	72.73%	34	79.41%	135	72.59%
Outpatient Facility		55.61%	591	54.31%	53	64.15%	102	56.86%	279	56.27%
Health Department or STD/Family Planning Clinic	713	35.01%	315	34.47%	83	36.14%	57	49.12%	258	27.52%
Blood Bank	110	10.91%	84	9.52%	4	0.00%	8	37.50%	14	7.14%
Correctional Facility	169	21.98%	109	18.35%	24	25.00%	1	0.00%	35	31.43%
Other/Unknown	10	20.00%	6	-	1	100.00%	0	-	3	33.33%
Missing	171	62.57%	79	56.96%	3	100.00%	30	63.33%	59	62.71%

Figures

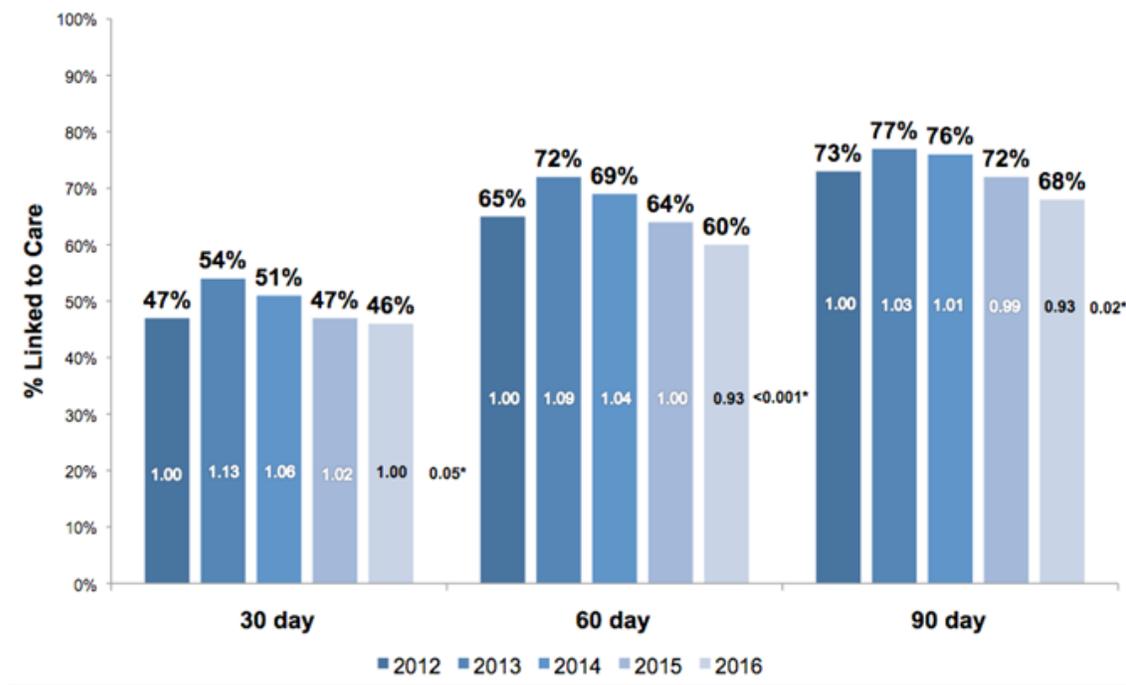
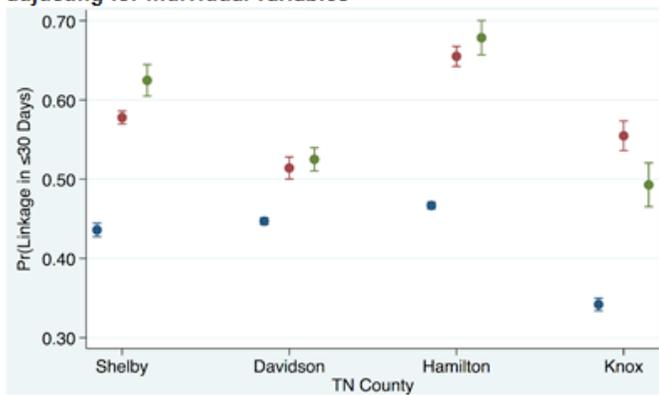


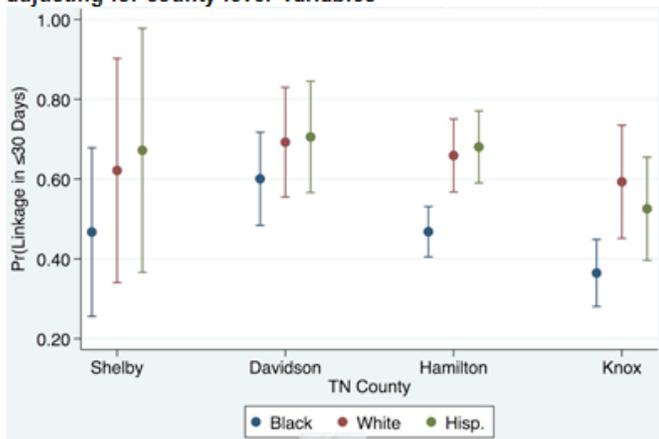
Figure 1

Multivariable analysis for odds ratio of failure to link adjusted for age, sex, transmission risk factor, race/ethnicity, and site of diagnosis

Panel A. Probability of HIV care linkage within 30 days adjusting for individual variables



Panel B. Probability of HIV care linkage within 30 days adjusting for county-level variables



TN= Tennessee
Hisp. = Hispanic

Figure 2

Decreased probability of linkage to care within 30 days for Black patients in the four highest HIV burdened counties in TN. Legend 1. Linkage to HIV care in Tennessee has not changed over time. This shows the rates of 30, 60, and 90-day linkage to HIV care in Tennessee for patients diagnosed between 2012 and 2015. Legend 2. Increased probability of not linking to care for young, heterosexual male and black patients. This show the probability of not linking to HIV within 30 days of diagnosis by race/ethnicity, sexual orientation and age. Legend 3. Decreased probability of linkage to care within 30 days for black patients in the four highest HIV-burdened counties in Tennessee. This shows the probability of linking to care within 30 days of diagnosis by race/ethnicity for patients living in the four counties with the highest burden of HIV in Tennessee.