Increased Antiretroviral Therapy Use and Virologic Suppression in the Bronx in the Context of Multiple HIV Prevention Strategies

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Abstract

Multiple population-based HIV prevention strategies from national, state, local, and institutional levels have been implemented in the Bronx, which has one of the highest HIV prevalences in the U.S. We examined changes in antiretroviral therapy (ART) use and associated outcomes between 2007 and 2014 among patients seen at one of >20 outpatient clinics affiliated with the largest Bronx HIV care provider. Among eligible HIV-infected patients age ≥13 years, we examined annual trends in ART use, mean HIV RNA level, and virologic suppression (<200 copies/ml) overall and among prespecified subgroups. In a subset with suppressed HIV RNA at the end of each year, we determined the percentage whose levels remained suppressed within the next year. Regression models assessed disparities in outcomes. Among 7,196 patients (median age 50, 47% Hispanic, 45% black), we identified consistent increases over time in the percent prescribed ART (78% in 2007 to 93% in 2014) and with virologic suppression (58% to 80%), as mean HIV RNA decreased (351 to 73 copies/ml) (all $p < .001$). Sustained virologic suppression improved markedly beginning in 2011, coinciding with local test-and-treat initiatives and adoption of expanded treatment guidelines. While disparities among population groups were most pronounced for sustained virologic suppression, those aged 13–24 fared relatively poorly for all outcomes examined (e.g., rate ratio 0.57 for virologic suppression, 95% confidence interval 0.52–0.62, vs. age 65+). Population-wide HIV prevention strategies coincided with improvements in virologic suppression among most population groups. However, more attention is needed to address continued disparities in the HIV care continuum among young people.

Keywords: antiretroviral therapy, HIV viral load, HIV prevention, test-and-treat, community viral load, young adult

Introduction

FOR INDIVIDUALS LIVING with HIV infection, achieving and maintaining suppression of HIV RNA levels is the most important goal of antiretroviral therapy (ART), leading to reduced viral replication, slowing or reversal of disease progression, and reduction in transmission.¹ The term “community viral load” is a population-based measure of how much virus, measured by HIV RNA levels, is circulating within a community. Community viral load has been proposed to “assess progress in treating HIV-infected persons with antiretroviral medications that would lower the community’s viremia,”² and in turn reduce transmission. Ecologic studies have linked community viral load with the number of new infections in the same area.^{3,4} “Monitored viral load” is a similar concept to community viral load, but excludes individuals who are not in care or who do not have

viral load measurements available. Estimating the true contribution of such individuals to community viral load is challenging since their true number is unknown and their measurements are unavailable, and therefore monitored viral load has been described as a reasonable proxy.²

High prevalence areas may benefit the most from monitoring viral load in a community, particularly in the context of HIV prevention strategies that encourage earlier ART use such as “test-and-treat.”⁵ The Bronx borough of New York City has one of the largest HIV epidemics in the United States, with an estimated 2% of the 1.4 million Bronx residents reported to be living with HIV.⁶ Recently, several interventions have been implemented population wide or by individual institutions providing care in the Bronx that could reduce the community’s viral load and thus HIV transmission. For example, “The Bronx Knows” was an initiative between 2008 and 2011 by the New York City health department to provide

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HIV testing to every Bronx resident not previously screened for HIV and link those testing positive to HIV care and services.⁷ Potential downstream consequences of this program included diagnosis of individuals earlier in the course of infection, earlier treatment, and decreases in community viral load.

Another initiative occurring between 2011 and 2013 was TLC-Plus (HPTN065), a randomized study evaluating the feasibility of a test, linkage-to-care, and treat strategy at participating sites in the Bronx and Washington, DC.⁸ Other national and local HIV prevention efforts occurring contemporaneously included national treatment guidelines recommending ART initiation at increasingly higher CD4+ counts⁹; a New York State law mandating HIV testing in health care settings implemented in 2010¹⁰; and a New York City health department recommendation that ART be offered to all HIV-infected individuals starting in 2011.¹¹

In the context of these multiple HIV prevention strategies, which may facilitate reduced HIV transmission both across and within certain population risk groups, we aimed to assess whether use of ART and related virologic outcomes improved between 2007 and 2014 among HIV-infected individuals in the Bronx. Our objectives were to (1) describe temporal trends in ART use and monitored viral load, as a proxy for community viral load; (2) determine temporal changes in sustained virologic suppression; and (3) identify relative and absolute disparities in these outcomes between population subgroups.

Materials and Methods

Data source

The Einstein/Rockefeller/Hunter CFAR's Clinical Cohort Database (CCDB) contains deidentified data on HIV-infected patients receiving care at hospitals and clinics affiliated with Montefiore Medical Center (MMC), which is the largest provider of HIV care in the Bronx. MMC is an integrated healthcare delivery system with three adult hospitals, a children's hospital, ≥50 ambulatory care sites, and two substance abuse treatment programs (SATPs). Clinics providing HIV primary care include a large infectious disease clinic, an adolescent HIV care clinic, the SATPs, and a network of over 15 general outpatient facilities. Patients in the CCDB are demographically representative with respect to age, sex, race/ethnicity, and HIV transmission risk of the overall HIV-positive population in the Bronx that is described by public health surveillance data.¹²

The CCDB combines electronic medical information, including inpatient and outpatient records; laboratory test results; prescription data; and intake data from New York State's AIDS Institute Reporting System (AIRS), which records key risk factor information at facilities receiving Ryan White funding. Records are captured through existing electronic systems and combined in a centralized location, where they undergo standardized data checks and are deidentified. This study was approved by the Albert Einstein College of Medicine/Montefiore Medical Center IRB.

Study population

The study population included all HIV-infected persons with at least one encounter in the MMC health system between 2007 and 2014. HIV infection was defined by either a

positive HIV Western blot or Multispot; a detectable HIV-1 viral load; or at least three undetectable HIV-1 viral loads ordered concurrently with a CD4+ count. This last criterion captures HIV-infected patients without antibody testing who are well controlled on ART.¹³

We limited the study to patients with visit records in AIRS (74% of HIV-infected patients) to have systematically collected data on HIV transmission risk, which was one of the characteristics for which we were interested in understanding disparities. This restriction also excluded patients receiving HIV care only through emergency room or inpatient services, or through outpatient clinics not funded by the Ryan White Program. Additional inclusion criteria included age ≥13 years and at least one HIV-1 viral load recorded during the period.

Variables of interest

We assessed three outcomes during each calendar year: ART use, monitored viral load, and sustained virologic suppression. We defined ART use as having at least one ART prescription recorded. Monitored viral load was assessed in multiple ways providing complementary information on viremia, based on guidance developed by the CDC²: first, as the average of the last recorded HIV-1 viral load in each year for all eligible patients; second, as the total monitored viral load, based on the sum of each patient's last recorded viral load in each year; third, as the percent of patients whose last recorded viral load was suppressed, defined as <200 copies/ml.⁹ Viral load was assessed by Versant HIV-1 RNA 3.0 (bDNA), used until 2010, or Abbott Real-Time HIV Viral Load, introduced in 2010.

Virologic suppression assessed at a single point in time does not capture whether suppression is maintained over time. We determined "sustained virologic suppression" among the subset of patients whose last viral load in each year was suppressed and who had at least one additional viral load recorded over the next 366 days. We calculated the time from initial suppression to virologic rebound (≥200 copies/ml).¹⁴ If rebound did not occur within 366 days, the patient was censored. Sustained virologic suppression is represented by the Kaplan–Meier estimate of the percent of suppressed individuals who did not experience virologic rebound within 1 year.

Other variables examined included sex, age (13–24, 25–44, 45–64, 65+ years), race/ethnicity (non-Hispanic black, Hispanic, non-Hispanic white, other/unknown), and insurance status (public, private, self-pay). HIV transmission risk factor was categorized as men who have sex with men (MSM), injection drug use (IDU) history, perinatal, and heterosexual contact or other risk. Nine percent of both male and female patients did not report an HIV risk factor; these patients were also categorized as heterosexual/other risk.

Statistical methods

To examine time trends in ART use, monitored viral load, and sustained virologic suppression, we reported annual percentages, means, or Kaplan–Meier estimates. For mean viral load, we used the geometric mean to reduce the influence of outlying measurements.² We tested trends using Poisson regression, except for the time-to-event sustained virologic suppression outcome, for which we used Cox regression.

To assess disparities in ART use and virologic suppression over the study period by patient characteristics, we developed Poisson regression models that included sex, age, race/ethnicity, transmission risk, insurance status, and calendar year. Because patients could contribute data to each year of the study, we used generalized estimating equations with an independent correlation structure to account for clustering by individuals. We did not institute a variable selection strategy owing to the limited number of covariates included. We determined differences in time trends by population groups with time $\times$ covariate interaction terms. We used Cox regression to assess disparities in sustained virologic suppression, with a frailty term to account for multiple observations per patient. Models for sustained virologic suppression included the same covariates as those for ART use and monitored viral load.

We performed sensitivity analyses to examine whether disparities in the youngest age group were affected by transmission category or by expanding the age group to age 29. When possible, we also performed sensitivity analyses

that included patients not in the AIRS system. Analyses used SAS 9.3 and R 3.0.2.

Results

There were 7,196 HIV-infected individuals between 2007 and 2014 who met inclusion criteria, with 31,052 eligible person-years of data, reported from over 20 general and specialty outpatient clinics across the Bronx (Table 1).

Females comprised 43% of the population. Median age at the end of the study period was 50 years, and median CD4+ count was 450 cells/ μ L. Most patients were either Hispanic (of any race) (47%) or non-Hispanic black (45%). The vast majority (89%) of patients were publicly insured. Individuals reporting either heterosexual/other risk comprised 48% of men, with additional 32% of men reporting sex with men, 19% a history of IDU, and 1% perinatal transmission. Among women, 12% reported a history of IDU, 2% perinatal transmission, and the remainder heterosexual/other risk. Among those aged 13–24, 44% were MSM, 31% reported perinatal transmission, and the remainder heterosexual/other risk.

TABLE 1. CHARACTERISTICS OF HIV-INFECTED OUTPATIENTS IN THE EINSTEIN/ROCKEFELLER/HUNTER CENTER FOR AIDS RESEARCH'S CLINICAL COHORT DATABASE, 2007–2014 (N=7,196)

Characteristics	N	%
Sex		
Male	4,113	57
Female	3,083	43
Age ^a (median years, IQR)	50	42–57
13–24 years	266	4
25–44 years	1,945	27
45–64 years	4,413	61
65+ years	572	8
Race/ethnicity		
Hispanic	3,373	47
Black, non-Hispanic	3,216	45
White, non-Hispanic	296	4
Other or unknown	311	4
Transmission risk, among men		
MSM	1,306	32
IDU history	774	19
Heterosexual, other, or unknown	1,957	48
Perinatal	76	2
Transmission risk, among women		
Transgender women	32	1
Injection drug use history	371	12
Heterosexual, other, or unknown	2,570	83
Perinatal	110	4
Insurance status ^a		
Public	6,439	89
Private	602	8
Self-paid	155	2
CD4+ count ^a (median cells/ μ L, IQR) (N=7,161)	450	232–695
<200 cells/ μ L	1,541	22
200–349 cells/ μ L	1,198	17
350–499 cells/ μ L	1,231	17
500+ cells/ μ L	3,192	45

^aAt most recent visit.

IDU, injection drug use; IQR, interquartile range; MSM, men who have sex with men.

Trends and disparities in ART use and monitored viral load

Figure 1 shows calendar-year trends in ART use and monitored viral load. The percent of patients with at least one ART prescription increased from 78% in 2007 to 93% in 2014 ($p_{\text{trend}} < .001$). The mean viral load decreased during the time period, from 351 copies/ml in 2007 to 73 copies/ml in 2014, while the percent of patients with a suppressed viral load (<200 copies/ml) increased from 58% to 80% (each $p_{\text{trend}} < .001$). Increases in ART use and virologic suppression were observed across all population subgroups defined by age, sex, race/ethnicity, transmission risk factor, and insurance status (Supplementary Figs. 1–5; Supplementary Data are available online at www.liebertpub.com/aid). Significant changes over time for these measures were observed by age ($p < .001$).

Table 2 shows the percent of patients with at least one ART prescription and with suppressed viral load, as well as mean

FIG. 1. Use of antiretroviral therapy and monitored viral load measures among HIV-infected outpatient clinical population, 2007–2014.

TABLE 2. ART USE AND MONITORED VIRAL LOAD MEASURES BY PATIENT CHARACTERISTICS, 2007–2014

Characteristics	ART use			Monitored viral load measures					
	Total person-years	Percent (%) with at least one ART prescription ^a	Adjusted RR for ART prescription (95% CI)	p	Mean viral load ^b (copies/ml) (SD)	Total monitored viral load (×1 million copies) ^c	Percent (%) with suppressed viral load ^a	Adjusted RR for suppressed viral load (95% CI)	p
Calendar year (per year)									
2007	3,354	—	1.02 (1.02, 1.03)	<.001	—	—	—	1.04 (1.04, 1.05)	<.001
2008	3,544	78	1.00	Ref.	351 (16)	32.3	58	1.00	Ref.
2009	3,835	80	1.03 (1.02, 1.05)	.002	275 (15)	28.1	61	1.06 (1.03, 1.09)	<.001
2010	3,890	83	1.07 (1.05, 1.09)	<.001	229 (13)	26.3	65	1.10 (1.07, 1.13)	<.001
2011	3,963	88	1.13 (1.11, 1.15)	<.001	191 (21)	39.5	64	1.08 (1.05, 1.12)	<.001
2012	4,111	90	1.15 (1.13, 1.17)	<.001	140 (18)	32.8	69	1.16 (1.12, 1.19)	<.001
2013	4,178	91	1.17 (1.15, 1.19)	<.001	86 (13)	22.3	76	1.26 (1.22, 1.30)	<.001
2014	4,177	93	1.18 (1.16, 1.21)	<.001	82 (13)	24.2	78	1.29 (1.25, 1.33)	<.001
		93	1.18 (1.16, 1.21)	<.001	73 (11)	20.9	80	1.31 (1.27, 1.35)	<.001
Sex									
Male	16,713	88	1.00	Ref.	155 (17)	16.8	69	1.00	Ref.
Female	14,334	87	0.97 (0.96, 0.99)	.0002	139 (14)	11.6	70	1.01 (0.99, 1.04)	.27
Age									
13–24 years	1,703	65	0.70 (0.66, 0.75)	<.001	497 (20)	2.4	48	0.57 (0.52, 0.62)	<.001
25–44 years	9,795	85	0.97 (0.94, 0.999)	.04	240 (19)	11.8	62	0.76 (0.72, 0.79)	<.001
45–64 years	17,968	91	1.02 (0.99, 1.05)	.17	109 (13)	13.4	75	0.91 (0.88, 0.94)	<.001
65+ years	1,581	90	1.00	Ref.	62 (9)	0.7	83	1.00	Ref.
Race/ethnicity									
Black, non-Hispanic	13,396	86	0.90 (0.74, 1.10)	.31	166 (17)	13.1	68	1.13 (0.84, 1.51)	.42
Hispanic	15,370	89	0.88 (0.77, 1.01)	.08	137 (15)	13.1	71	0.89 (0.91, 1.02)	.22
White, non-Hispanic	1,196	86	1.00	Ref.	129 (16)	1.2	74	1.00	Ref.
Other race/ethnicity	1,085	88	0.90 (0.78, 1.03)	.12	118 (14)	0.9	74	0.92 (0.76, 1.12)	.41
Transmission risk									
IDU history	5,103	89	0.99 (0.97, 1.01)	.36	142 (15)	4.4	70	0.97 (0.93, 1.00)	.05
MSM	5,297	85	0.99 (0.97, 1.01)	.26	165 (17)	5.4	68	1.04 (1.01, 1.08)	.02
Perinatal	849	82	1.17 (1.11, 1.24)	<.001	303 (20)	1.1	57	1.11 (0.999, 1.23)	.05
Heterosexual risk or other	19,803	88	1.00	Ref.	140 (15)	17.4	70	1.00	Ref.
Insurance status									
Public	27,769	88	1.00	Ref.	149 (16)	25.6	69	1.00	Ref.
Private	2,717	83	0.94 (0.92, 0.97)	<.001	114 (13)	1.9	74	1.08 (1.04, 1.12)	<.001
Self-paid	561	70	0.83 (0.78, 0.88)	<.001	343 (21)	0.8	57	0.88 (0.81, 0.95)	.002

Suppressed viral load defined as <200 copies/ml. Rate ratios adjusted for all other variables in table.

^aPercent of all person-years.^bGeometric mean.^cAnnualized total viral load multiplied by 1,000,000, except for calendar year-specific estimates.

ART, antiretroviral therapy; CI, confidence interval; RR, rate ratio; SD, standard deviation.

and total monitored viral load in different population groups. Groups with the highest percentage of ART use had consequently the highest percentage with virologic suppression and lowest mean viral load.

Among those with the least amount of ART use and virologic suppression were those aged 13–24 and those with perinatal transmission. When examining the 13–24 age group, only those with perinatal transmission had higher ART use than the MSM or heterosexual groups that approached levels of the older age groups toward the end of the time frame (Supplementary Fig. 6a). However, virologic suppression was low among the 13–24 age group regardless of the mode of transmission (Supplementary Fig. 6b). Sensitivity analyses that also included HIV+ patients seen exclusively in emergency room or inpatient settings, or non-Ryan White-funded outpatient settings, resulted in slightly lower percentages of ART use and virologic suppression (Supplementary Table S1).

In multivariable analyses, disparities by age in ART use and virologic suppression persisted. However, for some factors, differences in the association with ART use versus virologic suppression were observed. For example, women were less likely to be prescribed ART compared with men (rate ratio [RR] 0.97, 95% confidence interval [CI] 0.96–0.99), but virologic suppression was similar by sex. Those infected perinatally were more likely to be prescribed ART than those with heterosexual transmission (RR 1.17, 95% CI 1.11–1.24), whereas the association with virologic suppression was not statistically significant.

Population groups with greater total monitored viral load differed from those with greater mean viral load in a few respects, due to differences in underlying population size and HIV prevalence. While the youngest individuals had the highest mean viral load, those aged 25–44 and 45–64 had a higher annual total monitored viral load (11.8 and 13.4 million copies, respectively), due to a greater number of individuals in each of these groups. By transmission risk, heterosexual individuals had one of the lowest mean viral loads, but the highest total monitored viral load. MSM represented an increasing proportion of the total monitored viral load in the Bronx in more recent years, surpassing IDU in 2010 (Supplementary Fig. 7).

Trends and disparities in sustained virologic suppression

There were 4,681 individuals (16,381 person-years) eligible for analysis of sustained virologic suppression. Figure 2 shows Kaplan–Meier curves of sustained virologic suppression across successive cohorts of virologically suppressed patients over the study period. For most of the period, the percent of patients with sustained virologic suppression over 1 year was ~80%, increasing by 2012 to about 85%.

Table 3 shows differences in sustained virologic suppression by population group. Many observed disparities were in the same direction as those of initial virologic suppression, but more pronounced. For example, the age gradient observed for sustained virologic suppression was greater, with the youngest patients (age 13–24) more than twice as likely to not sustain virologic suppression as those 65 or older (hazard ratio [HR] 2.53, 95% CI 1.67–3.82), controlling for sex, race/ethnicity, transmission category, insurance status, and year. The association was similar in a sensitivity analysis that ex-

FIG. 2. Sustained virologic suppression among HIV-infected outpatient population, by year of suppression, 2007–2013.

cluded perinatally infected patients (HR 2.70, 95% CI 1.75–4.14). Both black and Hispanic patients were significantly less likely to sustain virologic suppression compared with white patients. While there were relatively few disparities by transmission risk in adjusted analyses for ART and virologic suppression, IDU were significantly less likely to sustain suppression compared to those with heterosexual risk.

Discussion

During a time when multiple changes to HIV screening and treatment practices occurred in the Bronx, we identified a consistent increase in ART use in our HIV population, with a concurrent increase in virologic suppression and decrease in the overall monitored viral load. We observed improvements across most population subgroups, including those traditionally believed to be less engaged in care such as IDU, but adolescents and young adults had the worst results for all outcomes. In contrast to the consistent increases in ART use and virologic suppression, the proportion of patients with sustained virologic suppression increased only in more recent years, after 2010. This improvement seemed most prominent when “test-and-treat” strategies and more aggressive treatment guidelines were being implemented.

Our observations extend findings of earlier U.S. studies reporting greater ART use and virologic suppression over time,^{15–17} linked, in part, to improved risk profiles of available ART drugs and regimens with fewer pills or dosings.^{18,19} Our study is unique in that it addresses the poorest urban county in the U.S.,²⁰ one that is disproportionately affected by HIV,⁶ yet home to multiple recent initiatives intended to improve HIV care continuum outcomes,²¹ including those focused on the early initiation of ART.^{8–11} It is especially encouraging that with recent calls by the White House to increase the number of HIV-infected people receiving ART to ≥90% and viral suppression to ≥80%,²² despite persistent socioeconomic disparities in the Bronx, our patient population is at or very close to these targets. In a broader context,

TABLE 3. ASSOCIATION WITH SUSTAINED VIROLOGIC SUPPRESSION AFTER 1 YEAR, 2007–2013 (N=4,681)

Characteristics	Estimated % with sustained virologic suppression ^a	Estimated % with virologic rebound within 1 year	Adjusted HR for time to virologic rebound (95% CI)	p
Overall	82	18		
Calendar year (per year)				
2007	80	20	1.00	Ref.
2008	79	21	1.09 (0.94, 1.28)	.24
2009	77	23	1.31 (1.13, 1.52)	<.001
2010	81	19	1.18 (1.01, 1.38)	.04
2011	84	16	0.93 (0.79, 1.09)	.36
2012	85	15	0.69 (0.59, 0.81)	<.001
2013	86	14	0.65 (0.55, 0.76)	<.001
Sex				
Male	82	18	1.00	Ref.
Female	82	18	0.97 (0.84, 1.12)	.72
Age				
13–24 years	74	26	2.53 (1.67, 3.82)	<.001
25–44 years	78	22	1.85 (1.36, 2.53)	<.001
45–64 years	84	16	1.25 (0.92, 1.68)	.15
65+ years	89	11	1.00	Ref.
Race/ethnicity				
Black, non-Hispanic	82	18	1.49 (1.11, 2.00)	.008
Hispanic	82	18	1.42 (1.06, 1.90)	.02
White, non-Hispanic	87	13	1.00	Ref.
Other race/ethnicity	92	8	0.47 (0.24, 0.90)	.02
Transmission risk				
IDU history	79	21	1.31 (1.10, 1.57)	.003
MSM	84	16	0.81 (0.66, 0.99)	.04
Perinatal	75	25	0.93 (0.60, 1.46)	.76
Heterosexual risk or other	83	17	1.00	Ref.
Insurance status				
Public	82	18	1.00	Ref.
Private	87	13	0.65 (0.53, 0.79)	<.001
Self-paid	83	17	0.88 (0.60, 1.28)	.51

HRs adjusted for all other variables in table.

^aBased on Kaplan–Meier estimate.

CI, confidence interval; HR, hazard ratio; IDU, injection drug use; MSM, men who have sex with men.

because early initiation of ART has now been adopted as a central tenet of the global response to HIV,²³ our study provides early insight into the potential impact that such “test-and-treat” strategies may have in real-world scenarios.

We observed an improvement in sustained virologic suppression that occurred only after 2010, in contrast to consistent improvements over the entire period in overall virologic suppression. This suggests that there had been a steady core of patients for whom efforts at maintaining virologic suppression after initial success were unsuccessful in earlier years, but that this group is diminishing, potentially due to more recent improvements in ease of treatment regimens, adherence levels, or more consistent messaging on the importance of maintaining suppression by providers. While other studies have shown mixed results in sustained virologic suppression over time,^{24–28} the gains we observed are encouraging. Continued monitoring would be useful to ensure durability of individual and public health benefits of ART, as recommended in the *National HIV/AIDS Strategy for the United States*.²²

Assessing community viral load by specific risk characteristics may be informative in understanding how within-

group and between-group transmission may be affected by prevention initiatives. We confirmed known disparities in young people: less than half of patients aged 13–24 were virologically suppressed and over one-quarter could not sustain suppression for 1 year, despite the existence in our network of an adolescent medical clinic specifically devoted to their care. These findings were observed regardless of mode of transmission and are consistent with recent U.S. studies reporting suboptimal virologic suppression^{29,30} and retention in care in this age group.³¹

While the prescribing of ART in the past may have been delayed among those in the early stages of HIV who were not expected to be adherent to complicated regimens, our study shows that ART use in youth has increased more recently, likely due to the availability of more tolerable regimens. Nonetheless, inadequate virologic suppression as a whole suggests that targeted programs are needed among youth who encourage care retention and emphasize the value of consistent ART use to maintain health and reduce the risk of transmission to others.²⁹ Developmental barriers (e.g., incomplete brain development, fear of disclosure, lack of family support as a result of stigma or homophobia) may

require more intensive adherence support and interventions addressing contextual barriers to ongoing care (e.g., housing, transportation, job security) within this group.

As a contrast, older HIV-infected adults were more likely to be prescribed ART and sustain virologic suppression; yet, the sheer number of older individuals in our HIV+ population relative to younger individuals resulted in a larger disparity in the total viral load potentially circulating in the community (e.g., 13.4 million copies in those aged 45–64 vs. 2.4 million copies among those aged 13–24). For “test-and-treat” initiatives to be successful within transmission networks that often cross demographic categories, including age,³² emphasis on viral suppression among groups with low individual viral loads, but high total viral loads, may be important.

We found that ART use was slightly, but significantly lower in women than men overall, by 3% in adjusted analyses. However, examining ART use by sex over time showed that this disparity rapidly disappeared over the course of the study. This is consistent with a report from a similar urban clinical cohort in Baltimore showing diminishing disparities in ART use by sex between 1997 and 2010.¹⁷ Our finding that virologic suppression by sex was similar despite this small difference in ART use is notable, given mixed findings in the literature regarding sex differences in ART adherence and HIV clinical outcomes.^{33,34} While our findings hold promise that sex in itself may contribute less to health disparities than in the past, continued assessment of its role in HIV clinical outcomes is warranted given known sex differences in pathogenesis that are independent of health care access.³⁵

Race/ethnicity did not appear to impede ART use, suggesting that our system may not have the same barriers to prescribing ART with respect to racial and ethnic minorities as has been observed in other settings.³⁶ We acknowledge, however, that a limited number of white patients in our population may limit our ability to fully support this claim. Indeed, black race (vs. white race) as well as public insurance were negatively associated with sustained virologic suppression, potentially reflecting underlying differences in health care access or socioeconomic background that persist despite availability of ART. Neither access to health care nor socioeconomic status beyond insurance status is systematically assessed in our database.

While some studies have found that differences in HIV outcomes by race/ethnicity and insurance status are attenuated or disappear when controlling for socioeconomic factors,^{37,38} other studies have found these differences to persist despite confounder control.^{39–41} Similarly, IDU, a group traditionally believed to be less engaged in care, were able to achieve virologic suppression at levels similar to other risk groups, but sustaining virologic response remained more difficult for them as well. In summary, a further understanding of the factors contributing to sustained virologic suppression is warranted.

This analysis illustrates the translation of evidence-based recommendations to real-world clinical practice. Because multiple overlapping initiatives occurred simultaneously in the Bronx, we could not easily evaluate the effectiveness of individual programs, but were nonetheless able to observe contemporaneous improvements in key treatment outcomes. Our cohort is unique in that it includes a high proportion of women (>40%) and measures care in an area with HIV prevalence consistent with a generalized epidemic. We used indicators established to evaluate prevention, treatment, and

care services,^{42–44} and thus our findings can be compared with other jurisdictions. Prescription data provided face validity that changes in viral load were due at least, in part, to increased ART use, and go beyond what most public health surveillance systems contain.

Our study has some limitations. First, we do not capture individuals not receiving care in our network or episodes of care among our cohort occurring outside of our system, and we do not account for those who are infected, but not diagnosed with HIV. We also excluded patients receiving care through emergency room or inpatient services or those not seen at Ryan White-funded outpatient clinics. Therefore, our use of monitored viral load in this study as a proxy for community viral load may result in estimates of virologic suppression that are higher than the true value in the underlying population, if individuals not in active care have unsuppressed RNA levels.⁴⁵ This is supported by our sensitivity analyses that show slightly worse outcomes when relaxing our exclusion criteria. Nonetheless, our institution is the largest HIV care provider in the Bronx, and our population has been shown to be similar to the overall Bronx HIV-positive population,¹² suggesting that the monitored viral load that we report may be generalizable to the entire borough.

Another limitation is that a change in viral load assays used institutionally occurred in 2010, resulting in slight discontinuities in time trends that year. This is an unavoidable consequence of using real-world clinical data. We partially accounted for this by calculating the geometric mean viral load, which reduces measurement variability. Finally, our findings may not apply to other areas.

Conclusion

In summary, we demonstrated improvements in several ART outcomes over time in one of the poorest U.S. communities, broadly correlating with the implementation of multiple population-based HIV prevention strategies. Continued emphasis should be placed on efforts to improve maintenance of virologic suppression, such as those improving treatment adherence and retention in care, across all population groups. Adolescents and young adults may need additional efforts once in HIV care to overcome barriers that impede virologic suppression, as the implications of life-long treatment with ART are most salient for this age group.

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