

# Improvements in HIV Care Engagement and Viral Load Suppression Following Enrollment in a Comprehensive HIV Care Coordination Program

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**Background.** Substantial evidence gaps remain regarding human immunodeficiency virus (HIV) intervention strategies that improve engagement in care (EiC) and viral load suppression (VLS). We assessed EiC and VLS before and after enrollment in a comprehensive intervention for persons at risk of poor HIV care outcomes.

**Methods.** New York City's Ryan White Part A HIV Care Coordination Program (CCP), launched at 28 agencies in 2009, applies multiple strategies to promote optimal utilization of medical and social services. Using laboratory test records from an HIV surveillance registry, we examined pre-post outcomes among 3641 CCP clients enrolled before April 2011. For the year before and after enrollment, we assessed EiC (defined as  $\geq 2$  tests,  $\geq 90$  days apart, with  $\geq 1$  in each half-year) and VLS (defined as viral load [VL]  $\leq 200$  copies/mL on latest VL test in the second half of the year). We estimated relative risks (RRs), comparing pre- and postenrollment proportions achieving EiC and VLS.

**Results.** Among newly diagnosed clients, 90.5% (95% confidence interval [CI], 87.9%–93.2%) and 66.2% (95% CI, 61.9%–70.6%) achieved EiC and VLS, respectively. Among previously diagnosed clients, EiC increased from 73.7% to 91.3% (RR = 1.24; 95% CI, 1.21–1.27) and VLS increased from 32.3% to 50.9% (RR = 1.58; 95% CI, 1.50–1.66). Clients without evidence of HIV care during the 6 months preenrollment contributed most to overall improvements. Pre-post improvements were robust, retaining statistical significance within most sociodemographic and clinical subgroups, and in 89% (EiC) and 75% (VLS) of CCP agencies.

**Conclusions.** Clients in comprehensive HIV care coordination for persons with evident barriers to care showed substantial and consistent improvement in short-term outcomes.

**Keywords.** public health surveillance; implementation science; intervention effectiveness; Ryan White; outcomes evaluation.

Advances in care and treatment have improved opportunities for health, quality of life, and longevity among persons with human immunodeficiency virus (HIV), as well as opportunities for preventing infections at the population level [1–4]. The challenge for realizing the

individual and public health benefits of HIV treatment resides in ensuring a continuum of HIV care, from timely diagnosis to prompt linkage to care, and from linkage to retention in care over time [5,6], with consistent access and adherence to antiretroviral medications [7–11]. In recognition of this challenge, the 2010 US National HIV/AIDS Strategy issued a call to increase HIV care access and enhance outcomes along the care continuum, with specific targets to be met by 2015 [12].

National estimates have suggested suboptimal population-level care continuum outcomes, with 72%–80% of those diagnosed with HIV promptly linked to care, 45%–59% retained in care, and 24%–43% virally suppressed [13–17]. Factors associated with suboptimal

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HIV healthcare utilization and clinical outcomes include black or Latino race/ethnicity [15, 17, 18], younger age [17–19], lower income [19], non-AIDS status at baseline [17–19], mental health or substance use disorders [15, 17, 20–23], stigma or low social support [24], non-US country of birth [15, 18], and unstable housing [25, 26]. However, there remains little evidence on how best to address these disparities, or which interventions are broadly capable of improving both care utilization and specific biomedical outcomes, such as viral load (VL) suppression [27], in real-world service settings [28–31]. We report here on a large-scale, multisite evaluation of short-term (1-year) care engagement and VL suppression outcomes, as well as subgroup variations in those outcomes, among clients enrolling in a comprehensive HIV care coordination intervention delivered in New York City (NYC).

## METHODS

### Intervention Description

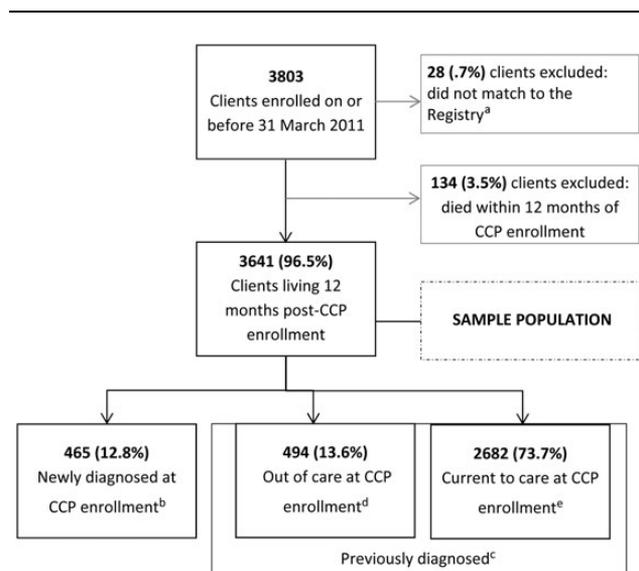
In December 2009, using Ryan White Part A funds, the NYC Department of Health and Mental Hygiene (DOHMH) launched an HIV Care Coordination Program (CCP) to support clients with high risk for, or a recent history of, suboptimal HIV care outcomes. CCP eligibility criteria permit enrollment of HIV-infected adults or emancipated minors who are eligible for local Ryan White Part A services (based on residence within the New York grant area and household income <435% of federal poverty level) and who are (1) newly diagnosed with HIV; (2) never in care or lost to care for at least 9 months; (3) irregularly in care or often missing appointments; (4) starting a new antiretroviral treatment (ART) regimen; (5) experiencing ART adherence barriers; or (6) manifesting treatment failure or ART resistance. The NYC CCP model combines several evidence-based or best-practice programmatic elements [27]: outreach for initial case finding and after any missed appointment; case management; multidisciplinary care team communication; and decision making via case conferences; patient navigation including accompaniment to primary care visits; ART adherence support, including directly observed therapy for individuals with greatest need; and structured health promotion utilizing a curriculum developed by the Prevention and Access to Care and Treatment program [32, 33]. Many of these intervention components are offered in the client's home and other field-based settings. The 28 CCP-funded agencies (17 hospitals and 11 community-based organizations that have colocation and/or formal partnerships with clinical facilities) operate approximately 70 service sites across the 5 boroughs of NYC, with higher concentration in areas with the highest HIV prevalence. Further program description and materials can be found on the DOHMH website (<http://www.nyc.gov/html/doh/html/living/hiv-care-coord.shtml>).

## Data Sources

The population-based NYC DOHMH HIV/AIDS Surveillance Registry (the Registry) contains demographic and clinical information on all diagnoses of HIV (since 2000) and AIDS (since 1981) reported in NYC, with the addition of comprehensive HIV-related laboratory reporting (including all CD4 and VL test results) starting in 2005. Vital status information is updated through regular matches with the NYC Death Registry, National Death Index, and Social Security Death File. Data on CCP clients and service utilization were drawn from the Electronic System for HIV/AIDS Reporting and Evaluation (eSHARE), a secure, Web-based, named reporting system developed and maintained by the DOHMH. NYC Ryan White Part A service providers are contractually required to submit programmatic data through eSHARE.

## Study Population

We conducted a pre-post retrospective cohort evaluation of CCP intervention effectiveness using individuals as their own



**Figure 1.** Sample population selection and categorization: New York City (NYC) Care Coordination Program (CCP) clients. <sup>a</sup>CCP clients were matched between the Electronic System for HIV/AIDS Reporting and Evaluation (eSHARE) and the NYC HIV Registry in August 2013, utilizing eSHARE data as of 15 July 2013 and Registry data as of 30 September 2013. <sup>b</sup>Newly diagnosed: CCP clients who were diagnosed in the 12 months prior to their CCP enrollment window (defined as the 31 days leading up to and including date of enrollment). <sup>c</sup>Previously diagnosed: CCP clients who were diagnosed >12 months prior to their CCP enrollment window. <sup>d</sup>Out of care: previously diagnosed CCP clients who had no evidence of primary care (CD4 or viral load [VL] test) in the 6 months prior to their CCP enrollment window. <sup>e</sup>Current to care: previously diagnosed CCP clients who had evidence of primary care in the 6 months prior to their CCP enrollment window. (Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the NYC HIV Registry as of 30 September 2013). Abbreviation: HIV, human immunodeficiency virus.

**Table 1. Demographic and Clinical Characteristics of New York City Care Coordination Program Clients at Baseline**

Characteristic	NYC CCP Clients <sup>a</sup>	
	No.	%
Total	3641	100.0
Care status at enrollment		
Newly diagnosed <sup>b</sup>	465	12.8
Out of care <sup>c</sup>	494	13.6
Current to care <sup>d</sup>	2682	73.7
Sex <sup>e</sup>		
Male	2286	62.8
Female	1355	37.2
Race/Ethnicity <sup>e</sup>		
Black	1936	53.2
Hispanic	1393	38.3
White	204	5.6
Other/Unknown	108	3.0
Age, y, at CCP enrollment <sup>e</sup>		
≤24	224	6.2
25–44	1534	42.1
45–64	1767	48.5
≥65	116	3.2
Age, y, at CCP enrollment, median (IQR) <sup>e</sup>	45 (35–52)	
Primary language spoken at home <sup>f</sup>		
English	2717	74.6
Spanish	736	20.2
Other	188	5.2
Insurance status at CCP enrollment <sup>f</sup>		
Insured	2643	72.6
Uninsured	998	27.4
Housing status at CCP enrollment <sup>f</sup>		
Homeless	820	22.5
Not homeless	2707	74.3
Unknown	114	3.1
Household income level at CCP enrollment <sup>f</sup>		
<\$9000	1403	38.5
≥\$9000	1229	33.8
Missing	1009	27.7
Taking ART at CCP enrollment <sup>f</sup>		
Yes	2562	70.4
No	1079	29.6
Country of birth <sup>e</sup>		
US/US dependency	2403	66.0
Foreign country	828	22.7
Unknown	410	11.3
Year of HIV diagnosis <sup>e</sup>		
<1995	690	19.0
1995–2004	1732	47.6
2005–2011	1219	33.5
Viral suppression (≤200 copies/mL) at enrollment <sup>e,g</sup>		
Yes	1072	29.4
No <sup>h</sup>	2569	70.6

Table 1 continued.

Characteristic	NYC CCP Clients <sup>a</sup>	
	No.	%
Viral load, copies/mL, at enrollment, median (IQR) <sup>e,g</sup>	1660.5 (0–35 072)	
CD4 count, cells/μL, at enrollment <sup>e,g</sup>		
<200	972	26.7
200–349	683	18.8
350–499	509	14.0
≥500	692	19.0
Unknown (no CD4 count 6 mo prior to enrollment)	785	21.6
CD4 count, cells/μL, at enrollment, median (IQR) <sup>e,g</sup>	302 (141–494)	

Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the New York City (NYC) HIV Registry as of 30 September 2013.

Abbreviations: ART, antiretroviral therapy; CCP, Care Coordination Program; HIV, human immunodeficiency virus; IQR, interquartile range; NYC, New York City; US, United States.

<sup>a</sup> Clients enrolled in the NYC CCP between 1 December 2009 and 31 March 2011, matched to the NYC HIV Registry, and living 12 months after the date of enrollment.

<sup>b</sup> Newly diagnosed: CCP clients who were diagnosed in the 12 months prior to their CCP enrollment window (defined as the 31 days leading up to and including date of enrollment).

<sup>c</sup> Out of care: CCP clients who were diagnosed >12 months prior to their CCP enrollment window and had no evidence of primary care (CD4 or viral load [VL] test) in the 6 months prior to their CCP enrollment window.

<sup>d</sup> Current to care: CCP clients who were diagnosed >12 months prior to their CCP enrollment window and had evidence of primary care in the 6 months prior to their CCP enrollment window.

<sup>e</sup> Client characteristic based on information reported to the NYC HIV Registry.

<sup>f</sup> Client characteristic as reported on client's first intake assessment for CCP in the Electronic System for HIV/AIDS Reporting and Evaluation.

<sup>g</sup> Median VL, viral suppression, median CD4, and CD4 at enrollment are determined by client's most recent CD4 or VL test occurring in the 6 months prior to their enrollment window.

<sup>h</sup> Clients who did not have a VL test reported during the 6 months prior to their CCP enrollment window were categorized as unsuppressed.

controls. The intent-to-treat analysis examined all CCP clients who met inclusion criteria, regardless of service activity or duration of CCP exposure. Included clients were enrolled in the CCP by 31 March 2011 and matched to the Registry, based on a previously described deterministic algorithm [34]. Additionally, to ensure adequate follow-up time, we excluded clients who died within 12 months of enrollment. All clients in the analysis were categorized as either newly diagnosed (diagnosed with HIV in the 12 months prior to enrollment) or previously diagnosed (diagnosed >12 months prior to enrollment). To explore outcome differences by care status immediately prior to enrollment in the CCP, previously diagnosed clients were further classified as current to care at baseline (with a CD4 or VL reported to the Registry in the 6 months prior to enrollment) or

**Table 2. Previously Diagnosed Care Coordination Program Clients<sup>a</sup>: 12-Month Pre- and Postenrollment Engagement in Care Outcomes and Relative Risk Estimates, by Demographic and Clinical Characteristics at Baseline**

Characteristic	All Previously Diagnosed Clients: Engagement in Care <sup>b</sup>			
	Total	12 mo Prior to CCP Enrollment <sup>c</sup> % (95% CI)	12 mo After CCP Enrollment % (95% CI)	Post- vs Preenrollment RR <sup>d</sup> (95% CI)
Total	3176	73.7 (72.2–75.2)	91.3 (90.3–92.3)	1.24 (1.21–1.27)
Care status				
Out of care <sup>e</sup>	494	0	82.8 (79.5–86.1)	NA <sup>f</sup>
Current to care <sup>g</sup>	2682	87.3 (86.0–88.5)	92.9 (92.0–93.9)	1.06 (1.05–1.08)
Sex <sup>h</sup>				
Male	1957	71.5 (69.5–73.5)	91.1 (89.8–92.4)	1.27 (1.24–1.31)
Female	1219	77.3 (74.9–79.6)	91.6 (90.1–93.2)	1.19 (1.15–1.23)
Race/Ethnicity <sup>h</sup>				
Black	1733	72.8 (70.7–74.9)	91.2 (89.9–92.6)	1.25 (1.22–1.29)
Hispanic	1193	74.7 (72.2–77.2)	92.5 (91.0–94.0)	1.24 (1.20–1.28)
White	170	72.4 (65.6–79.1)	84.7 (79.2–90.2)	1.17 (1.06–1.30)
Other/Unknown	80	81.3 (72.5–90.0)	90.0 (83.3–96.7)	1.11 (0.99–1.23)
Age, y, at CCP enrollment <sup>h</sup>				
≤24	153	61.4 (53.6–69.2)	88.9 (83.9–93.9)	1.45 (1.27–1.65)
25–44	1297	66.7 (64.1–69.3)	88.7 (86.9–90.4)	1.33 (1.28–1.38)
45–64	1629	80.0 (78.0–81.9)	93.6 (92.4–94.7)	1.17 (1.14–1.20)
≥65	97	81.4 (73.6–89.3)	92.8 (87.5–98.0)	1.14 (1.03–1.26)
Primary language spoken at home <sup>i</sup>				
English	2421	73.6 (71.8–75.3)	91.0 (89.8–92.1)	1.24 (1.21–1.27)
Spanish	615	74.5 (71.0–77.9)	92.7 (90.6–94.7)	1.24 (1.19–1.31)
Other	140	72.9 (65.4–80.3)	91.4 (86.7–96.1)	1.25 (1.13–1.40)
Insurance status at CCP enrollment <sup>i</sup>				
Insured	2387	77.2 (75.5–78.9)	91.5 (90.4–92.6)	1.19 (1.16–1.21)
Uninsured	789	63.2 (59.9–66.6)	90.7 (88.7–92.8)	1.43 (1.36–1.51)
Housing status at CCP enrollment <sup>i</sup>				
Homeless	726	69.0 (65.6–72.4)	91.6 (89.6–93.6)	1.34 (1.26–1.40)
Not homeless	2346	75.4 (73.7–77.1)	91.5 (90.3–92.6)	1.21 (1.18–1.24)
Unknown	104	68.3 (59.2–77.4)	85.6 (78.7–92.4)	1.25 (1.10–1.43)
Household income level at CCP enrollment <sup>i</sup>				
<\$9000	1213	70.0 (67.4–72.6)	91.3 (89.8–92.9)	1.31 (1.26–1.36)
≥\$9000	1070	76.1 (73.5–76.8)	91.6 (89.9–93.3)	1.20 (1.16–1.25)
Missing	893	75.9 (73.1–78.7)	90.3 (89.0–92.8)	1.20 (1.15–1.25)
Taking ART at CCP enrollment <sup>i</sup>				
Yes	2389	80.0 (78.4–81.6)	92.9 (91.9–94.0)	1.16 (1.14–1.19)
No	787	54.6 (51.2–58.1)	86.4 (84.0–88.8)	1.58 (1.48–1.69)
Country of birth <sup>h</sup>				
US/US dependency	2185	74.3 (72.4–76.1)	90.8 (89.5–92.0)	1.22 (1.19–1.25)
Foreign country	596	71.0 (67.3–74.6)	92.8 (90.7–94.9)	1.31 (1.24–1.38)
Unknown	395	74.7 (70.4–79.0)	92.2 (89.5–94.8)	1.23 (1.16–1.31)
Year of HIV diagnosis <sup>h</sup>				
<1995	690	80.4 (77.5–83.4)	93.9 (92.1–95.7)	1.17 (1.12–1.21)
1995–2004	1732	76.0 (74.0–78.1)	91.4 (90.1–92.7)	1.20 (1.17–1.24)
2005–2011	754	62.2 (58.7–65.7)	88.7 (86.5–91.0)	1.43 (1.35–1.51)
Evidence of viral suppression (≤200 copies/mL) at enrollment <sup>h,j</sup>				
Yes	1026	92.3 (90.7–93.9)	94.2 (92.7–95.6)	1.02 (0.99–1.04)
No <sup>k</sup>	2150	64.8 (62.8–66.9)	90.0 (88.7–91.2)	1.39 (1.34–1.43)

Table 2 continued.

Characteristic	Total	All Previously Diagnosed Clients: Engagement in Care <sup>b</sup>		
		12 mo Prior to CCP Enrollment <sup>c</sup> % (95% CI)	12 mo After CCP Enrollment % (95% CI)	Post- vs Preenrollment RR <sup>d</sup> (95% CI)
CD4 count, cells/ $\mu$ L, at enrollment <sup>h,j</sup>				
<200	909	85.5 (83.2–87.8)	93.5 (91.9–95.1)	1.09 (1.06–1.13)
200–349	632	87.3 (84.7–89.9)	91.0 (88.7–93.2)	1.04 (1.00–1.08)
350–499	465	87.3 (84.3–90.3)	94.0 (91.8–96.1)	1.08 (1.03–1.12)
$\geq$ 500	634	90.7 (88.4–93.0)	93.4 (91.4–95.3)	1.03 (1.00–1.06)
Unknown (no CD4 count 6 mo prior to enrollment)	536	5.8 (3.8–7.8)	83.2 (80.0–86.4)	14.39 (10.22–20.25)

Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the New York City (NYC) HIV Registry as of 30 September 2013.

Abbreviations: ART, antiretroviral therapy; CCP, Care Coordination Program; CI, confidence interval; HIV, human immunodeficiency virus; NA, not applicable; RR, relative risk; US, United States.

<sup>a</sup> Clients enrolled in the NYC CCP between 1 December 2009 and 31 March 2011, matched to the NYC HIV Registry, and living 12 months after the date of enrollment.

<sup>b</sup> Engagement in care is defined as  $\geq$ 2 CD4 or viral load (VL) tests  $\geq$ 90 days apart, with  $\geq$ 1 test in each half of the 12-month period specified.

<sup>c</sup> Twelve months prior to the client's CCP enrollment window (defined as the 31 days leading up to and including date of enrollment).

<sup>d</sup> RR calculated using generalized estimating equations.

<sup>e</sup> Out of care: CCP clients who were diagnosed  $>$ 12 months prior to their CCP enrollment window and had no evidence of primary care (CD4 or VL test) in the 6 months prior to their CCP enrollment window.

<sup>f</sup> By definition, clients in this group had no evidence of care in the 6 months prior to CCP enrollment, and thus were not engaged or suppressed at baseline; no post- vs preenrollment relative risk can be constructed.

<sup>g</sup> Current to care: CCP clients who were diagnosed  $>$ 12 months prior to their CCP enrollment window and had evidence of primary care in the 6 months prior to their CCP enrollment window.

<sup>h</sup> Client characteristic based on information reported to the NYC HIV Registry.

<sup>i</sup> Client characteristic as reported on client's first intake assessment for CCP in the Electronic System for HIV/AIDS Reporting and Evaluation.

<sup>j</sup> Median VL, viral suppression, median CD4, and CD4 at enrollment are determined by client's most recent CD4 or VL test occurring in the 6 months prior to their enrollment window.

<sup>k</sup> Clients who did not have a VL test reported during the 6 months prior to their enrollment window were categorized as unsuppressed.

out of care at baseline (with no CD4 or VL in the 6 months prior to enrollment) (Figure 1).

### Outcome Measures

Complete outcome histories pre- and post-CCP enrollment were derived by merging CCP client data from eSHARE with the HIV Registry. Using Registry-based CD4 and VL test records as proxies for medical care visits, 2 primary outcome variables, engagement in care (EiC) and viral load suppression (VLS), were constructed for the 12-month review periods pre- and post-CCP enrollment. EiC was defined as having at least 2 laboratory tests (CD4 or VL) dated at least 90 days apart, with at least 1 of those tests in each half of a given 12-month review period. VLS was defined as having a VL value  $\leq$ 200 copies/mL at the most recent VL test in the second half of the 12-month review period. Individuals with no VL test in the Registry in the second half of the 12-month review period were considered to have unsuppressed VL.

### Descriptive Data

All enrollment details and some client characteristics were drawn from Ryan White provider reporting in eSHARE. Other

demographic characteristics and baseline clinical/care history factors were drawn from the Registry. eSHARE-based frequencies were generated (for CCP clients only) to ascertain 12-month enrollment/closure status as well as provider-reported reasons for CCP enrollment and closure. Using Registry-based characteristics, the eligible CCP sample was directly compared to the population of other (non-CCP-enrolled) HIV-infected New Yorkers who were in medical care at some point during the CCP enrollment period of interest (1 December 2009–31 March 2011).

### Statistical Methods

For each outcome, proportions were computed for the 12-month period before CCP enrollment (previously diagnosed only) and the 12-month period after CCP enrollment (all eligible CCP clients). Relative risks (RRs) were used to compare postenrollment with preenrollment proportions for EiC and VLS among previously diagnosed clients, both overall and within client subgroups defined according to baseline care status, sociodemographic characteristics (sex, race/ethnicity, age, primary language spoken, insurance status, housing status, income level, and country of birth), and clinical/treatment factors (ART

status at enrollment, year of HIV diagnosis, viral suppression at enrollment, and CD4 cell count at enrollment). To account for correlation in the repeated-measure, pre-post design, we used generalized estimating equations to estimate pre-post RRs and 95% confidence intervals (CIs). All analyses were conducted using SAS software version 9.2.

### Ethics Statement

This study was approved by the NYC DOHMH and the City University of New York School of Public Health institutional review boards.

## RESULTS

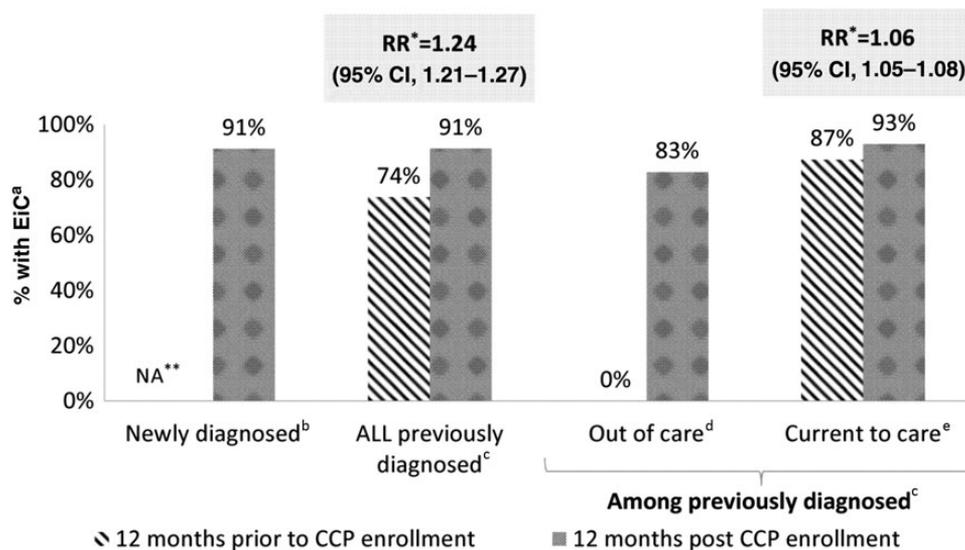
### Sample Characteristics

Table 1 describes client characteristics at time of CCP enrollment. Most of the 3641 CCP clients in the analysis were black or Hispanic (91.5%), male (62.8%), US-born (66.0%), and diagnosed prior to 2005 (66.6%). At CCP enrollment, median client age was 45 years, and 45.5% of clients had a CD4 count <350 cells/ $\mu$ L. In terms of baseline care status, 73.7% were current to care, 13.6% were out of care; and 12.8% were newly diagnosed.

Compared with others receiving HIV care in NYC during the same period ( $n = 70\,823$ ), CCP clients included in this analysis were more often female (37.2% vs 29.5%), black or Hispanic (91.5% vs 77.7%), and diagnosed since 2005 (33.5% vs 24.2%). They were also slightly younger (median age, 45 vs 47 years), with lower CD4 counts (median, 302 vs 464 cells/ $\mu$ L), and with a lower proportion showing viral suppression at baseline (29.4% vs 46.7%). Based on the (non-mutually exclusive) reasons reported by their providers for enrollment in the CCP, half (50.0%) of the clients in this sample had irregular care patterns; 41.3% had adherence issues; 13.0% were newly diagnosed; 10.7% were lost to care/never in care; 9.2% were starting a new ART regimen; and 9.0% had treatment failure or ART resistance.

### Engagement in Care and Viral Load Suppression

Among previously diagnosed clients, the proportion with EiC (Table 2 and Figure 2) increased from 73.7% to 91.3% ( $RR_{EiC} = 1.24$  [95% CI, 1.21–1.27]), and the proportion with VLS (Table 3 and Figure 3) increased from 32.3% to 50.9% ( $RR_{VLS} = 1.58$  [95% CI, 1.50–1.66]) from the pre- to the post-CCP enrollment period. Clients out of care at CCP enrollment contributed most to overall improvements. However, even



**Figure 2.** Pre- and postenrollment engagement in care (EiC) outcomes, by Care Coordination Program (CCP) client primary care status at baseline. Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the NYC HIV Registry as of 30 September 2013. \*Relative risks calculated using generalized estimating equations. \*\*By definition, clients in this group had no evidence of primary care (CD4 or viral load [VL] test) in the 6 months prior to CCP enrollment, and thus were not engaged or suppressed at baseline; no post- vs preenrollment relative risk can be constructed. <sup>a</sup>EiC is defined as  $\geq 2$  CD4 or VL tests  $\geq 90$  days apart, with  $\geq 1$  test in each half of the 12-month period specified. <sup>b</sup>Newly diagnosed: CCP clients who were diagnosed in the 12 months prior to their CCP enrollment window (defined as the 31 days leading up to and including date of enrollment). <sup>c</sup>Previously diagnosed: CCP clients who were diagnosed >12 months prior to their CCP enrollment window. <sup>d</sup>Out of care: previously diagnosed CCP clients who had no evidence of primary care in the 6 months prior to their CCP enrollment window. <sup>e</sup>Current to care: previously diagnosed CCP clients who had evidence of primary care in the 6 months prior to their CCP enrollment window. Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; NA, not applicable; NYC, New York City; RR, relative risk.

**Table 3. Previously Diagnosed Care Coordination Program Clients<sup>a</sup>: 12-Month Pre- and Postenrollment Viral Load Suppression Outcomes and Relative Risk Estimates, by Demographic and Clinical Characteristics at Baseline**

Characteristic	No.	All Previously Diagnosed Clients: Viral Load Suppression <sup>b</sup>		
		12 mo Prior to CCP Enrollment <sup>c</sup> % (95% CI)	12 mo After CCP Enrollment % (95% CI)	Post- vs Preenrollment RR <sup>d</sup> (95% CI)
Total	3176	32.3 (30.7–33.9)	50.9 (49.2–52.7)	1.58 (1.50–1.66)
Care status				
Out of care <sup>e</sup>	494	0	50.0 (45.6–54.4)	NA <sup>f</sup>
Current to care <sup>g</sup>	2682	38.3 (36.4–40.1)	51.1 (49.2–53.0)	1.34 (1.27–1.40)
Sex <sup>h</sup>				
Male	1957	31.0 (29.0–33.1)	51.1 (48.9–53.4)	1.65 (1.54–1.76)
Female	1219	34.4 (31.7–37.0)	50.5 (47.7–53.3)	1.47 (1.36–1.59)
Race/Ethnicity <sup>h</sup>				
Black	1733	28.9 (26.8–31.0)	46.8 (44.4–49.1)	1.62 (1.51–1.75)
Hispanic	1193	35.4 (32.7–38.1)	53.9 (51.1–56.7)	1.52 (1.41–1.65)
White	170	33.5 (26.4–40.7)	60.6 (53.2–68.0)	1.81 (1.48–2.21)
Other/Unknown	80	57.5 (46.4–68.6)	75.0 (65.3–84.7)	1.30 (1.10–1.54)
Age, y, at CCP enrollment <sup>h</sup>				
≤24	153	19.6 (13.2–26.0)	35.9 (28.3–43.6)	1.83 (1.31–2.57)
25–44	1297	26.0 (23.6–28.4)	48.8 (46.1–51.5)	1.88 (1.71–2.06)
45–64	1629	37.3 (34.9–39.6)	52.7 (50.2–55.1)	1.41 (1.33–1.51)
≥65	97	53.6 (43.5–63.7)	73.2 (64.2–82.2)	1.37 (1.15–1.62)
Primary language spoken at home <sup>i</sup>				
English	2421	30.2 (28.3–32.0)	47.6 (45.6–49.6)	1.58 (1.48–1.68)
Spanish	615	37.1 (33.2–40.9)	59.5 (55.6–63.4)	1.61 (1.45–1.78)
Other	140	48.6 (40.2–57.0)	70.7 (63.1–78.3)	1.46 (1.24–1.71)
Insurance status at CCP enrollment <sup>i</sup>				
Insured	2387	33.7 (31.8–35.6)	51.7 (49.7–53.7)	1.54 (1.45–1.62)
Uninsured	789	28.1 (25.0–31.3)	48.4 (44.9–51.9)	1.72 (1.53–1.93)
Housing status at CCP enrollment <sup>i</sup>				
Homeless	726	22.2 (19.1–25.2)	38.3 (34.7–41.8)	1.73 (1.50–1.98)
Not homeless	2346	35.8 (33.8–37.7)	55.2 (53.2–57.2)	1.54 (1.46–1.63)
Unknown	104	25.0 (16.5–33.5)	42.3 (32.7–52.0)	1.69 (1.18–2.42)
Household income level at CCP enrollment <sup>i</sup>				
<\$9000	1213	28.9 (26.4–31.5)	49.2 (46.4–52.0)	1.70 (1.55–1.86)
≥\$9000	1070	35.4 (32.6–38.3)	52.2 (49.2–55.2)	1.47 (1.36–1.60)
Missing	893	33.1 (30.1–36.2)	51.6 (48.3–54.9)	1.56 (1.42–1.71)
Taking ART at CCP enrollment <sup>i</sup>				
Yes	2389	39.1 (37.1–41.1)	53.0 (51.0–55.0)	1.36 (1.29–1.43)
No	787	11.7 (9.4–13.9)	44.5 (41.0–48.0)	3.80 (3.13–4.62)
Country of birth <sup>h</sup>				
US/US dependency	2185	29.2 (27.3–31.2)	47.6 (45.5–49.6)	1.63 (1.52–1.74)
Foreign country	596	40.9 (37.0–44.9)	62.1 (58.2–66.0)	1.52 (1.38–1.67)
Unknown	395	36.2 (31.4–41.0)	52.7 (47.7–57.6)	1.45 (1.28–1.65)
Year of HIV diagnosis <sup>h</sup>				
<1995	690	33.5 (29.9–37.0)	47.5 (43.8–51.3)	1.42 (1.27–1.58)
1995–2004	1732	32.6 (30.4–34.8)	49.9 (47.6–52.3)	1.53 (1.43–1.64)
2005–2011	754	30.5 (27.2–33.8)	56.2 (52.7–59.8)	1.84 (1.65–2.06)
Evidence of viral suppression (≤200 copies/mL) at enrollment <sup>h,j</sup>				
Yes	1026	100.0	75.1 (72.5–77.8)	NA <sup>k</sup>
No <sup>l</sup>	2150	0	39.4 (37.3–41.4)	NA <sup>m</sup>

Table 3 continued.

Characteristic	No.	All Previously Diagnosed Clients: Viral Load Suppression <sup>b</sup>		
		12 mo Prior to CCP Enrollment <sup>c</sup> % (95% CI)	12 mo After CCP Enrollment % (95% CI)	Post- vs Preenrollment RR <sup>d</sup> (95% CI)
CD4 count, cells/ $\mu$ L, at enrollment <sup>h,j</sup>				
<200	909	19.7 (17.1–22.3)	37.0 (33.8–40.1)	1.88 (1.63–2.16)
200–349	632	34.3 (30.6–38.0)	49.7 (45.8–53.6)	1.45 (1.30–1.61)
350–499	465	44.5 (40.0–49.1)	60.2 (55.7–64.7)	1.35 (1.22–1.50)
$\geq$ 500	634	63.6 (59.8–67.3)	65.8 (62.1–69.5)	1.03 (0.97–1.10)
Unknown (no CD4 count 6 mo prior to enrollment)	536	3.7 (2.1–5.3)	50.4 (46.1–54.6)	13.50 (8.83–20.65)

Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the New York City (NYC) HIV Registry as of 30 September 2013.

Abbreviations: ART, antiretroviral therapy; CCP, Care Coordination Program; CI, confidence interval; HIV, human immunodeficiency virus; NA, not applicable; RR, relative risk; US, United States.

<sup>a</sup> Clients enrolled in the NYC CCP between 1 December 2009 and 31 March 2011, matched to the NYC HIV Registry, and living 12 months after the date of enrollment.

<sup>b</sup> Viral load (VL) suppression is defined as VL  $\leq$ 200 copies/mL on most recent test in the second half of the 12-month period specified.

<sup>c</sup> Twelve months prior to the client's CCP enrollment window (defined as the 31 days leading up to and including date of enrollment).

<sup>d</sup> RR calculated using generalized estimating equations.

<sup>e</sup> Out of care: CCP clients who were diagnosed >12 months prior to their CCP enrollment window and had no evidence of primary care (CD4 or VL test) in the 6 months prior to their CCP enrollment window.

<sup>f</sup> By definition, clients in this group had no evidence of care in the 6 months prior to CCP enrollment, and thus were not engaged or suppressed at baseline; no post- vs preenrollment relative risk can be constructed.

<sup>g</sup> Current to care: CCP clients who were diagnosed >12 months prior to their CCP enrollment window and had evidence of primary care in the 6 months prior to their CCP enrollment window.

<sup>h</sup> Client characteristic based on information reported to the NYC HIV Registry.

<sup>i</sup> Client characteristic as reported on client's first intake assessment for CCP in the Electronic System for HIV/AIDS Reporting and Evaluation.

<sup>j</sup> Median VL, viral suppression, median CD4, and CD4 at enrollment are determined by client's most recent CD4 or VL test occurring in the 6 months prior to their enrollment window.

<sup>k</sup> By definition, all clients in this group were virally suppressed in the 6 months prior to CCP enrollment; due to a lack of variance in the baseline measure, no post- vs preenrollment relative risk can be constructed.

<sup>l</sup> Clients who did not have a VL test reported during the 6 months prior to their enrollment window were categorized as unsuppressed.

<sup>m</sup> Because all clients in this group were unsuppressed at baseline, no post- vs preenrollment relative risk can be constructed.

among those current to care, significant improvements were observed for both outcomes (RR<sub>EiC</sub> = 1.06 [95% CI, 1.05–1.08] and RR<sub>VLS</sub> = 1.34 [95% CI, 1.27–1.40]). Among newly diagnosed clients (Table 4), the proportions with EiC and VLS at 12 months after CCP enrollment were 90.5% and 66.2%.

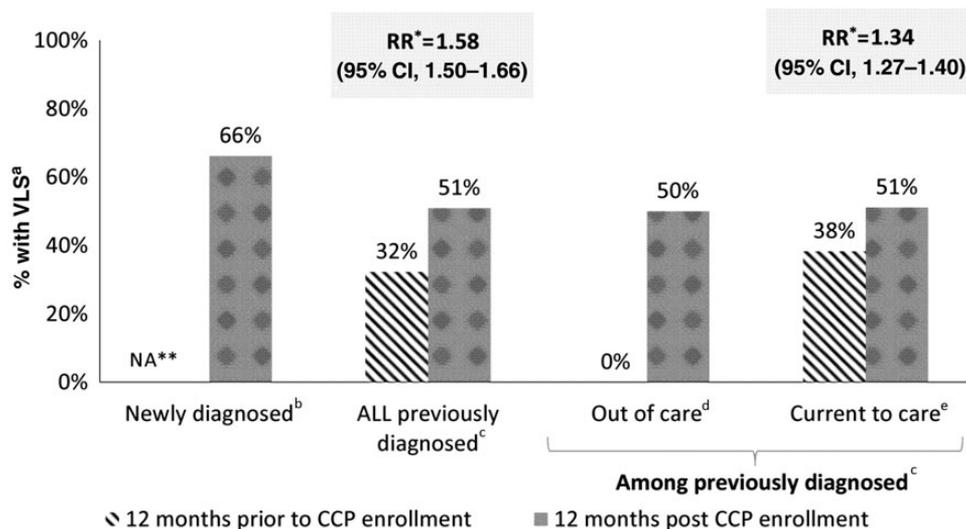
### Stratified Analysis to Assess CCP Effects Within Subgroups

In analyses stratified by baseline demographic and clinical/treatment variables, the significant overall improvements observed for both study outcomes generally held across the examined subgroups (Tables 2 and 3), except for those clients with baseline CD4 count  $\geq$ 500 cells/ $\mu$ L (VLS only), baseline VL  $\leq$ 200 copies/mL, or "other/unknown" race (EiC only). Within stratifying variables, the greatest relative improvements were observed among those aged <45 years, diagnosed after 2004, without an antiretroviral prescription at enrollment, born male (EiC only), making <\$9000/year (EiC only), uninsured (EiC only), homeless (EiC only), virally unsuppressed at enrollment (EiC only), and having CD4 count <200 cells/ $\mu$ L at

enrollment (VLS only). Stratifying by agency of first CCP enrollment, statistically significant improvements were observed for EiC at 25 (89%) and for VLS at 21 (75%) of the 28 CCP agencies.

### CCP Enrollment Status and Duration at 12-Month Follow-up

As of 12 months postenrollment, 61.3% of clients were still enrolled. Among the 38.7% with a program closure during the 12-month follow-up period, the median CCP enrollment was 197 days or 0.54 years (interquartile range, 117–278 days), and 6.9% had graduated due to achieving self-sufficiency (defined as meeting specific criteria including  $\geq$ 95% treatment adherence, reduced hospitalizations, and maintenance of scheduled appointments). Other reasons for closure included discharge based on program requirements (eg, due to client nonparticipation, staff safety concerns, or income or residence-based ineligibility) (47.2%); loss to follow-up (19.0%); relocation out of neighborhood (7.2%), or transfer of care to another provider (19.5%). A check of both outcomes by enrollment duration



**Figure 3.** Pre- and postenrollment viral load suppression (VLS) outcomes, by Care Coordination Program (CCP) client primary care status at baseline. Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the NYC HIV Registry as of 30 September 2013. \*Relative risks calculated using generalized estimating equations. \*\*By definition, clients in this group had no evidence of primary care (CD4 or viral load [VL] test) in the 6 months prior to CCP enrollment, and thus were not engaged or suppressed at baseline; no post- vs preenrollment relative risk can be constructed. <sup>a</sup>VLS is defined as VL  $\leq$ 200 copies/mL on most recent test in the second half of the 12-month period specified. <sup>b</sup>Newly diagnosed: CCP clients who were diagnosed in the 12 months prior to their CCP enrollment window (defined as the 31 days leading up to and including date of enrollment). <sup>c</sup>Previously diagnosed: CCP clients who were diagnosed >12 months prior to their CCP enrollment window. <sup>d</sup>Out of care: previously diagnosed CCP clients who had no evidence of primary care in the 6 months prior to their CCP enrollment window. <sup>e</sup>Current to care: previously diagnosed CCP clients who had evidence of primary care in the 6 months prior to their CCP enrollment window. Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; NA, not applicable; NYC, New York City; RR, relative risk.

confirmed significant improvements even for those enrolled <6 months. Although the 95% CIs overlapped, RRs trended upward with longer enrollment, comparing 0–6 and 6–12 months with continuous enrollment throughout the follow-up period (data not shown).

## DISCUSSION

These findings suggest substantial and robust positive impact of an HIV care coordination model on short-term EiC and VLS, especially among those out of care prior to CCP enrollment. The gains observed among CCP clients reinforce and extend the findings from a recent evaluation of a similar, Washington, D.C.-based, Ryan White-funded comprehensive medical case management (MCM) program. In a comparison of client outcomes at MCM-funded and non-MCM-funded facilities, adjusting for demographic and clinic-level differences, that study found greater likelihood of retention in HIV care among patients at the MCM-funded facilities, but did not detect a significant difference in likelihood of VLS [35]. Among newly diagnosed individuals, the CCP 12-month outcomes (>90% EiC and >66% VLS) compare favorably against 12-month outcomes from the multisite ART and Access Study, in which

64% of newly diagnosed individuals exposed to the strengths-based case management intervention achieved regular care [36], and 12-month outcomes from the US Special Projects of National Significance Outreach Initiative, in which 45% of newly diagnosed individuals achieved undetectable VL [37].

Interestingly, a recent randomized trial of enhanced personal contact between patients and staff showed significant improvements in HIV primary care retention, but little benefit among patients with unmet needs [21]. Our estimates of improvements in EiC and VLS remained robust within nearly all subgroups examined, suggesting advantages in the comprehensive approach of the CCP, with tailoring of clinical and supportive services to the needs of the individual.

Nonetheless, the outcome variations by baseline care status in our study suggest the potential value of even more specifically prioritizing for CCP enrollment those never in care or out of care for at least 6 months, as well as those newly diagnosed. Differences found in the degree of improvement post-CCP enrollment by demographic characteristics suggest a higher potential impact among low-income, uninsured, unstably housed, and younger populations, whereas differences by clinical/treatment factors suggest a higher potential impact for those with lower CD4, unsuppressed VL, and/or no current prescription

**Table 4. Newly Diagnosed<sup>a</sup> Care Coordination Program Clients<sup>b</sup>: 12-Month Postenrollment Engagement in Care and Viral Load Suppression Outcomes, by Demographic and Clinical Characteristics at Baseline**

Characteristic	All Newly Diagnosed Clients, 12 mo After CCP Enrollment		
	No.	Engagement in Care <sup>c</sup> % (95% CI)	Viral Load Suppression <sup>d</sup> % (95% CI)
Total	465	90.5 (87.9–93.2)	66.2 (61.9–70.6)
Sex <sup>e</sup>			
Male	329	90.6 (87.4–93.8)	65.7 (60.5–70.8)
Female	136	90.4 (85.4–95.4)	67.6 (59.7–75.6)
Race/Ethnicity <sup>e</sup>			
Black	203	91.1 (87.2–95.1)	63.1 (56.4–69.8)
Hispanic	200	92.5 (88.8–96.2)	71.0 (64.7–77.3)
White	34	82.4 (68.9–95.9)	61.8 (44.6–79.0)
Other/Unknown	28	82.1 (67.0–97.3)	60.7 (41.4–80.0)
Age, y, at CCP enrollment <sup>e</sup>			
≤24	93	92.5 (87.0–97.9)	55.9 (45.6–66.2)
25–44	270	89.3 (85.5–93.0)	69.3 (63.7–74.8)
45–64	94	91.5 (85.7–97.2)	67.0 (57.3–76.7)
≥65	8	100.0	75.0 (36.3–100.0)
Primary language spoken at home <sup>f</sup>			
English	296	90.2 (86.8–93.6)	62.5 (57.0–68.0)
Spanish	121	94.2 (90.0–98.4)	77.7 (70.2–85.2)
Other	48	83.3 (72.4–94.3)	60.4 (46.1–74.8)
Insurance status at CCP enrollment <sup>f</sup>			
Insured	256	91.4 (87.9–94.7)	68.4 (62.6–74.1)
Uninsured	209	89.5 (85.3–93.7)	63.6 (57.1–70.2)
Housing status at CCP enrollment <sup>f</sup>			
Homeless	94	15.0 (7.6–22.2)	55.3 (45.1–65.6)
Not homeless	361	92.0 (89.1–94.8)	69.3 (64.5–74.0)
Unknown	10	90.0 (67.4–100.0)	60.0 (23.1–96.9)
Household income level at CCP enrollment <sup>f</sup>			
<\$9000	190	87.4 (82.6–92.1)	67.9 (61.2–74.6)
≥\$9000	159	93.7 (89.9–97.5)	69.2 (61.9–76.4)
Missing	116	91.4 (86.2–96.6)	59.5 (50.4–68.6)
Taking ART at CCP enrollment <sup>f</sup>			
Yes	173	93.1 (89.2–96.9)	80.9 (75.0–86.8)
No	292	89.0 (85.4–92.6)	57.5 (51.8–63.2)
Country of birth <sup>e</sup>			
US/US dependency	218	89.9 (85.9–93.9)	59.2 (52.6–65.8)
Foreign country	232	91.4 (87.7–95.0)	72.4 (66.6–78.2)
Unknown	15	86.7 (67.2–100.0)	73.3 (48.0–98.7)
Year of HIV diagnosis <sup>e</sup>			
<1995	0	...	...
1995–2004	0	...	...
2005–2011	465	90.5 (87.9–93.2)	66.2 (61.9–70.6)
Evidence of viral suppression (≤200 copies/mL) at enrollment <sup>e,g</sup>			
Yes	46	91.3 (82.8–99.8)	82.6 (71.2–94.0)
No <sup>h</sup>	419	90.5 (87.6–93.3)	64.4 (59.8–69.0)
CD4 count, cells/μL, at enrollment <sup>e,g</sup>			
<200	63	95.2 (89.8–100.0)	85.7 (76.8–94.6)
200–349	51	90.2 (81.7–98.6)	76.5 (64.4–88.5)
350–499	44	93.2 (85.4–100.0)	63.6 (48.8–78.4)

Table 4 continued.

Characteristic	All Newly Diagnosed Clients, 12 mo After CCP Enrollment		
	No.	Engagement in Care <sup>c</sup> % (95% CI)	Viral Load Suppression <sup>d</sup> % (95% CI)
≥500	52	89.7 (81.6–97.7)	44.8 (31.6–58.0)
Unknown (no CD4 6 mo prior to enrollment)	249	89.2 (85.3–93.0)	64.7 (58.7–70.6)

Prepared by the Bureau of HIV/AIDS Prevention and Control with data reported to the New York City (NYC) HIV Registry as of 30 September 2013.

Abbreviations: ART, antiretroviral therapy; CCP, Care Coordination Program; CI, confidence interval; HIV, human immunodeficiency virus; US, United States.

<sup>a</sup> Newly diagnosed: CCP clients who were diagnosed in the 12 months prior to their CCP enrollment window (defined as the 31 days leading up to and including date of enrollment).

<sup>b</sup> Clients enrolled in the NYC CCP between 1 December 2009 and 31 March 2011, matched to the NYC HIV Registry, and living 12 months after the date of enrollment.

<sup>c</sup> Engagement in care is defined as ≥2 CD4 or viral load (VL) tests ≥90 days apart, with ≥1 test in each half of the 12-month period specified.

<sup>d</sup> Viral load suppression is defined as VL ≤200 copies/mL on most recent test in the second half of the 12-month period following CCP enrollment.

<sup>e</sup> Client characteristic based on information in the NYC HIV Registry.

<sup>f</sup> Client characteristic as reported on client's first intake assessment for CCP in the Electronic System for HIV/AIDS Reporting and Evaluation.

<sup>g</sup> Median VL, viral suppression, median CD4, and CD4 at enrollment are determined by client's most recent CD4 or VL test occurring in the 6 months prior to their enrollment window.

<sup>h</sup> Clients who did not have a VL test reported during the 6 months prior to their enrollment window were categorized as unsuppressed.

for ART at enrollment. These differences (even among groups sharing significant improvements) will inform future phases of effectiveness and cost-effectiveness research and guide future applications of the program model.

As recent reviews have described, complex intervention designs, employing multiple evidence-informed strategies and means of service delivery (eg, home-based, clinic-based, and via telecommunications) appear to represent the direction of retention/adherence support services evolution, and may be essential for addressing the multiple impediments to accessing and maintaining HIV primary care and ART [30, 38]. Further research is needed, however, to investigate the relative effectiveness and cost-effectiveness of different components of such complex interventions, to assess the cost-effectiveness of retaining all elements (vs a pared-down package), and to continue to examine outcomes for longer periods postenrollment, given that interventions to improve HIV care outcomes often show a tapering of the effect with distance in time from the intervention (eg, [38]).

As an observational study based in a real-world setting, this study has certain limitations. For example, we could not account for exposure to other contemporaneous interventions or environmental changes external to the CCP, which may have partially driven some of the improvements observed. Because there was no separate control group in our analysis (individuals served as their own controls), we could not offer a comparison to what might have happened in the absence of CCP exposure. In addition, due to CCP selection criteria, there is the potential that previously diagnosed individuals may have come into the program at a time when they were more vulnerable to (and expressive of) suboptimal outcomes than at other times in their postdiagnosis

history. However, we were able to measure client health at baseline via clinical markers, and we observed significant improvements in EiC and VLS in all CD4 categories except CD4 >500 cells/μL (accounting for 19.0% of the sample).

The selection of clients based on known care and treatment barriers may in part explain the programmatic closure of more than a third of the sample during the follow-up period, generally for reasons other than graduation. However, the significant improvements observed in this analysis even for those enrolled <6 months, as well as the small group of clients graduating during the follow-up period, suggest that some individuals obtain what they need from the program in less than a year. The upward trend in RRs with increased enrollment duration suggests that exposure time does matter, and warrants further dose-response analyses.

Regarding data sources, the use of laboratory data from a surveillance registry may result in under- or overestimation of engagement in HIV primary care. Some primary care visits may not be accompanied by laboratory tests, and some laboratory tests may be ordered outside of the context of primary care, including during emergency department visits or inpatient stays [39]. However, this would only introduce bias in our study if it occurred differentially (pre- vs post-), in which case the more likely scenario would be overestimating care engagement prior to CCP enrollment (due to misclassification of acute care encounters as HIV primary care), potentially leading to underestimates of the CCP effect on care engagement.

Our study also has several strengths. The use of subjects as their own controls helps to address many potential confounding variables at the client level, such as factors predicting enrollment

in the program. Furthermore, in contrast to many observational HIV treatment adherence intervention studies [40], we employed an intent-to-treat approach including all persons enrolled in the CCP (regardless of how long they remained in the program), to avoid selection bias stemming from factors that would affect both the outcomes of interest and the ability to remain and participate in the CCP. Finally, the merging of programmatic data with surveillance data permitted standardized, objective, and highly complete outcome measurement across all clients and program sites before and after CCP enrollment, regardless of enrollment duration.

## CONCLUSIONS

Among vulnerable populations with HIV, comprehensive care coordination may substantially improve short-term outcomes for previously diagnosed clients, especially those returning to care after a gap of >6 months. Newly diagnosed clients in this study also fared well in the year after enrollment. It is particularly encouraging that observed improvements for previously diagnosed individuals held across subgroups defined by baseline care status, as well as most demographic or clinical/treatment experience categories. Despite the limitations of an observational pre-post design, our initial analyses of short-term CCP client outcomes suggest the promise of this comprehensive combination intervention model for optimizing the individual and community impact of HIV care.

## Notes

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