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MAJOR ARTICLE

Longitudinal Improvements in Viral Suppression for Persons With New HIV Diagnosis Receiving Care in the Ryan White Program: A 10-Year Experience in New Haven, CT (2009–2018)

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Background. The Ryan White (RW) program funds medical and other support services for low-income persons with HIV, significantly improving progress along the HIV care continuum. Although the program has shown overall improvements in achievement of viral suppression, the relative contributions of changes in clinical practice and RW service components to the optimization of the HIV care continuum, particularly for those with new HIV diagnoses, remain unknown.

Methods. The target population was patients with recent HIV diagnoses who received care at RW-funded clinics in the greater New Haven area between 2009 and 2018. Client data were extracted from the RW-funded database, CAREWare, and the electronic medical record. Primary outcomes included time between HIV diagnosis and first HIV primary care (PC) visit, antiretroviral therapy (ART) initiation, and viral suppression (VS).

Results. There were 386 eligible patients. Between 2009 and 2018, the median number of days from HIV diagnosis to first PC visit decreased from 58.5 to 8.5 days, and ART initiation decreased from 155 to 9 days. In 2018, 86% of participants achieved viral suppression within 1 year, compared with 2.5% in 2009. Patients who initiated single-tablet ART and integrase inhibitor–containing regimens were more likely to reach viral suppression within 1 year ($P < .001$). Receipt of medical case management services was also associated with achieving viral suppression ($P < .001$).

Conclusions. Longitudinal improvements over 10 years in ART initiation and viral suppression were observed due to clinical advances and their effective implementation through the RW comprehensive care model. Further study of the essential components promoting these outcomes is needed.

Keywords. care continuum; new HIV diagnoses.

In the United States, there are currently about 1.2 million people with HIV (PWH) [1]. The federal Ryan White (RW) HIV/AIDS Program, authorized in 1990 and administered by the Health Resources and Services Administration (HRSA), funds comprehensive HIV medical care, medication, and support services for low-income PWH. Over half of PWH in the United States receive services through RW programs [2], which serve vulnerable patients who suffer disproportionately poor health outcomes due to disparities in social determinants of health and access to care [3]. The achievement of viral suppression among PWH is an essential component of the federal initiative Ending the HIV Epidemic in the United States; the RW program offers major contributions to these federal goals, achieving viral suppression in 89.4% of clients compared with the national viral suppression rate of 66% [2]. These favorable clinical outcomes may be attributed, in part, to frequently used core services such as outpatient ambulatory health, medical case management (MCM), substance abuse and mental health services, as well as noncore services including medical transportation, housing, food, and emergency financial assistance [3]. Such services accelerate progress along the HIV care continuum for people who are newly diagnosed with HIV. The HIV care continuum is a framework that outlines steps essential to the achievement of viral suppression, including linkage to primary care (PC), initiation of antiretroviral therapy (ART), and viral suppression (<200 copies/mL) [4].

Over the past few decades, significant improvements have been made in the achievement of viral suppression among PWH. Such improvements can be attributed to the widespread availability and utilization of ART since 1996 [5]. More recently

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approved forms of ART are increasingly effective, more conveniently formulated, and better tolerated. In addition to improvements in ART availability, previous studies have shown improved clinical outcomes among individuals who initiate ART following diagnosis regardless of CD4+ cell count [6, 7]. Early initiation of ART has been shown to improve clinical outcomes by promoting continuity in care, decreasing time to virologic suppression, and increasing overall suppression rates [8, 9]. Other advantages include decreased size of the HIV reservoir and risk of AIDS-defining and non-AIDS-defining conditions [10, 11]. Additionally, utilizing ART for treatment as prevention decreases HIV community viral load, thus reducing HIV transmission [12–14].

Given this growing evidence of the utility of early ART initiation, guidelines have included recommendations for shortening the time between initial HIV diagnosis and ART initiation [15]. Through its comprehensive care services, the RW program offers resources that rapidly link patients to care following HIV diagnosis, potentially minimizing the time between initial diagnosis and ART initiation [16, 17]. In addition to efforts to shorten times between diagnosis and ART initiation, the HRSA has encouraged efforts to promote rapid ART start, citing models similar to those in San Francisco and Atlanta that aim to initiate ART on the same day as the first PC visit or within days of diagnosis [8, 18, 19]. However, there is a lack of data presenting the impact of traditional RW-supported services on steps of the HIV care continuum, particularly on patients with newly diagnosed HIV. This study evaluates longitudinal data of people with recent HIV diagnoses from 4 RW-funded clinics in New Haven, Connecticut, to examine the trends in patient outcomes and the factors associated with linkage to care, ART initiation, and viral suppression.

METHODS

RW-Funded Clinics in New Haven, Connecticut

New Haven County is an Eligible Metropolitan Area (EMA) that has received RW Part A funding since 1995. Since 2009, the New Haven Part A office has administered funds through the Lead Agency, a model that requires a single subrecipient (in each of 5 regions) to coordinate administration and governance of grant funds to community subcontractors. The Lead Agency in the New Haven Region is Yale University School of Medicine, which coordinates a multistakeholder group (the RW Care Continuum) that includes 4 HIV clinics, a community health care van, 2 housing agencies, an inpatient substance abuse rehabilitation agency, and other community-based AIDS service organizations that offer support services.

Study Design

This was a retrospective longitudinal study to assess outcomes along the HIV continuum of care for people who received a new diagnosis of HIV (January 1, 2009, and December 31, 2018) and who received clinical care at a participating RW-funded clinic in New Haven. Eligible participants were followed for at least 1 year following diagnosis to monitor for viral suppression and other clinical outcomes.

Eligibility Criteria

Study participants were included if they met the following criteria: (1) aged 18 years and above; (2) diagnosed with HIV between January 1, 2009, and December 31, 2018; (3) received outpatient care at any of the study sites within the New Haven RW Care Continuum group; (4) did not initiate ART during inpatient admission. A person with a new diagnosis was defined as someone with a first known recorded HIV-positive test within the medical care system.

Data Extraction

Client data were extracted from CAREWare, which is a free, scalable HRSA-supported software program for managing and monitoring HIV clinical and supportive care. Individual information about services, laboratory results, clinical finds, and demographics are collected and entered manually into CAREWare. Data extraction and manual data entry are performed on a routine basis at each agency by their respective clinic staff and are monitored for accuracy by RW-Part A-funded medical case managers and data managers. A New Haven–specific RW Quality Committee meets monthly and is a group of medical care providers and data managers from each of the RW-funded clinics. The committee follows the standards of care provided by the HRSA and conducts quality improvement projects to ensure that performance measures are being met. Data integrity is an ongoing project run by the committee, and results are reported to the Ryan White Part A Office during quarterly state-wide quality assurance meetings. Furthermore, in accordance with HRSA requirements, each clinic/agency that receives Ryan White Part A funding submits the Ryan White HIV/AIDS Program Services Report (RSR) to the Part A office. CAREWare data are stored in a remote server in Hartford, Connecticut, and are available for different clinics from the Part A Office.

Patient information extracted included demographics, HIV risk factors, mental health and substance use comorbidities, date of HIV diagnosis, date of primary care visits, date of ART initiation, viral suppression status and date first measured, and type of ART initiated. Data sources included CAREWare and the electronic medical record; all clinical sites used EPIC (Verona, WI, USA). The data were manually entered into Microsoft Excel spreadsheets.

Primary Outcome Measures

The 3 primary outcomes were time between initial HIV diagnosis and (1) first primary care visit, (2) ART initiation, and (3)

viral suppression within 1 year of diagnosis. ART initiation was defined as a patient's first documented prescription written by a medical provider at a participating clinic. Viral suppression was defined as a patient's first measured viral load of <200 copies/mL or an undetectable level.

Statistical Analysis

Demographic and clinical characteristics of eligible subjects were summarized by enrollment year using descriptive statistics. Linear regression models were fit to examine the trend for the first 2 primary outcomes. Variable selection for multivariable models was based on statistical significance from univariate analyses and clinical relevance. Due to the fact that a lot of missingness in some key outcome variables occurred in the early years, a series of sensitivity analyses was performed using a subgroup of patients from year 2014 to 2018 (Supplementary Table 1) to show the robustness of the analysis. A logistic regression model was built to study the trend of the viral suppression rate and the effects of demographic and clinical characteristics on the odds of achieving viral suppression within 1 year after HIV diagnosis. This model was applied to both complete cases and 20 multiple imputed data sets, and the pooled results from multiple imputation were presented (Supplementary Table 2). *P* values <.05 were considered statistically significant. All statistical analyses were performed using the statistical software R4.0.2 [20].

Patient Consent

This study includes only aggregate data extracted from the CAREWare database, so it did not require patients' written consent to be included in the study. CAREWare is a database that is contractually required to be used by all grantees and subgrantees in the New Haven RW Part A program, and all patients are required to sign consent for inclusion in the database as part of their routine clinical care. The information recorded for this project is considered secondary research and is coded in such a manner that the patients cannot be identified directly or through identifiers linked to the patient. As such, the Yale Human Investigations Committee did not require approval at the time that the study was originally initiated.

RESULTS

Demographic and Clinical Characteristics

Between 2009 and 2018, there were 422 patients with new HIV diagnoses; 36 patients were diagnosed or started ART as inpatients and were not eligible for the study (Table 1). Of the eligible 386 patients, the mean age at diagnosis was 37.3 years, and 74.6% were male. Blacks/African Americans and Whites accounted for 29.5% and 47.2% of patients, respectively. Among risk factors, the proportion of men having sex with men (MSM) increased longitudinally from 35.0% to 53.6%, heterosexual patients increased from 25.0% to 39.3%, and patients with injection drug use (IDU) and perinatal transmission decreased from 35.0% to 7.1%. The proportion of patients with AIDS at presentation was 29% in 2009 compared with 3.2% in 2018. During the same time frame, the median initial CD4+ cell count at the time of HIV diagnosis increased from 400 cells/mm^3 to 457 cells/mm^3. The proportion of patients who were initially prescribed single-pill (fixed-dose combination) ART increased from 35.0% to 100.0%, and the proportion of initial integrase strand transfer inhibitor (INSTI) prescriptions increased from 7.5% to 92.9%. The proportion of patients who utilized MCM services increased from 12.5% to 75.0%.

Primary Outcomes

Supplementary Figure 1 shows the algorithmic data flow of eligible patients and tracks patients for whom there were missing data for ART initiation (either due to noninitiation or not recorded) or viral suppression. Overall, of 386 eligible patients, 316 (81.9%) initiated ART; of these, viral load suppression data at 1 year were recorded in 269 (83.5%). The primary outcomes are shown in Table 2 and Figure 1. The median number of days from initial diagnosis to first PC visit decreased from 58.5 to 8.5 ($P < .001$) (Figure 1A), and time to ART initiation decreased from 155 to 9 days ($P < .001$) (Figure 1B). The median number of days between the first PC visit and ART initiation decreased from 28 to 0 days. The proportion of patients with new diagnoses that achieved viral suppression within 1 year increased from 2.5% to 85.7%. The time from initial diagnosis to viral suppression decreased from a mean of 1040 to 61 days ($P < .001$) (Figure 1C).

Analysis of Factors Associated With Primary Outcomes

Table 3 shows analysis for the first 2 primary outcomes. On univariate analysis, factors associated with time from HIV diagnosis to first PC visit and time to ART initiation included year of diagnosis (later years had shorter time to outcome) and use of MCM services (use was associated with shorter time to outcome). On multivariate analysis, factors associated with these primary outcomes included year of diagnosis (patients diagnosed with HIV in later years had significantly shortened times to both first PC visit [$P < .001$] and ART initiation [$P < .001$]). Patients with HIV risk factors other than heterosexual or MSM (such as IDU and perinatal) had significantly increased times to ART initiation ($P = .02$). Additionally, patients with higher initial CD4+ cell counts had significantly longer periods to ART initiation ($P < .001$) in both univariate and multivariate analysis. In sensitivity analyses using complete cases from 2014 to 2018 (Supplementary Table 1), the decreasing trend in both time to first PC visit and time to ART initiation remained significant. The magnitude of effect for all variables of interest remained the same, though some of them were no longer statistically significant due to the small sample size in later years. Therefore, we believe that the impact of missing data on our major conclusions is limited.

Table 1. Demographics, Presenting Clinical Characteristics, and Clinical Services of Patients Newly Diagnosed with HIV at RW-funded Clinics in the Greater New Haven Area (2009–2018)

Variable	2009 (n = 40)	2010 (n = 55)	2011 (n = 52)	2012 (n = 53)	2013 (n = 49)	2014 (n = 34)	2015 (n = 30)	2016 (n = 27)	2017 (n = 18)	2018 (n = 28)	Total (n = 386)
Demographics											
Age at diagnosis											
Mean (SD), y	41.1 (11.5)	37.0 (11.8)	37.5 (13.1)	38.3 (12.5)	36.4 (13.4)	37.9 (12.0)	37.0 (11.9)	34.8 (13.3)	31.8 (11.5)	37.8 (13.3)	37.3 (12.5)
Gender, No. (%)											
Female	9 (22.5)	15 (27.3)	14 (26.9)	20 (37.7)	7 (14.3)	8 (23.5)	8 (26.7)	3 (11.1)	2 (11.1)	8 (28.6)	94 (24.4)
Male	31 (77.5)	40 (72.7)	37 (71.2)	33 (62.3)	42 (85.7)	25 (73.5)	22 (73.3)	23 (85.2)	15 (83.3)	20 (71.4)	288 (74.6)
Other	0 (0)	0 (0)	1 (1.9)	0 (0)	0 (0)	1 (2.9)	0 (0)	1 (3.7)	1 (5.6)	0 (0)	4 (1.0)
Race/ethnicity, No. (%)											
Black	14 (35.0)	14 (25.5)	25 (48.1)	25 (47.2)	11 (22.4)	6 (17.6)	8 (26.7)	9 (33.3)	2 (11.1)	8 (28.6)	114 (29.5)
White	17 (42.5)	24 (43.6)	27 (51.9)	27 (50.9)	26 (53.1)	18 (52.9)	19 (63.3)	14 (51.9)	10 (55.6)	12 (42.9)	182 (47.2)
Other[a]	9 (22.5)	17 (30.9)	0 (0)	1 (1.9)	12 (24.5)	10 (29.4)	3 (10.0)	4 (14.8)	6 (33.3)	8 (28.6)	90 (23.3)
Risk factor, No. (%)											
Heterosexual	10 (25.0)	26 (47.3)	22 (42.3)	30 (56.6)	16 (32.7)	13 (38.2)	13 (43.3)	11 (40.7)	3 (16.7)	11 (39.3)	155 (40.2)
MSM	14 (35.0)	25 (45.5)	29 (55.8)	21 (39.6)	26 (53.1)	16 (47.1)	17 (56.7)	16 (59.3)	12 (66.7)	15 (53.6)	191 (49.5)
Other[b]	14 (35.0)	4 (7.3)	1 (1.9)	1 (1.9)	6 (12.2)	3 (8.8)	0 (0)	0 (0)	3 (16.7)	2 (7.1)	34 (8.8)
Presenting clinical characteristics											
AIDS at diagnosis, No. (%)											
Yes	9 (22.5)	13 (23.6)	20 (38.5)	13 (24.5)	10 (20.4)	10 (29.4)	6 (20.0)	8 (29.6)	6 (33.3)	1 (3.6)	96 (24.9)
No	31 (77.5)	42 (76.4)	32 (61.5)	40 (75.5)	39 (79.6)	23(67.6)[c]	24 (80.0)	19 (70.4)	12 (66.7)	27 (96.4)	289 (74.9)
Initial CD4 count											
Mean (SD)	384 (263)	435 (316)	386 (317)	364 (292)	404 (268)	342 (224)	471 (335)	399 (258)	429 (328)	433 (201)	401 (284)
Median (range)	400 [20.0–1010]	452 [10.0–1690]	290 [8.00–1160]	330 [3.00–1460]	370 [5.00–1130]	331 [7.00–860]	417 [70.0–1440]	366 [45.0–1100]	398 [8.34–1140]	457 [3.00–848]	357 [3.00–1690]
Initial viral load (10^5 copies)											
Mean (SD)	1.78 (3.60)	0.909 (1.80)	1.02 (1.65)	3.96 (14.8)	3.45 (10.1)	5.29 (17.6)	12.2 (31.4)	0.733 (1.39)	1.12 (1.92)	3.60 (12.8)	3.25 (13.0)
Median (range)	0.109 [0.000480–15.9]	0.102 [0–7.98]	0.169 [0.00105–7.36]	0.231 [0–74.2]	0.604 [0–54.5]	0.416 [0.000200–100]	0.577 [0.000200–100]	0.320 [0.000540–6.12]	0.450 [0.000200–6.45]	0.247 [0–68.1]	0.275 [0–100]
Clinical services											
Use of MCM services, No. (%)											
Yes	5 (12.5)	9 (16.4)	10 (19.2)	0 (0)	33 (67.3)	27 (79.4)	23 (76.7)	16 (59.3)	12 (66.7)	21 (75.0)	156 (40.4)
No	35 (87.5)	46 (83.6)	42 (80.8)	53 (100)	14 (28.6)	7 (20.6)	7 (23.3)	11 (40.7)	6 (33.3)	7 (25.0)	228 (59.1)
ART class, No. (%)											
INSTI	3 (7.5)	7 (12.7)	7 (13.5)	10 (18.9)	23 (46.9)	14 (41.2)	25 (83.3)	24 (88.9)	13 (72.2)	26 (92.9)	152 (39.4)
NNRTI	16 (40.0)	24 (43.6)	28 (53.8)	23 (43.4)	16 (32.7)	16 (47.1)	2 (6.7)	2 (7.4)	4 (22.2)	2 (7.1)	133 (34.5)
Other	4 (10.0)	11 (20.0)	7 (13.5)	9 (17.0)	2 (4.1)	1 (2.9)	2 (6.7)	0 (0)	1 (5.6)	0 (0)	37 (9.6)
Missing	17 (42.5)	13 (23.6)	10 (19.2)	11 (20.8)	8 (16.3)	3 (8.8)	1 (3.3)	1 (3.7)	0 (0)	0 (0)	64 (16.6)
Single-pill or multiple-pill ART prescription, No. (%)											
Multiple	9 (22.5)	19 (34.5)	14 (26.9)	18 (34.0)	6 (12.2)	3 (8.8)	4 (13.3)	3 (11.1)	3 (16.7)	0 (0)	79 (20.5)
Single	14 (35.0)	23 (41.8)	28 (53.8)	24 (45.3)	35 (71.4)	28 (82.4)	25 (83.3)	23 (85.2)	15 (83.3)	28 (100)	243 (63.0)
Missing	17 (42.5)	13 (23.6)	10 (19.2)	11 (20.8)	8 (16.3)	3 (8.8)	1 (3.3)	1 (3.7)	0 (0)	0 (0)	64 (16.6)

Abbreviations: ART, antiretroviral therapy; INSTI, integrase strand transfer inhibitor; MCM, medical case management; MSM, men who have sex with men; NNRTI, non-nucleoside reverse transcriptase inhibitor.

[a]Denotes races including Asian, Hispanic, mixed, or unspecified race.

[b]Denotes risk factors including perinatal, injection drug use, transfusion, or unspecified.

[c]One patient in the 2014 cohort did not have a documented initial CD4 count.

Table 2. Primary Outcomes of Patients Newly Diagnosed With HIV at RW-Funded Clinics in the Greater New Haven Area (2009–2018)

Variable	2009 (n = 40)	2010 (n = 55)	2011 (n = 52)	2012 (n = 53)	2013 (n = 49)	2014 (n = 34)	2015 (n = 30)	2016 (n = 27)	2017 (n = 18)	2018 (n = 28)	Total (n = 386)
Time between diagnosis and first PC visit											
Mean (SD), d	193 (285)	110 (145)	51.3 (76.4)	72.4 (160)	23.6 (30.7)	25.4 (46.6)	21.7 (39.1)	18.9 (20.4)	18.4 (29.6)	10.2 (11.7)	62.9 (138)
Median [min, max], d	58.5 [0, 1080]	28.0 [0, 448]	18.5 [0, 353]	19.0 [0, 989]	14.5 [0, 170]	11.5 [0, 206]	9.50 [0, 156]	12.0 [0, 66.0]	7.00 [0, 111]	8.50 [0, 52.0]	15.0 [0, 1080]
Missing, No. (%)	0 (0)	0 (0)	0 (0)	0 (0)	5 (10.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (1.3)
Time between diagnosis and ART initiation											
Mean (SD), d	391 (592)	288 (428)	219 (368)	381 (587)	105 (223)	98.1 (193)	42.8 (53.2)	33.7 (24.2)	33.4 (36.4)	12.5 (12.0)	179 (373)
Median [min, max], d	155 [20.0, 2720]	123 [7.00, 2440]	76.5 [1.00, 1950]	92.5 [0, 2010]	36.0 [3.00, 1050]	23.0 [0, 827]	21.0 [0, 207]	26.0 [6.00, 92.0]	21.5 [0, 135]	9.00 [0, 54.0]	46.0 [0, 2720]
Missing, No. (%)	17 (42.5)	13 (23.6)	10 (19.2)	11 (20.8)	10 (20.4)	2 (5.9)	1 (3.3)	2 (7.4)	0 (0)	4 (14.3)	70 (18.1)
Time between first PC visit and ART initiation											
Mean (SD), d	194 (524)	184 (425)	172 (341)	320 (523)	69.0 (189)	72.3 (191)	20.3 (36.2)	13.6 (15.7)	15.1 (19.7)	2.83 (7.04)	125 (337)
Median [min, max], d	28.0 [0, 2490]	38.5 [0, 2440]	40.0 [0, 1670]	34.0 [0, 1710]	14.0 [0, 1050]	10.5 [0, 801]	13.0 [0, 189]	9.00 [0, 72.0]	8.50 [0, 72.0]	0 [0, 32.0]	16.0 [0, 2490]
Missing, No. (%)	17 (42.5)	13 (23.6)	10 (19.2)	11 (20.8)	15 (30.6)	2 (5.9)	1 (3.3)	2 (7.4)	0 (0)	4 (14.3)	75 (19.4)
Achievement of viral suppression, No. (%)											
No	16 (40.0)	23 (41.8)	26 (50.0)	21 (39.6)	7 (14.3)	1 (2.9)	2 (6.7)	0 (0)	1 (5.6)	0 (0)	97 (25.1)
Yes, within 1 y of HIV diagnosis	1 (2.5)	9 (16.4)	12 (23.1)	20 (37.7)	20 (40.8)	29 (85.3)	22 (73.3)	19 (70.4)	16 (88.9)	24 (85.7)	172 (44.6)
No HIV viral load data recorded	23 (57.5)	23 (41.8)	14 (26.9)	12 (22.6)	22 (44.9)	4 (11.8)	6 (20.0)	8 (29.6)	1 (5.6)	4 (14.3)	117 (30.3)

Abbreviations: ART, antiretroviral therapy; PC, primary care; RW, Ryan White.

Figure 1. A, Average number of days between initial HIV diagnosis and first PC visit by enrollment year (year of initial HIV diagnosis) on a log10 scale. B, Average number of days between initial HIV diagnosis and ART initiation by enrollment year (year of initial HIV diagnosis) on a log10 scale. C, Average number of days from HIV diagnosis to HIV viral suppression by enrollment year (year of initial HIV diagnosis). Abbreviations: ART, antiretroviral therapy; PC, primary care.

Table 4 shows analysis for time from HIV diagnosis to viral suppression. On univariate analysis, year of diagnosis, race (other vs White), time from diagnosis to ART initiation, and time to first PC visit were significantly associated with viral suppression within 1 year of diagnosis. Compared with INSTI-containing regimens, patients initiated on

Table 3. Univariate and Multivariate Analysis of Linear Regression Model for Time From Initial HIV Diagnosis to First PC Visit and ART Initiation

	Univariate Analysis						Multivariate Analysis					
	Time to First PC Visit, d			Time to ART Initiation, d			Time to First PC Visit,[a] d			Time to ART Initiation,[b] d		
Variable	Estimate	Standard Error	*P* Value	Estimate	Standard Error	*P* Value	Estimate	Standard Error	*P* Value	Estimate	Standard Error	*P* Value
Year of diagnosis												
Year of diagnosis	−17	2.5	<.**001**	−44	7.6	<.**001**	−13	2.4	<.**001**	−39.39	8.55	<.**001**
Gender (R: female)												
Male vs female	−13	17	.43	−41	50	.41						
Other vs female	−61	71	.39	−190	190	.32						
Age at diagnosis												
Age at diagnosis	0.1	0.57	.86	−1.7	1.7	.33				−3.27	1.77	.07
Race (R: White)												
Black vs White	−4.4	16	.78	−2.8	47	.95				−29.32	45.92	.52
Other vs White	36	21	.08	−52	62	.4				−71.47	59.12	.23
AIDS at diagnosis (R: no)												
Yes vs no	−9.7	16	.55	−81	48	.092						
HIV risk factor (R: heterosexual)												
MSM vs heterosexual	−7.4	15	.62	−40	44	.36	9.8	12	.42	−77.33	44.04	.08
Other vs heterosexual	73	26	.**0054**	240	87	.**0056**	16	22	.45	202.67	83.23	.**02**
Initial CD4+, cells/mm^3												
Initial CD4+ count	0.007	0.021	.74	0.3	0.073	<.**001**	0.006	0.02	.77	0.34	0.07	<.**001**
Use of medical case management services (R: no)												
Yes vs no	−59	14	<.**001**	−150	41	<.**001**	−7.9	13	.55	−32.29	45.79	.48

Abbreviations: ART, antiretroviral therapy; MSM, men who have sex with men; PC, primary care.

[a]Analysis using complete observations (n = 351).

[b]Analysis using complete observations (n = 308).

non-nucleoside reverse transcriptase inhibitors (odds ratio [OR], 0.21; 95% CI, 0.11–0.38; $P < .001$) and other regimens (OR, 0.22; 95% CI, 0.08–0.55; $P = .0012$) had lower odds of viral suppression within 1 year of diagnosis. Patients on a single-pill regimen were more likely to achieve viral suppression than those on a multiple-pill regimen (OR, 2.4; 95% CI, 1.31–4.48; $P = .0048$). Receipt of MCM services was significantly associated with achievement of viral suppression (OR, 2.4; 95% CI, 4.06–13.46; $P < .001$).

In the multivariate analysis, year of diagnosis and time from diagnosis to ART initiation were the only 2 factors that remained significant. Patients diagnosed in later years were more likely to reach viral suppression (OR, 2.04; 95% CI, 1.59–2.73; $P < .001$), and increased time from diagnosis to ART initiation was negatively associated with viral suppression (OR, 0.999; 95% CI, 0.997–1.000; $P = .01$). To address the missingness in covariates, we utilized a 20-fold multiple imputation. The pooled regression results in Supplementary Table 2 were very close to the analysis based on the complete cases (Table 4).

DISCUSSION

Within RW-funded programs in New Haven, Connecticut, a longitudinal analysis of people newly diagnosed with HIV infection between 2009 and 2018 showed dramatic improvements in clinical outcomes critical to the HIV Care continuum, notably demonstrating an increase in the proportion of people who achieved viral suppression within 1 year of diagnosis from 2.5% to 85.7%. This compares favorably with national estimates that show that about 85% of people newly diagnosed with HIV have achieved viral suppression (but not necessarily within 1 year of diagnosis) [21]. Further, it compares favorably with a similar study in 2015 conducted in New York City's Ryan White Part A HIV Care Coordination Program that identified HIV viral suppression among 66.2% of people newly diagnosed with HIV [22].

Improvements in patient achievement of viral suppression may be attributed to significant process improvements among RW-funded clinics that accelerated the care continuum. Such improvements were initiated by the Lead Agency model in New Haven; all funded organizations met monthly to discuss and optimize interventions. Such interventions throughout the study period included a monthly subcommittee meeting with medical case managers to improve linkage to care, a quality improvement effort to prioritize appointments within 48 hours after referral for people newly diagnosed with HIV, and Early Intervention Services, which began in 2011 and used unique points of access such as a community health care van to rapidly link individuals into care. Median initial CD4+ cell counts

Table 4. Univariate and Multivariate Analysis of Logistic Regression Model for Odds of Achieving Viral Suppression Within 1 Year of Diagnosis[a]

	Univariate Analysis			Multivariate Analysis		
Variable	OR	95% CI	*P* Value	OR	95% CI	*P* Value*
Year of diagnosis						
Year of diagnosis	2.3	1.92–3.0	<.**001**	2.04	1.59–2.73	<.**001**
Gender (R: female)						
Male vs female	0.99	0.54–1.79	.98			
Other vs female	1.7	−1.6–3.6	.66			
Age at diagnosis						
Age at diagnosis	0.99	0.97–1.01	.43			
Race (R: White)						
Black vs White	1.11	0.64–1.91	.72			
Other** vs White	2.12	0.98–4.87	.**06**			
AIDS at diagnosis (R: no)						
Yes vs no	0.76	0.44–1.34	.34			
HIV risk factor (R: heterosexual)						
MSM vs heterosexual	1.1	0.66–1.90	.67			
Other*** vs heterosexual	0.66	0.22–1.88	.43			
Initial CD4+, cells/mm^3						
Initial CD4+ Count	1	1.00–1.00	.60			
Use of medical case management services (R: no)						
Yes vs no	7.4	4.06–13.46	<.**001**	1.73	0.70–4.23	.23
Single or multiple pill initiated (R: multiple)						
Single vs multiple	2.4	1.31–4.48	.**0048**	1.26	0.35–4.61	.73
ART class (R: INSTI)						
NNRTI vs INSTI	0.21	0.11–0.38	<.**001**	0.96	0.31–2.94	.95
Other vs INSTI	0.22	0.08–0.55	.**0012**	1.63	0.4–6.77	.49
Time from diagnosis to ART initiation, mo						
Duration	0.92	0.89–0.95	<.**001**	0.96	0.92–0.99	.**02**
Time from diagnosis to first PC visit, mo						
Duration	0.75	0.65–0.86	<.**001**	0.96	0.83–1.12	.60

Abbreviations: ART, antiretroviral therapy; INSTI, integrase strand transfer inhibitor; MSM, men who have sex with men; NNRTI, non-nucleoside reverse transcriptase inhibitor; OR, odds ratio; PC, primary care.

Bolded *P*-values are considered statistically significant (<0.05).

**P* values from type III test.

***Denotes races including Asian, Hispanic, mixed, or unspecified race.

****Denotes risk factors including perinatal, injection drug use, transfusion, or unspecified.

[a]Analysis using complete observations (n = 254).

increased over the study period, suggesting implementation of earlier HIV testing. Following initial HIV diagnosis, there were longitudinal improvements in earlier linkage to PC visits, with individuals diagnosed in 2018 being linked into PC at a median of 8.5 days since initial HIV diagnosis. Shortened time between HIV diagnosis and PC visit was also found to be significantly associated with improved odds of achieving viral suppression within 1 year of diagnosis. Time from diagnosis to ART initiation significantly improved between 2009 and 2018, with a median of 9 days among patients diagnosed with HIV in 2018. Earlier ART initiation was also significantly associated with increased odds of achieving viral suppression within 1 year of diagnosis and by 2018. However, further data are needed to investigate the impact of the acceleration of ART initiation on long-term retention in care and durability of viral suppression.

In addition to improvements among steps of the HIV care continuum, improved viral suppression rates may also be attributed to changing national guidelines, which have evolved to include a universal ART treatment recommendation for patients regardless of CD4+ cell count in 2012 and recommendations for earlier ART initiation after HIV diagnosis. Additionally, therapeutic options have improved; since 2009, the number of conveniently formulated and highly effective ART options has increased [23]. The convenience of a single pill promotes adherence to ART; within our study population, by 2018, all patients who were newly diagnosed with HIV were prescribed a single-pill regimen. Further, a single-pill regimen was significantly associated with higher odds of viral suppression within 1 year of HIV diagnosis compared with a multiple-pill regimen. The increased adoption of INSTI-containing regimens is in line with national guidelines and may have also played a role in improved viral suppression rates because INSTIs are generally better tolerated, have a favorable resistance profile, and show more rapid decline in viral load [24, 25]. The proportion of patients included in our study who were initiated on an INSTI-containing regimen following diagnosis increased between 2009 and 2018, with 92.9% initiated on such regimens in 2018. Initiation of an INSTI-containing regimen was also significantly associated with increased odds of achieving viral suppression within 1 year, compared with non-nucleoside reverse transcriptase inhibitor and protease inhibitor regimens.

Given its comprehensive and multidisciplinary care model, the RW program offers multifaceted services that serve as the implementation arm for new guidelines and technologies and has been linked to improved clinical outcomes [26, 27]. Specifically, MCM and its impact on care coordination have been shown in other studies to be linked to more rapid improvements in HIV clinical outcomes including HIV viral loads [28]. In this study, use of MCM services was similarly correlated with increased odds of achievement of viral suppression within 1 year of diagnosis (univariate analysis). Such care coordination, as well as resources dedicated to other supportive services within the RW program (eg, substance use and mental health counseling, access to medications, provision of medical transportation, housing, food), provides the potential for implementation of a Rapid ART Start model without a complete program restructure. Current dedicated Rapid ART Start models aim to initiate ART on the same day as HIV diagnosis and have been shown to significantly improve rates of viral suppression among people with new HIV diagnoses [8, 29–32]. Some of these programs (outside of RW programs) require resource-intensive implementation. It is also possible that our particular Ryan White system of care coordination using a Lead Agency (Yale School of Medicine) that partners with community clinics and other

organizations may have facilitated interagency referrals due to streamlined and efficient working relationships among multiple stakeholders.

This study had several limitations. Data were extracted from CAREWare, a database requiring manual data entry, and the electronic medical record EPIC, presenting the possibility of errors or missing data. Missing data were frequent, especially in earlier years, given that EPIC was rolled out in the Ryan White Care system in 2013. However, a sensitivity analysis and multiple imputations were conducted to confirm the robustness of the analyses. Additionally, CAREWare data may not account for transitions in care or relocations outside of the RW-funded clinics, which previous studies have shown to be common among PWH [33]. This may have affected our estimates of time to PC visit or ART initiation, as well as viral suppression, if data were captured elsewhere. Additionally, initiation of ART data was based on prescription date and may not reflect actual filling of prescriptions.

CONCLUSIONS

Between 2009 and 2018, we observed longitudinal improvements along the HIV cascade of care, such as decreased time to primary care visit, ART initiation, and viral suppression, among patients newly diagnosed with HIV receiving care within a network of RW-funded clinics in New Haven, Connecticut. Longitudinal changes in therapeutic options (including INSTI and single-pill regimens), as well as in ART initiation guidelines, have contributed to the successful achievement of HIV viral suppression. Additionally, the RW program serves as the necessary implementation arm by providing comprehensive care services, including MCM, which coordinates care for all patients but particularly during the vulnerable time period immediately following initial HIV diagnosis. The existing infrastructure within the RW program can be further adapted to accelerate rapid ART after initial diagnosis.

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