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Receipt and timing of HIV drug resistance testing in six U.S. jurisdictions

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Abstract

The Department of Health and Human Services recommends drug resistance testing at linkage to HIV care. Because receipt and timing of testing are not well characterized, we examined testing patterns among persons with diagnosed HIV who are linked to care. Using surveillance data in six jurisdictions for persons aged ≥13 years with HIV infection diagnosed in 2013, we assessed the proportion receiving testing, and among these, the proportion receiving testing at linkage. Multivariable log-binomial regression modeling estimated associations between selected characteristics and receipt of testing (1) overall, and (2) at linkage among those tested. Of 9,408 persons linked to care, 66% received resistance testing, among whom 68% received testing at linkage. Less testing was observed among male persons who inject drugs (PWID), compared with men who have sex with men (adjusted prevalence ratio [aPR]: 0.88; 95% confidence interval [CI]: 0.81–0.97) and persons living in areas with population <500,000 compared with those in areas with population ≥2,500,000 (aPR: 0.88; CI: 0.84–0.93). In certain jurisdictions, testing was lower for persons with initial CD4 counts ≥500 cells/mm^3, compared with those with CD4 counts <200 cells/mm^3 (aPR range: 0.80–0.85). Of those tested, testing at linkage was lower among male PWID (aPR: 0.85; CI: 0.75–0.95) and, in some jurisdictions, persons with CD4 counts ≥500 cells/mm^3 (aPR range: 0.63–0.73). Two-thirds of persons with diagnosed HIV who were linked to care received resistance testing, and most received testing at linkage as recommended. Improving receipt and timing of testing among male PWID, persons in less populous settings, and in all jurisdictions, regardless of CD4 count, may improve care outcomes.

Keywords

HIV; resistance testing; linkage

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Disclosure statement

No potential conflict of interest was reported by the authors.

Background

Antiretroviral therapy (ART) has dramatically reduced morbidity and mortality among people living with diagnosed HIV infection around the world (Palella et al., 1998). However, sub-optimal adherence to ART can result in resistance to medications, thereby limiting the effectiveness of prescribed ART (Deeks et al., 2009) and perpetuating the transmission of a drug-resistant virus. Major viral drug resistance mutations have been reported among people with diagnosed HIV infection (Buchacz et al., 2015; Little et al., 2002; Palella et al., 1998; Ross et al., 2007; Weinstock et al., 2004; Wheeler et al., 2010; Yanik et al., 2012). Prevalence of drug resistance among persons with diagnosed HIV infection who have not initiated ART has been estimated to be 6–15% based on studies published in the previous decade (Buchacz et al., 2015; Little et al., 2002; Torian & Forgione, 2013; Weinstock et al., 2004). Transmitted drug resistance is more commonly detected among persons with recent HIV infection (Yanik et al., 2012) and may be higher among certain demographic and transmission risk groups, such as whites and gay, bisexual, and other men who have sex with men (MSM) (Buchacz et al., 2015; Ross et al., 2007; Weinstock et al., 2004; Yanik et al., 2012). People who take ART medications to which their HIV infection is resistant may not achieve viral suppression (Gill et al., 2010; Kantor et al., 2015; Little et al., 2002). Thus, identifying drug resistance before initiation of treatment may help ensure selection of appropriate ART regimens, viral suppression, and improved overall survival. Given the importance of early identification of drug resistance, the U.S. Department of Health and Human Services (HHS) began recommending drug resistance testing at entry to care among all persons who have received a diagnosis of HIV infection in 2007 (DHHS, *Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents*). However, the extent to which these recommendations are followed, including the timing with which testing occurs with respect to linkage to HIV care, is not fully known.

This analysis used data from the Centers for Disease Control and Prevention's (CDC) U.S. National HIV Surveillance System (NHSS) to estimate the prevalence and timing of HIV drug resistance testing among persons with diagnosed HIV infection who have been linked to care, and to investigate demographic and geographic factors associated with (1) receipt of drug resistance testing, and (2) receipt of testing at linkage among those tested. These findings address knowledge gaps related to timing of HIV drug resistance testing and identify key populations in which testing might be less prevalent. These results may inform targeted interventions to increase resistance testing, thus improving HIV outcomes in the United States.

Methods

Population

We analyzed data from NHSS, a population-based surveillance system that collects demographic, risk, and clinical information on persons with diagnosed HIV infection in the United States. All fifty states, the District of Columbia, and six U.S. territories collect information on all persons with diagnosed HIV infection in the United States; this HIV case information is then reported to CDC. As a part of surveillance, health care providers and

laboratories report demographic data, risk information, and CD4 and viral load test results to state and local HIV surveillance programs according to local public health disease reporting requirements. As a part of routine HIV care, healthcare providers also order HIV drug resistance tests at entry to care. Nucleotide sequence data generated through these tests are reported to state and local health departments in 27 jurisdictions that conduct Molecular HIV Surveillance, a component of NHSS. All HIV surveillance data are subsequently reported to CDC without personal identifiers.

For this analysis, NHSS data reported to CDC through December 2015 were restricted to persons aged ≥13 years with HIV infection diagnosed in 2013 who were linked to care within 3 months after diagnosis. Data were also restricted to persons residing in a jurisdiction with (1) complete laboratory reporting of CD4 and viral load tests to CDC (CDC, 2015) and (2) a drug resistance test reported within 12 months of HIV diagnosis for ≥50% of persons. The six jurisdictions included in the analysis were Los Angeles County, Michigan, New York, South Carolina, Texas, and Washington.

Measures

We defined linkage to care as having evidence of HIV laboratory testing (at least one CD4, viral load, or nucleotide sequence test) with a specimen collection date within 3 months after diagnosis. Among those who were linked to HIV care, we examined the proportion of persons who received HIV drug resistance testing, and calculated the number of months between linkage to care and HIV drug resistance testing for those who received testing. Persons who received HIV drug resistance testing within one month of linkage were considered to have received testing at linkage to care according to the HHS guidelines.

We assessed resistance testing by age at HIV diagnosis, race/ethnicity, sex, transmission category, and initial CD4 count at or after HIV diagnosis. Age at diagnosis was grouped as 13–24, 25–34, 35–44, 45–54, and ≥55 years. Race/ethnicity categories included: black/African American (henceforth referred to as black), Hispanic/Latino, and white; due to small numbers, we collapsed the American Indian/Alaska Native, Asian, Native Hawaiian/other Pacific Islander, multiple races, and other groups into a single category titled “other.” We combined sex and transmission category into a single variable with the following categories: males whose HIV infection was attributed to male-to-male sexual contact (men who have sex with men, or MSM), males whose HIV infection was attributed to both male-to-male sexual contact and injection drug use (MSM who inject drugs), males whose HIV infection was attributed to injection drug use (male persons who inject drugs, or male PWID), females whose HIV infection was attributed to injection drug use (female PWID), males whose HIV infection was attributed to heterosexual contact (heterosexual males), and females whose HIV infection was attributed to heterosexual contact (heterosexual females). When missing, information on transmission category was imputed based on methodology used to generate NHSS surveillance reports (Harrison, Kajese, Hall, & Song, 2008). Initial CD4 counts were categorized as <200, 200–349, 350–499, and ≥500 cells/mm^3. Population of area of residence at diagnosis was derived from OMB standards in defining metropolitan statistical areas (MSAs) and Decennial 2010 Census estimates of the population of the MSA where the person resided at diagnosis (CDC, 2016; OMB, 2010).

Analytic methods

Descriptive statistics—Of those linked to HIV care within 3 months after diagnosis, we assessed the proportion of persons who received HIV drug resistance testing, and among these, the proportion who received testing at linkage (i.e., within one month of linkage). We used Mantel-Haenszel chi-square tests to identify differences in drug resistance testing patterns by demographic, geographic, and clinical characteristics, including age, race/ethnicity, transmission category, initial CD4 count at or after HIV diagnosis, area of residence at diagnosis, and population of area of residence at diagnosis.

Modeling—We used multivariable log-binomial regression models to estimate associations between these selected characteristics and (1) receipt of HIV drug resistance testing, as well as (2) receipt of HIV drug resistance testing at linkage among those who were tested, where two-sided $P < .05$ indicated statistical significance. Both models included age, race/ethnicity, transmission category, initial CD4 count at or after HIV diagnosis, area of residence at diagnosis, and population of area of residence at diagnosis as covariates. We also considered a two-way statistical interaction between initial CD4 count and area of residence at diagnosis to assess any differences in provider practices, by jurisdiction, with respect to resistance testing based on initial CD4 count. No other interaction terms were of interest, and thus, were not considered in this analysis. Both models excluded persons with transmission category of “other” and those who lived in an area of unknown population size at HIV diagnosis due to small numbers in these categories. We estimated adjusted prevalence ratios (aPRs) and corresponding 95% confidence intervals (CIs) and highlighted in the text statistically significant covariates with a PR ≥1.1 or ≤0.9 for at least one estimate. All statistical analyses were conducted using SAS 9.3 (Cary, NC).

Results

Descriptive statistics

Of 40,203 adults and adolescents who received a diagnosis of HIV infection in 2013, 11,261 (28%) resided in one of the six jurisdictions eligible for inclusion. Among these, 9408 (84%) persons were linked to HIV care within three months of HIV diagnosis and were included in the analysis. Overall, just over half of persons were under the age of 35 years at diagnosis, 37% were black, and 69% were MSM (Table 1). A majority of persons included in the analysis resided in Texas (37%) or New York (30%) at diagnosis. Most people (66%) resided in areas with populations ≥2,500,000.

Of those linked to care, 6229 (66%) received an HIV drug resistance test (Table 1). Prevalence of drug resistance testing varied significantly by race/ethnicity ($P < 0.001$), with the lowest level of testing among blacks; transmission category ($P < 0.001$), with less testing among male PWID and heterosexual females; area of residence at diagnosis ($P < 0.001$), with lower levels of testing in South Carolina, Texas, and Washington; initial CD4 count ($P < 0.001$), with less testing among persons with CD4 counts ≥500 cells/mm^3; and population of area of residence at diagnosis ($P < 0.001$), with the lowest testing among persons residing in areas with population <2,500,000. Among the 6229 persons who received an HIV drug resistance test, 4264 (68%) received a test at linkage to care. Patterns in drug resistance

testing at linkage differed by age ($P = 0.017$), with lower prevalence of testing among persons 13–24 years; race/ethnicity ($P = 0.009$), with lower prevalence of testing among blacks, and initial CD4 count at or after HIV diagnosis ($P < 0.001$), with less prevalent testing among persons with a CD4 count ≥500 cells/mm^3.

Modeling

Drug resistance testing—In the multivariable analysis, persons less likely to receive HIV drug resistance testing included persons aged 55 years and older (aPR: 0.90; 95% CI: 0.85, 0.96), compared with those 13–24 years of age; male PWID (aPR: 0.88; 95% CI: 0.81, 0.97), compared with MSM; and those living in areas with populations <500,000 (aPR: 0.88; 95% CI: 0.84, 0.93), compared with those living in more populous areas (Table 2). Lower prevalence of testing was also observed among persons with an initial CD4 count ≥500 cells/mm^3, compared with those with a CD4 count <200 cells/mm^3, but only in selected jurisdictions, including Michigan (aPR: 0.85; 95% CI: 0.77, 0.94), New York (aPR: 0.84; 95% CI: 0.80, 0.89), and Texas (aPR: 0.80; 95% CI: 0.75, 0.86). Less testing was also observed among persons with CD4 counts 350–499 cells/mm^3 in Texas (aPR: 0.85; 95% CI: 0.79, 0.92).

Drug resistance testing at linkage—Even among those who received drug resistance testing, male PWIDs were significantly less likely to receive testing at linkage to care (aPR: 0.85; 95% CI: 0.75, 0.95), compared with MSM (Table 3). Compared with persons with initial CD4 counts <200 cells/mm^3, prevalence of HIV drug resistance testing at linkage was significantly lower among persons with initial CD4 counts ≥500 cells/mm^3 in certain jurisdictions, including Los Angeles County (aPR: 0.73; 95% CI: 0.64, 0.83), South Carolina (aPR: 0.69; 95% CI: 0.51, 0.94), and Washington (aPR: 0.63, 95% CI: 0.47, 0.83). Levels of drug resistance testing at linkage were also lower among those who received a diagnosis in New York but the adjusted prevalence ratio was not ≤0.9 (aPR: 0.92; 95% CI: 0.86, 0.99). Further, point estimates indicated lower levels of testing among persons with higher CD4 counts in selected jurisdictions, such as Los Angeles County, South Carolina, and Washington, but not all of these associations were statistically significant. This may be due to limited sample size in these jurisdictions. Finally, those living in areas with a population size between 500,000–2,499,999 were more likely to receive testing at linkage (aPR: 1.12; 95% CI: 1.07, 1.17), compared with those in areas with population ≥2,500,000.

Discussion

This analysis examined the prevalence of HIV drug resistance testing among persons with diagnosed HIV infection in selected jurisdictions in the United States and sought to identify factors associated with (1) drug resistance testing, and (2) receipt of testing at linkage among those tested. Overall, nearly two-thirds of persons with diagnosed HIV infection who were linked to care received drug resistance testing, among whom almost 70% received testing at linkage. The prevalence of drug resistance testing was lower among male PWID, persons living in less populous areas, and those with higher initial CD4 counts in certain jurisdictions included in this analysis. Among persons who received drug resistance testing, testing at linkage was lower among male PWID and persons with higher initial CD4 counts

in selected jurisdictions. Based on these findings, implementation of timely resistance testing among these groups may improve HIV care outcomes.

Identifying drug resistance at the time of diagnosis facilitates selection of ART medications to which the HIV strain is sensitive. This can reduce the time to viral suppression and transmission of drug-resistant HIV strains to others. Improving drug resistance testing is particularly important for PWID, among whom prevalence of risk behaviors associated with HIV transmission, such as sharing injection equipment and engaging in condomless sex, may be quite high (Spiller et al., 2015). Reasons for lack of drug resistance testing or delayed testing in this group are unknown, although a recent report showed that nearly a third of PWID in selected U.S. cities reported not having health insurance and nearly 80% were living at or below the federal poverty level (Spiller et al., 2015). Lack of health insurance access and lower socioeconomic status may be potential barriers to receiving medical care and laboratory testing in a timely manner within this population (Moneyham et al., 2010; Mueller, Patil, & Boilesen, 1998; *Public Financing and Delivery of HIV/AIDS Care: Securing the Legacy of Ryan White*, 2005). There may also be low awareness of free or subsidized HIV care through the Ryan White HIV/AIDS Program or through federally qualified health centers.

In addition, previous work has shown that non-HIV specialists are less likely to order resistance testing compared with HIV specialists (Ocfemia et al., 2016). Since there may be greater injection drug use in smaller, less populous areas (Zibbell et al., 2015), fewer and less specialized healthcare services in these settings may necessitate greater efforts to engage HIV-infected PWID in medical care. This may particularly be true since overall healthcare use may be lower in less populous settings (Mueller et al., 1998; Reschovsky & Staiti, 2005), potentially due to fewer available resources for comprehensive care, costs associated with healthcare, and lack of insurance coverage (Lu, Samuels, Kletke, & Whitler, 2010; Reschovsky & Staiti, 2005). With HIV-infected PWID being less likely to be engaged in care and virally suppressed (Bradley et al., 2014), prioritizing drug resistance testing at linkage and implementing measures to retain persons in care over time in this population may improve provision of appropriate ART regimens. This is especially important in light of the recent HIV outbreak among PWID in southern Indiana (Conrad et al., 2015), given the high HIV transmission potential through injection drug use and the substantial rise in the number of deaths attributed to opioid use in the United States (Rudd, Aleshire, Zibbell, & Gladden, 2016).

Despite HHS recommendations on drug resistance testing at entry to care (DHHS, *Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents*.), these data showed significantly lower levels of receipt and timing of drug resistance testing among persons with higher initial CD4 counts at or after HIV diagnosis, but only in some jurisdictions. These differences may indicate geographic differences in care practices related to drug resistance testing. For instance, providers in certain jurisdictions may prioritize resistance testing for persons with low initial CD4 counts. Further, in persons for whom HIV treatment may need to be delayed due to medical reasons such as TB co-infection (DHHS, *Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected*

adults and adolescents), providers may also decide to postpone resistance testing. Even if treatment is delayed, however, resistance testing should be conducted at entry to care, as drug resistance mutations may decay in the absence of drug pressure, potentially affecting treatment success if mutations are present at low levels that are no longer detectable (Johnson et al., 2008). Care practices related to receipt and timing of testing may also be influenced by variation in cost coverage of drug resistance testing, especially in regards to differential Medicaid expansion by state. Nevertheless, emphasizing the need to initiate drug resistance testing at entry to care across all jurisdictions, regardless of initial CD4 count, is vital to ensuring successful treatment outcomes.

There were also lower levels of resistance testing observed, regardless of initial CD4 count, in certain jurisdictions, specifically Los Angeles, South Carolina, and Washington. These differences by jurisdiction may be explained by other factors not accounted for in this analysis, including variation in cost coverage of drug resistance testing or differential completeness of laboratory reporting of viral genetic sequences to state and local health departments, and thus, to CDC. In any case, increasing testing in all jurisdictions will help in identifying and addressing drug resistance in a timely manner. In addition, state and local health departments should continue working to increase completeness of laboratory reporting of nucleotide sequence data and improve the quality of reported data on drug resistance testing.

This analysis is subject to several limitations. First, because these data were limited to adults and adolescents with HIV infection diagnosed in 2013, temporal trends in drug resistance testing could not be assessed. Only jurisdictions with complete laboratory reporting and adequate reporting of drug resistance testing were included in this analysis, so the results may not be generalizable to all people with diagnosed HIV infection in the United States. The results presented here may be an underestimate of prevalence of HIV drug resistance testing if laboratory reporting of resistance test results was incomplete. Finally, recommendations to start HIV treatment regardless of CD4 count and conduct resistance testing at entry to care are recent with respect to the analysis period and may have impacted a healthcare provider's decision to order resistance testing. Thus, future analyses using more recent data may yield higher estimates for prevalence of resistance testing.

In summary, these findings demonstrate that, in the six jurisdictions included in the analysis, a majority of persons with diagnosed HIV infection who are linked to care received drug resistance testing; the timing of drug resistance testing suggests that most providers order testing at linkage to care as recommended. Differences in receipt and timing of testing underscores the need to increase drug resistance testing among male PWID, those who live in less populous areas, and in all jurisdictions, regardless of initial CD4 count. Factors influencing lack of or delayed resistance testing should be further explored and addressed, with interventions tailored based on varying characteristics and needs, and accounting for differences in care practices and cost coverage by jurisdiction. Addressing such barriers to testing may increase the number of persons who receive appropriate treatment, thus reducing disparities in important HIV outcomes over time.

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Table 1

Receipt of drug resistance testing among adults and adolescents with HIV infection diagnosed in 2013 who were linked to HIV care within three months after diagnosis, overall and by selected characteristics – National HIV Surveillance System, six jurisdictions.

	Total linked within 3 months		Drug resistance testing			Drug resistance testing at linkage		
	n	(%)	*n*	(%)	*p*	*n*	(%)	*p*
Overall	9408	(100)	6229	(66)		4264	(68)	
Age, in years					0.059			0.017
13–24	2038	(22)	1393	(68)		918	(66)	
25–34	2943	(31)	1928	(66)		1310	(68)	
35–44	1987	(21)	1309	(66)		917	(70)	
45–54	1601	(17)	1068	(67)		752	(70)	
≥55	839	(9)	531	(63)		367	(69)	
Race/ethnicity					<0.001			0.009
Black/African American	3436	(37)	2170	(63)		1423	(66)	
Hispanic/Latino	3103	(33)	2136	(69)		1492	(70)	
White	2238	(24)	1490	(67)		1058	(71)	
Other	631	(7)	433	(69)		291	(67)	
Transmission category *					<0.001			0.472
Male to male sexual contact	6449	(69)	4381	(68)		3023	(69)	
Injection drug use (male)	311	(3)	186	(60)		112	(60)	
Injection drug use (female)	242	(3)	156	(65)		107	(68)	
Male to male sexual contact and injection drug use	284	(3)	187	(66)		124	(66)	
Heterosexual contact (male)	592	(6)	381	(64)		259	(68)	
Heterosexual contact (female)	1518	(16)	930	(61)		634	(68)	
Other	13		7			6		
Initial CD4 count (cells/mm^3)					<0.001			<0.001
Missing	120		32			28		
<200	2434	(26)	1719	(71)		1225	(71)	
200–349	1819	(20)	1294	(71)		905	(70)	
350–499	2009	(22)	1340	(67)		944	(70)	

	Total linked within 3 months		Drug resistance testing			Drug resistance testing at linkage		
	n	**(%)**	***n***	**(%)**	***p***	***n***	**(%)**	***p***
≥500	3026	(33)	1844	(61)		1162	(63)	
Area of residence at diagnosis					<0.001			0.567
Los Angeles County	1349	(14)	926	(69)		588	(63)	
Michigan	643	(7)	495	(77)		363	(73)	
New York	2861	(30)	2106	(74)		1549	(74)	
South Carolina	636	(7)	370	(58)		162	(44)	
Texas	3512	(37)	2078	(59)		1447	(70)	
Washington	407	(4)	254	(62)		155	(61)	
Population of area at diagnosis[†]					<0.001			0.877
Unknown	25		9			7		
<500,000	1226	(13)	720	(59)		478	(66)	
500,000–2,499,999	1987	(21)	1251	(63)		883	(71)	
≥2,500,000	6170	(66)	4249	(69)		2896	(68)	

[*] Other transmission category omitted due to small numbers.

[†] Unknown population of area at diagnosis omitted due to small numbers.

Table 2

Factors associated with receipt of drug resistance testing among adults and adolescents with HIV diagnosed in 2013 who were linked to HIV care within three months after diagnosis, overall and by selected characteristics – National HIV Surveillance System, six jurisdictions.

Characteristics	Resistance testing	No resistance testing	aPR* (95% CI)	p
Age, in years				
13–24	1379	619	Ref	
25–34	1916	980	0.94 (0.91, 0.97)	0.002
35–44	1303	659	0.95 (0.91, 0.99)	0.008
45–54	1062	516	0.95 (0.91, 0.99)	0.024
≥55	521	297	0.90 (0.85, 0.96)	<0.001
Race/ethnicity				
Black/African American	2147	1227	0.93 (0.89, 0.96)	<0.001
Hispanic/Latino	2127	933	1.02 (0.98, 1.05)	0.403
White	1477	715	Ref	
Other	430	196	0.99 (0.93, 1.05)	0.710
Transmission category†				
Male to male sexual contact	4351	1993	Ref	
Injection drug use (male)	184	120	0.88 (0.81, 0.97)	0.007
Injection drug use (female)	156	80	0.95 (0.87, 1.03)	0.220
Male to male sexual contact and injection drug use	187	95	0.99 (0.91, 1.07)	0.790
Heterosexual contact (male)	378	207	0.96 (0.91, 1.02)	0.186
Heterosexual contact (female)	925	575	0.94 (0.90, 0.98)	0.003
Initial CD4 counts in each area of residence at diagnosis (cells/mm^3)‡				
Los Angeles County				
<200	224	103	Ref	
200–349	196	61	1.10 (0.99, 1.21)	0.068
350–499	199	81	1.02 (0.92, 1.13)	0.682
≥500	305	153	0.96 (0.87, 1.06)	0.435
Michigan				
<200	153	30	Ref	
200–349	97	30	0.93 (0.83, 1.04)	0.183
350–499	89	17	1.01 (0.91, 1.12)	0.898
≥500	151	56	0.85 (0.77, 0.94)	0.001
New York				
<200	543	148	Ref	
200–349	459	124	0.98 (0.93, 1.04)	0.479
350–499	471	153	0.94 (0.89, 0.99)	0.032
≥500	617	301	0.84 (0.80, 0.89)	<0.001
South Carolina				
<200	114	75	Ref	

Characteristics	Resistance testing	No resistance testing	aPR* (95% CI)	p
200–349	74	38	1.05 (0.89, 1.25)	0.547
350–499	82	57	0.95 (0.79, 1.13)	0.538
≥500	99	87	0.87 (0.73, 1.03)	0.110
Texas				
<200	619	323	Ref	
200–349	411	247	0.94 (0.87, 1.02)	0.129
350–499	439	323	0.85 (0.79, 0.92)	<0.001
≥500	589	516	0.80 (0.75, 0.86)	<0.001
Washington				
<200	60	32	Ref	
200–349	54	24	1.06 (0.86, 1.30)	0.604
350–499	59	34	0.95 (0.77, 1.18)	0.659
≥500	80	59	0.88 (0.72, 1.08)	0.229
Population of area at diagnosis§				
<500,000	713	490	0.88 (0.84, 0.93)	<0.001
500,000–2,499,999	1240	716	0.94 (0.90, 0.99)	0.008
≥2,500,000	4229	1864	Ref	

*PR: adjusted prevalence ratio.

†Other transmission category omitted due to small numbers.

‡Unknown CD4 counts omitted due to small numbers.

§Unknown population of area at diagnosis omitted due to small numbers.

Table 3

Factors associated with receipt of drug resistance testing at linkage to HIV care among adults and adolescents with HIV diagnosed in 2013 who were linked to HIV care within three months after diagnosis and received drug resistance testing at or after linkage, overall and by selected characteristics – National HIV Surveillance System, six jurisdictions.

	Resistance testing	No resistance testing	aPR* (95% CI)	*p*
Age, in years				
13–24	907	472	Ref	
25–34	1301	615	1.03 (0.98, 1.08)	0.304
35–44	911	392	1.05 (1.00, 1.11)	0.059
45–54	747	316	1.04 (0.98, 1.10)	0.200
≥55	358	163	1.00 (0.93, 1.07)	0.997
Race/ethnicity				
Black/African American	1405	742	0.93 (0.89, 0.98)	0.003
Hispanic/Latino	1484	643	0.96 (0.92, 1.00)	0.057
White	1046	431	Ref	
Other	289	141	0.92 (0.86, 0.99)	0.029
Transmission category†				
Male to male sexual contact	2997	1354	Ref	
Injection drug use (male)	111	73	0.85 (0.75, 0.95)	0.006
Injection drug use (female)	107	49	0.97 (0.87, 1.08)	0.565
Male to male sexual contact and injection drug use	123	64	0.96 (0.87, 1.06)	0.422
Heterosexual contact (male)	257	122	0.97 (0.90, 1.04)	0.370
Heterosexual contact (female)	629	296	0.99 (0.94, 1.04)	0.688
Initial CD4 counts in each area of residence at diagnosis (cells/mm^3)‡				
Los Angeles County				
<200	164	60	Ref	
200–349	126	70	0.88 (0.77, 1.00)	0.053
350–499	136	63	0.94 (0.83, 1.06)	0.310
≥500	161	144	0.73 (0.64, 0.83)	<0.001
Michigan				
<200	114	40	Ref	
200–349	71	26	1.02 (0.87, 1.18)	0.841
350–499	62	27	0.94 (0.79, 1.11)	0.442
≥500	112	39	1.02 (0.89, 1.17)	0.750
New York				
<200	409	135	Ref	
200–349	348	114	1.01 (0.94, 1.08)	0.832
350–499	358	113	1.01 (0.94, 1.09)	0.721
≥500	426	191	0.92 (0.86, 0.99)	0.029
South Carolina				

	Resistance testing	No resistance testing	aPR* (95% CI)	p
<200	60	54	Ref	
200–349	30	44	0.75 (0.54, 1.04)	0.087
350–499	34	48	0.76 (0.56, 1.04)	0.08<5
≥500	37	62	0.69 (0.51, 0.94)	0.019
Texas				
<200	432	187	Ref	
200–349	292	119	1.02 (0.95, 1.11)	0.565
350–499	318	121	1.06 (0.98, 1.14)	0.165
≥500	386	203	0.95 (0.88, 1.02)	0.171
Washington				
<200	44	16	Ref	
200–349	38	16	0.97 (0.77, 1.22)	0.813
350–499	35	24	0.81 (0.63, 1.05)	0.112
≥500	37	43	0.63 (0.47, 0.83)	0.001
Population of area of residence at diagnosis§				
<500,000	471	242	1.04 (0.99, 1.11)	0.145
500,000–2,499,999	872	367	1.12 (1.07, 1.17)	<0.001
≥2,500,000	2880	1348	Ref	

*aPR: adjusted prevalence ratio.

†Other transmission category omitted due to small numbers.

‡Unknown CD4 counts omitted due to small numbers.

§Unknown population of area at diagnosis omitted due to small numbers.