Prevalence of Sexually Acquired Antiretroviral Drug Resistance in a Community Sample of HIV-Positive Men Who Have Sex with Men in New York City

Lloyd A. Goldsamt, Ph.D.,¹ Michael C. Clatts, Ph.D.,² Monica M. Parker, Ph.D.,³
Vivian Colon, Ph.D.,² Renee Hallack,³ and Maria G. Messina, Ph.D.¹

Abstract

To examine antiretroviral (ARV) drug resistance, we recruited a community sample ($n=347$) of sexually active HIV-positive men who have sex with men (MSM) in New York City, each of whom completed a structured interview and donated a blood sample for HIV genotyping. Participants reported high levels of sexual activity, with 94.6% reporting at least one sexual contact in the past month, and an average of 3.13 partners during this time. Anal intercourse was common, with 70.7% reporting at least one act of insertive anal intercourse (21% of whom reported ejaculating inside their partner without a condom) and 62.1% reporting at least one act of receptive anal intercourse during this time (22.6% of whom received ejaculate without a condom). Seventeen percent reported having sex with a woman in the past year. Although 17.4% of participants reported having ever injected drugs, no association was found between injection and antiretroviral resistance. Average HIV diagnosis was 12.1 years prior to the interview, and 92.1% had taken ARV medication. Sexually transmitted infections (STIs) were widely reported, with 78% having been diagnosed with an STI since being diagnosed with HIV. A genotype was obtained for 188 (54.7%) of the samples and 44.7% revealed mutations conferring resistance to at least one ARV. Resistance to at least one ARV within a given class of medication was most common for nucleoside reverse transcriptase inhibitors (30.3%) and non-nucleoside reverse transcriptase inhibitors (27.7%) and least common for protease inhibitors (18.1%). The combination of high prevalence of antiretroviral resistance and risky sexual practices makes transmission between sex partners a likely mode of acquisition.

Introduction

UNPROTECTED ANAL INTERCOURSE among men who have sex with men (MSM) is a major factor in the spread of HIV infection in this group. Early prevention efforts among MSM focused on primary prevention, primarily targeting HIV-negative or presumed HIV negative MSM.¹ More recently, increased attention has been given to secondary prevention among at-risk MSM, including broader participation in voluntary testing and early enrollment in antiretroviral care. Suppressing viral load reduces risk for opportunistic infection at an individual level and may also contribute to reduction in the incidence at a community level.^{2,3} The potential public health benefits of early detection have become more urgent following reports indicating high rates of HIV infection among urban MSM (many of whom are unaware of

their status)⁴ and identification of a number of cases of newly infected, treatment-naïve individuals who showed substantial levels of resistance to available HIV medications, suggesting that they may have acquired multiply drug-resistant strains of HIV at the time of their initial infection.⁵

Research on drug-resistant HIV has consistently shown that multiply resistant HIV can be transmitted sexually⁶ and rates of sexual transmission (as measured by the prevalence of drug-resistant virus among newly infected, treatment-naïve MSM) have increased as enrollment in HIV treatment has expanded.^{6,7} Estimates of the prevalence of drug-resistant HIV range from 5% to 17% among newly diagnosed and/or treatment-naïve individuals.^{8–13} Higher rates have been found among individuals with comorbid use of illicit drugs (particularly methamphetamine), notably a group with high rates of unprotected anal intercourse and high numbers of

¹National Development and Research Institutes, Inc., New York, New York.

²School of Public Health, University of Puerto Rico, San Juan, Puerto Rico.

³Wadsworth Center, New York State Department of Health, Albany, New York.

concurrent sexual partners.^{14–16} In studies not restricted to treatment-naïve patients, rates of drug-resistant HIV are substantially higher, Richman and colleagues¹⁷ found that among American adults who were viremic and receiving treatment, 88% were resistant to one or more drugs.

Improvement in HIV treatment has reduced mortality and morbidity among people living with HIV infection, improving quality of life and extending the time that HIV-infected individuals maintain healthy functioning, including sexual functioning. While there is abundant data regarding sexual risk of various groups of MSM, most community studies have targeted HIV negative or status unknown populations and settings. Conversely, most studies of HIV-infected MSM, including most of the available evidence of drug-resistant HIV, have been drawn from clinical populations. There are few community studies of HIV-positive MSM that include both detailed behavioral assessment and biological assessment of drug-resistant variants of HIV infection, with the result that there is limited information about the overall prevalence and types of drug resistance among sexually active, HIV-positive, MSM. With the overall goal of overcoming some of the limitations in the available data, this article describes data collected in an ethno-epidemiologic study of sexually active, HIV-positive MSM in New York City that combined ethnographic methods, behavioral epidemiology, antiretroviral treatment history, and laboratory assessment of treatment-resistant HIV infection among sexually active MSM.

Methods

Subjects

Between January 2006 and December 2007, 371 HIV-positive MSM were recruited for participation in an epidemiologic study that used targeted and chain-referral sampling methods¹⁸ in a wide variety of venues in which HIV-positive MSM were known to be present, including community advertisements in MSM commercial establishments and HIV services sites, and local sex parties for HIV-positive MSM. Eligibility was restricted to HIV-positive males who were at least 18 years of age who reported having engaged in sex with another man within the previous 6 months.

Measures

A face-to-face behavioral interview was conducted with each study subject. Interview domains included demographics, current sexual partnering strategies, characteristics of recent sex partners, and current sexual practices, including a detailed assessment of a recent exchange involving anal intercourse. Lifetime and current use of a wide range of illicit or illegal substances and the presence and perceived role of illicit drug use in recent sexual exchanges was also examined. Self-reported history of HIV infection and treatment as well as other diagnosed sexually transmitted diseases were reviewed. Awareness of treatment-resistant HIV and HIV superinfection was assessed. Additionally, a short (8-item) form of the Center for Epidemiologic Studies Depression Scale (CES-D)¹⁹ was used to evaluate current depression.

Study subjects were asked to donate a blood sample for research purposes to detect mutations associated with drug resistance. Participants were paid \$50 in compensation for their time. All study protocols and procedures were approved

by the Institutional Review Board at National Development and Research Institutes, Inc.

Data collection and management

Data from the behavioral interviews were collected using laptop computers and interviewer-administered survey programmed using QDS software (Nova Research, Bethesda, MD). This program outputs data directly into an SPSS database (SPSS Inc., Chicago, IL). Similarly, a spreadsheet of laboratory findings was produced and read into SPSS. The two data files were merged using each study participant's unique identifier code.

Laboratory Analysis

Plasma was extracted using the NucliSENS® EasyMAG or MiniMAG extraction system (bioMérieux, Inc., Durham, NC). Viral RNA was reverse transcribed and a 1.3-kb segment of the HIV-1 *pol* region was amplified and sequenced as previously described.²⁰ Sequencing was performed at the Applied Genomics Technology Core facility at the Wadsworth Center. The resulting consensus sequences of HIV protease (codons 1–99) and RT (codons 1–300) were edited using Sequencher™ (Gene Codes Corporation, Ann Arbor, MI) analyzed for drug resistance mutations using the programs available at the Stanford University HIV drug resistance database website.²¹ Mutations were interpreted using the Genotypic Resistance Interpretation Algorithm, which reports the degree of drug resistance as: S (susceptible, potential low-level resistance); I (low-level, intermediate-level resistance); or R (high-level resistance)²¹ for three categories of antiretrovirals: protease inhibitors (PI): atazanavir [ATV], darunavir [DRV], fosamprenavir [FPV], indinavir [IDV], lopinavir [LPV], nelfinavir [NFV], saquinavir [SQV], and tipranavir [TPV]; nucleoside reverse transcriptase inhibitors (NRTI): abacavir [ABC], didanosine [ddI], emtricitabine [FTC], lamivudine [3TC], tenofovir [TDF], stavudine [d4T], and zidovudine [AZT]; or nonnucleoside reverse transcriptase inhibitors (NNRTI): delavirdine [DLV], efavirenz [EFV], and nevirapine [NVP].

Plasma HIV RNA levels were measured for a representative subset of samples that did not produce an amplification product. Following the manufacturer's instructions, viral loads were determined using the Versant HIV-1 RNA 3.0 Assay (Siemens HealthCare Diagnostics, Tarrytown, NY).

Results

A total of 347 participants (93.5%) agreed to donate a blood sample. We were able to amplify plasma RNA in 188 (54.5%) of these samples, and data from these 188 participants are presented below.

Sample characteristics

The mean age of the study participants was 44.2 years old (range, 26–64, standard deviation [7.7]). Most (71.6%) described their ethnicity as non-Hispanic/Latino and their race as either African American (67.4%) or white (13.4%). Most (79.9%) lived alone and approximately one third (38.3%) were in a primary relationship. Although a minority (20.8%) reported sexual attraction to women, most (58.0%) were exclusively attracted to men, and most (83.0%) had only had sex with male partners in the last year. Over two thirds (73.4%)

were receiving some type of disability benefits. Only approximately one fifth (21.8%) reported having any kind of employment, with a median income of \$15,735 in the previous year.

Drug and alcohol use

Study participants were asked about their use of alcohol and a wide variety of illicit or illegal drugs during the 12 months prior to the interview. Most reported use of alcohol (78.7%), approximately half reported use of marijuana (52.7%). More modest rates of cocaine (36.1%), Crack-cocaine (33.2%), and "poppers" (26.5%) were also reported. Only 9.6% of participants reported amphetamine use; 17.4% reported having ever injected a drug. Sample characteristics and drug and alcohol use data are presented in Table 1.

Current sexual practices

Study participants were asked a series of questions about their sexual practices during the 30 days prior to the inter-

view. Most (94.6%) reported having at least one sexual exchange with a man during this interval, with an average of 3.13 male sex partners. Among study participants who had sex with a man within 30 days prior to the interview, nearly two thirds (62.1%) reported at least one act of receptive anal intercourse during the past 30 days, with a mean of 7.73 (range, 1–90) receptive sex acts during this interval. Among those who engaged in receptive anal intercourse, 26% reported receiving ejaculate without a condom. 70.7% of study participants engaged in at least one act of insertive anal sex, with an average of 6.09 insertive anal sex acts (range, 1–30) during the prior 30 days. Among those who had insertive anal sex, 21% reported ejaculating inside their partner without a condom.

Participants were also asked a series of event-oriented questions related to the last time they had anal sex. More than half (58.1%) had sex within 7 days prior to the interview; 14.4% of study participants reported that their most recent sexual event involved a new sex partner and 10.7% described their last sexual encounter as involving two or more sex partners. More than a third (40.8%) reported use of alcohol before or during their most recent anal sex event and a similar percent (37.4%) used some type of illicit drug. Overall, more than half (52.9%) reported using either alcohol or drugs before or during the event. Data on sexual practices are shown in Table 2.

HIV/STI diagnosis and HIV treatment history

The mean interval between study participants' first HIV positive test and the interview was 12.1 years (range, <1–24 years, SD 6.4 years), with a mean age of 32.1 years at the time of their first positive test for HIV infection. In addition, participants also evidenced a substantial history of having been diagnosed with other sexually transmitted infections (STI), including gonorrhea (54.3%), syphilis (40.3%), herpes (23.7%), genital warts (15.6%), and chlamydia (12.4%). Overall, over three quarters (78.0%) had been diagnosed with at least one STI in their lifetime and 18.2% had three or more different STIs. 18.3% had been diagnosed with one or more STIs in the past year.

Most (91.2%) reported some history of HIV treatment. Study participants were asked to indicate lifetime and current use of 25 different HIV medications. Four of these medications were combination therapies, and data on these medications were recoded to reflect each of the individual medications (e.g., study participants who took Combivir were coded as if they had taken both AZT and 3TC). Of the 21 individual HIV medications assessed, study participants with any history of HIV treatment had taken a mean of 4.74 different medications. More than three quarters (77.1%) had used at least one of the 10 PIs assessed, with a mean of 2.12 different PIs. Nearly all (89.5%) had used at least 1 of the 8 NRTIs assessed, with a mean number of 3.19. More than half (58.8%) had used at least 1 of the 3 NNRTIs assessed, with a 0.76 mean number of different NNRTIs. Overall, only 5.3% had used one class of HIV medication, 39.4% had used two classes, and 47.1% had used all three classes. Over half (55.6%) reported having purposely suspended taking their medication on at least one

TABLE 1. DEMOGRAPHICS AND CURRENT DRUG USE

Age	
Mean (SD)	44.2 (7.7)
Range	26–64
Ethnicity	
Hispanic/Latino	26.4%
Non-Hispanic/Latino	71.6%
Race	
African American	67.4%
Native American	0.6%
White	13.4%
More than one race	3.5%
Other	15.1%
Relationship status	
In a primary relationship	38.3%
Employment	
Yes	21.8%
No	78.2%
Disability	73.4%
Median income	\$15,735
Current drug use (past year)	
Alcohol	80.0%
Marijuana	52.7%
Poppers	26.5%
Cocaine	36.1%
Crack cocaine	33.2%
Heroin	5.5%
Amphetamine	9.6%
GHB	4.3%
Ketamine	4.3%
MDMA	7.5%
LSD	1.6%
PCP/Angel dust	0.5%
Viagra	9.1%
Xanax/Valium (no prescription)	3.8%
Steroids (no prescription)	1.6%
Oxycontin (no prescription)	1.6%
Cosmetic injection (no prescription)	0.5%
Other recreational drugs	1.1%

SD, standard deviation; GHB, γ -hydroxybutyric acid; MDMA, 3,4-methylenedioxy methamphetamine; LSD, lysergic acid diethylamide; PCP, phencyclidine.

TABLE 2. SEXUAL PRACTICES

Sexual attraction	
Exclusively men	58.0%
Mostly men	21.3%
Men and women equally	17.6%
Mostly women	3.2%
Exclusively women	0.0%
Sexual partners in past year	
Only men	83.0%
Mostly men	7.4%
About equal numbers of men and women	6.9%
Mostly women	2.7%
Only women	0.0%
Mean (SD) number of male partners	2.72 (1.4)
Range	1–6
Mean (SD) number of female partners	1.34 (.08)
Range	1–5
Last 30 days	
Sex with a man	94.6%
Mean (SD) number of male partners	3.13 (5.5)
Range	1–5
Sex with a man in the last 7 days	58.1%
Receptive anal intercourse	62.1%
Mean (SD) number of acts	7.73 (11.3)
Range	1–90
Received ejaculate without condom	45.4%
Insertive anal intercourse	70.7%
Mean (SD) number of acts	6.09 (7.0)
Range	1–30
Ejaculated inside partner without condom	39.0%
Most recent sexual event	
New sex partner	14.4%
Multiple sex partners	10.7%
Participant used alcohol before or during sex	40.8%
Participant used illicit drug before or during sex	37.4%
Participant used alcohol or illicit drug before or during sex	52.9%
Partner used alcohol before or during sex	42.4%
Partner used illicit drug before or during sex	36.6%
Partner used alcohol or illicit drug before or during sex	57.0%

SD, standard deviation.

occasion, with more than two fifths of these (45.2%) having done so in the past year. These data are shown in Table 3.

Antiretroviral drug resistance

Among the 347 blood samples collected, an HIV genotype was obtained on 188 (54.7%). A plasma viral load test was conducted on a subset of samples that failed to genotype (5.0%) and all had an undetectable viral load suggesting that the samples that failed to genotype had insufficient levels of virus. Of the 188 samples that were genotyped, nearly half of these (44.7%) were found to have a mutation that conferred resistance to at least one type of HIV medication. 18.1% had some resistance to PIs, 30.3% had some resistance to NRTIs, and 27.7% had some resistance to NNRTIs. Resistance was also seen across classes of drugs, with 13.3% resistant to two classes of medication and 9.0% resistant to all three classes. The most common mutations found were primarily in the RT and include: M184V (30.3%), K103N (24.2%), M41L (22.2%), and T215Y (16.2%). L90M was detected at a higher frequency (19.2%) than other mutations in the PR.

In general, resistance was most frequent for the NNRTIs and NRTIs, and seen less frequently for PIs. For individual drugs, resistance was most common to the NRTI abacavir (27.7%) and the NNRTIs efavirenz (27.7%), nevirapine (27.1%) and delavirdine (26.7%). We assessed the degree of drug resistance, dividing the level of resistance into three categories: low, intermediate, and high, according to the Stanford Genotypic Resistance Interpretation Algorithm. High levels of resistance to at least one class of drugs were seen in 34.6% of study participants. High levels of resistance to multiple classes of drugs was also observed, with 10.6% showing high levels of resistance to two classes of drugs and 7.4% highly resistant to all three classes. High levels of resistance to at least one PI were seen in 12.2% of study participants, and high levels of resistance to at least one NRTI and at least one NNRTI were seen in 23.4% and 24.5%, of study participants, respectively. For individual drugs, high levels of resistance were most common for nevirapine (23.9%), delavirdine (23.0%), efavirenz (20.7%), lamivudine (20.7%), and emtricitabine (20.7%).

We compared study participants' reports of both injection drug use and lifetime use of specific medications with laboratory analyses of resistance to these same medications. No association was found between resistance to medications and injection drug use. We also compared participants' reports of suspension of medication (drug holidays) with resistance and found that participants with at resistance to at least one medication were more likely to have ever suspended their medication (81.3% versus 18.8%, $\chi^2 = 32.97$, $p < 0.001$), but were less likely to have done so during the past 90 days (46.6% versus 53.4%, $\chi^2 = 12.57$, $p = 0.002$).

Participants who took combination drugs were coded as having taken each individual drug contained in the combination. Because of the possibility of cross-resistance to drugs within each class of medication, we reviewed the reported treatment history for exposure to any drug that selects for the resistance mutations observed. For example, for study participants whose virus had mutations that confer resistance to AZT, we reviewed their ARV exposure history for exposure to any drug that would select for those mutations. In this case, 5.9% of study participants who showed resistance to AZT did not report having ever taken any of type of NRTI that would cause resistance to AZT. Results differed by both individual medications and classes of medication. Among the NRTIs, we found resistance to all 7 medications analyzed, and between 5.9% and 7.3% of study participants with resistance to one of the NRTIs reported that they had never taken any of the medications in this class. Among PIs, we found resistance to all 8 medications, and between 3.3% and 6.3% of study participants who showed resistance to any single medication reported that they had not taken any of these drugs. Among the NNRTIs, we found resistance to all 3 medications, and between 28.8% and 30% of study participants who had resistance to an NNRTI reported never having taken any medication in this class. These results are shown in Table 4.

Discussion

Findings illustrate a high level of sexual activity among HIV-positive MSM, including multiple concurrent sex partners and participation in settings and groups in which multi-partner sex is prevalent. A small but substantial number

TABLE 3. HIV/STI DIAGNOSIS AND TREATMENT HISTORY

HIV diagnosis		
Time since diagnosis		
Mean (SD) number of years	12.1 (6.4)	
Range	< 1 year–24 years	
STI history		
	<i>Lifetime</i>	<i>Since HIV diagnosis</i>
Gonorrhea	54.3%	11.4%
Syphilis	40.3%	16.7%
Herpes	23.7%	13.4%
Genital warts	15.6%	5.9%
Chlamydia	12.4%	5.9%
At least one STI	78.0%	31.1%
At least three STIs	18.2%	4.3%
At least one STI diagnosis in past year	18.3%	
HIV treatment		
Mean (sd) number of different medications taken	4.74	
Mean (sd) number of PIs taken	2.12	
Mean (sd) number of NRTIs taken	3.19	
Mean (sd) number of NNRTIs taken	0.76	
Use of medication by class		
At least one PI	77.1%	
At least one NRTI	89.5%	
At least one NNRTI	58.8%	
Used only one class of medication	5.3%	
Used two different classes of medication	39.4%	
Used three different classes of medication	47.1%	
Never took any medication	8.2%	
Purposeful suspension of medication		
Lifetime	55.6%	
Past year	45.2%	

STI, sexually transmitted infection; SD, standard deviation; PIs, protease inhibitors; NRTIs, nucleoside reverse transcriptase inhibitors; NNRTIs, non-nucleoside reverse transcriptase inhibitors.

TABLE 4. ANTIRETROVIRAL DRUG RESISTANCE

Drug	Resistance			Total (any)	ARV ^a exposure		
	Low	Int.	High		Drug	Class	None
NRTI							
3TC	2.7%	0.5%	20.7%	23.9%	73.2%	92.7%	7.3%
ABC	12.2%	6.9%	8.5%	27.7%	49.0%	93.9%	6.1%
AZT	5.3%	6.4%	8.0%	19.7%	82.4%	94.1%	5.9%
d4T	6.9%	6.4%	8.5%	21.8%	50.0%	64.7%	5.9%
ddI	5.3%	7.4%	7.4%	20.2%	35.4%	93.8%	6.3%
FTC	2.7%	0.5%	20.7%	23.9%	53.7%	92.7%	7.3%
TDF	9.6%	9.6%	0.5%	19.7%	78.1%	93.8%	6.3%
PI							
ATV	4.8%	3.2%	8.5%	16.5%	50.0%	93.8%	6.3%
DRV	3.7%	5.9%	1.6%	11.2%	13.6%	95.5%	4.5%
FPV	5.3%	2.7%	6.4%	14.4%	17.2%	96.6%	3.4%
IDV	3.2%	3.7%	9.0%	16.0%	56.7%	96.7%	3.3%
LPV	5.3%	6.9%	3.7%	16.0%	66.7%	96.7%	3.3%
NFV	1.1%	5.3%	11.7%	18.1%	60.6%	93.9%	6.1%
SQV	3.2%	4.8%	8.5%	16.5%	41.4%	96.6%	3.4%
TPV	3.7%	7.4%	2.7%	13.8%	10.0%	96.7%	3.3%
NNRTI							
DLV	3.2%	0.5%	23.0%	26.7%	6.0%	70.0%	30.0%
EFV	5.3%	1.6%	20.7%	27.7%	59.6%	71.2%	28.8%
NVP	3.2%	0.0%	23.9%	27.1%	30.8%	71.2%	28.8%

^aIncludes any ARV within the class that selects for a mutation conferring resistance to the drug.

NRTI, nucleoside reverse transcriptase inhibitor; 3TC, lamivudine; ABC, abacavir; AZT, zidovudine; d4T, stavudine; ddI, didanosine; FTC, emtricitabine; TDF, tenofovir; PI, protease inhibitor; ATV, atazanavir; DRV, darunavir; FPV, fosamprenavir; IDV, indinavir; LPV, lopinavir; NFV, nelfinavir; SQV, saquinavir; TPV, tipranavir; NNRTI, non-nucleoside reverse transcriptase inhibitor; DLV, delavirdine; EFV, efavirenz; NVP, nevirapine.

reported sex with both male and female concurrent partners. Findings also show high rates of drug-resistant HIV detectable in blood samples. Coupled with high rates of sexual concurrency, this suggests high risk for diffusion of drug-resistant HIV among multiple types of risk partners.

Resistance to HIV medications was found in nearly half (44.7%) of the participants from whom we were able to obtain an HIV genotype, and 7.4% of these participants were resistant to drugs from all three classes of HIV medication analyzed. While new classes of HIV medications have and will continue to be developed, resistance to multiple drugs and classes of drugs among a sexually active population is a serious concern, both for the individuals involved and for their sexual partners.

Among participants in whom drug resistant HIV was found, resistance was associated with having ever suspended medication, but inversely associated with having done so recently. However, a substantial number reported no history of exposure to any medication that is known to select for the resistance mutations detected. This finding suggests sexual transmission of drug resistant HIV in this population. While there was some self-reported lifetime history of drug injection (17.4%), no association between lifetime history of drug injection and resistance to any medication was found, and it is therefore likely that any transmission of drug resistant HIV occurred via unprotected sexual activity.

The participants in this study differ in several important ways from those in other studies of HIV drug resistance. Participants in this study were recruited from street- and community-based venues, rather than clinical settings, and may therefore be more representative of the overall sexually active HIV-positive MSM population in New York City. This study also included a much higher proportion of minority HIV-positive MSM, highlighting the heightened risk of acquiring and potentially transmitting drug resistant HIV in minority MSM populations. The majority of participants were ARV-experienced and provided a detailed history of drugs taken. We were able to use these data and compare it to the laboratory data to determine which mutations were caused by selective pressure and which mutations may have been transmitted. It is also noteworthy that illicit drug use, while not widely reported, and especially injection drug use, was not likely to have been the source of infection suggesting that among this population, sexual transmission is the primary factor in the spread of drug resistant HIV.

This study has several limitations. Most importantly, data on sexual practices and medication history were collected via self-report, and are thus vulnerable to recall and social desirability biases. While relatively high rates of sexual activity were reported, we did not assess participants' rationales for unprotected sex, such as barebacking or sexual compulsivity. In addition, participants in this study are not representative of the overall HIV-positive MSM population in New York City or elsewhere. Finally, a genotype could be obtained for only 54.7% of all blood samples. However, no differences in demographics, sexual practices, or medication history were found between participants for whom genotype could be obtained and those for whom it could not. While it is possible for drug-resistant HIV to be present even when viral loads are extremely low,²² it remains unknown whether similar levels of drug resistance were present in the group of subjects for which a genotype was not available for analysis.

In the past 10 years, improved HIV treatment has led to a great reduction in opportunistic infections, wasting and other serious complications of HIV disease, and consequently has allowed people living with HIV to remain sexually active while infected. Unfortunately, resistance to HIV medications continues to pose a serious public health challenge, and diffusion of drug resistant forms of HIV has the potential to negatively impact the effectiveness of current HIV medications. It is therefore essential that new public health interventions be developed that can help to reduce the spread of drug resistant HIV among MSM. Based on this study and others,²³ these interventions will need to focus not only on safer sex, but also on drug-resistant HIV, secondary transmission of drug-resistant HIV, stigma, and disclosure of HIV status.

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Author Disclosure Statement

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Address correspondence to:

Lloyd A. Goldsamt, Ph.D.

Institute for International Research on Youth at Risk

National Development and Research Institutes, Inc.

71 West 23rd Street

8th floor

New York, NY 10010

E-mail: lloyd.goldsamt@ndri.org