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ORIGINAL PAPER

The Impact of COVID-19 on HIV Care in Rio de Janeiro, Brazil 2019–2021: Disparities by Age and Gender

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Abstract
We evaluated COVID-19's impact on HIV care indicators among INI/FIOCRUZ's HIV Clinical Cohort in Rio de Janeiro, Brazil: (1) Adequate care visits: two visits ≥ 90 days apart; (2) Adequate viral load monitoring: ≥ 2 viral load results ≥ 90 days apart; (3) Consistent viral suppression: all viral loads < 40 copies/mL; and (4) ART medication possession ratio (MPR) ≥ 95%. Chi-square tests compared the fraction of participants meeting each indicator per period: pre-pandemic (3/1/2019–2/29/2020) and post-pandemic (3/1/2020–2/28/2021). Logistic regression models were used to assess disparities in adequate care visits. Among 906 participants, care visits and viral load monitoring decreased pre-pandemic to post-pandemic: 77.0–55.1% and 36.6–11.6% (both $p < 0.001$), respectively. The optimal MPR rate improved from 25.5 to 40.0% ($p < 0.001$). Post-pandemic period (aOR 0.33, CI 0.28–0.40), transgender women (aOR 0.34, CI 0.22–0.53), and those aged 18–24 years (aOR 0.67, CI 0.45–0.97) had lower odds of adequate care visits. COVID-19 disrupted care access disproportionately for transgender women and younger participants.

Keywords COVID-19 · HIV care continuum · Brazil · Health disparities

Introduction

The HIV care continuum, which constitutes HIV diagnosis, linkage to care, retention in care, use of antiretroviral therapy (ART), and virologic suppression, is an important tool to identify gaps in access to care and treatment for people living with HIV (PLWH) [1]. Longstanding socioeconomic inequalities have shaped disparities in the HIV care continuum endpoints in Brazil. For example, transgender women (TGW) have been shown to bear the greatest burden of HIV in Brazil, with not only a higher prevalence of HIV but also worse linkage to care (i.e., ART prescription) and retention in care [2–4]. A 2016 study of sociodemographic factors associated with gaps in the HIV care continuum in Brazil found that non-white individuals and those of lower educational attainment, black/indigenous, or brown race/skin color had worse access to HIV testing, ART treatment initiation and virologic suppression; younger age was strongly associated with lack of ART use and virologic suppression [5]. Furthermore, a 2018 study of HIV care in Rio Grande do Sul, Brazil found that younger, non-white, and lower educated individuals had the greatest attrition rates and that, while cisgender women were more likely to achieve viral suppression, they were less likely to be retained in care [6].

With approximately 34.8 million COVID-19 cases and 688,000 deaths as of November 4, 2022 [7], Brazil experienced severe sociopolitical and economic disruptions that threatened access to the continuum of care for PLWH. Furthermore, studies have found that the COVID-19 pandemic has disproportionately adversely impacted socioeconomically marginalized populations (those experiencing housing instability, unemployment, and lower income) and also

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racial, gender, and sexual minorities, further widening existing health and socioeconomic disparities [8, 9]. For instance, overall COVID-19 mortality was significantly higher among black and those with lower educational attainment among a São Paulo cohort of PLWH [10]. Additionally, more socially marginalized individuals were more susceptible to COVID-19 related interruptions to HIV care, such as social distancing capabilities, transportation issues, and financial constraints [11]. Thus, many of the same socially vulnerable groups—lower educated and *pardo* (mixed) or black individuals—who experience worse outcomes for HIV may have been additionally burdened with the simultaneous increased risk of mortality from COVID-19 and COVID-19-related interrupted access to HIV care [9, 12].

In this study, we aimed to compare pre-pandemic (March 2019–February 2020) and post-pandemic era (March 2020–February 2021) HIV care continuum indicators to evaluate COVID-19's impact on access to HIV care. Furthermore, we described disparities in HIV care indicators by gender and sexual orientation, and by race. Finally, we evaluated whether period and gender and sexual orientation were jointly predictive of disparities in HIV care visits.

Methods

Study Population and Setting

We conducted a longitudinal study using data from the HIV Clinical Cohort of PLWH cared for at the Instituto Nacional de Infectologia Evandro Chagas (INI) of Fundação Oswaldo Cruz (FIOCRUZ) in Rio de Janeiro, Brazil. The HIV Clinical Cohort was established in 1986 with a longitudinal clinical database that has been regularly updated with inpatient, outpatient, and laboratory data since 1998. Cohort procedures have been previously described and published [13].

PLWH equal to or greater than 18 years old who initiated ART at INI between January 1, 2015, and February 28, 2019, with at least one subsequent ART prescription pickup, were eligible for analysis. This time period was chosen so that, firstly, most participants would be on a standardized regimen of tenofovir/lamivudine + dolutegravir (TDF/3TC + DTG), given that the Brazilian Ministry of Health standardized antiretroviral first-line regimens in 2017 [14]. Secondly, the enrollment period ensures that participants would have at least 12 months of follow-up before the start of the pandemic. Eligibility criteria were also restricted to those who were alive as of May 31st of each respective study year to meet standards of care in each study period. Follow-up data was available through November 2021. The pre-pandemic period was defined as March 1, 2019–February 29, 2020. The post-pandemic period was defined as March 1, 2020–February 28, 2021.

Variables of Interest

Outcomes: HIV Care Indicators

(1) HIV care visits: adequate care visits were defined according to the Brazilian Ministry of Health recommendations for at least two ambulatory care visits at least 90 days apart every 12 months [14].
(2) Viral load monitoring: adequate viral load monitoring was defined as having two plasma viral load tests at least 90 days apart in 12 months, consistent with the Brazilian Ministry of Health's recommendation for at least two CD4 or viral load monitoring tests at least once every 6 months for those stable on ART [14].
(3) Viral suppression: among participants undergoing viral load monitoring, viral suppression was defined as having an undetectable viral load. Consistent viral suppression was considered as having an undetectable viral load on all viral load tests. Viral load testing was performed with the Abbott *RealTime* HIV-1 test (Abbott Molecular Inc., Des Plaines, IL) with a lower limit of detectability of 40 copies/mL.
(4) Medication possession ratio (MPR): pharmacy prescription pickup data was obtained from INI's pharmacy records. ART MPR was calculated as the total days-supply of ART dispensed per 365 days. The total days-supply for each period was calculated as the sum of the number of pills dispensed for each prescription divided by the number of pills taken per day. Given that most of the study participants (98.6% pre-pandemic; 97.2% post-pandemic) were on a lamivudine-containing regimen, lamivudine was used to calculate days-supply. For those not on lamivudine, dolutegravir (n = 11 pre-pandemic, n = 18 post-pandemic) or ritonavir (n = 0 pre-pandemic, n = 2 post-pandemic) was used to calculate MPR. MPR was then stratified: 0, 1–49, 50–79, 80–89, 90–94, ≥ 95% [15, 16]. Optimal MPR was defined as an MPR ≥ 95% and would indicate that a participant would have adequate number of ART pills to take all pills necessary during the respective study period [15–17]. Those without any ART pickups during a period were considered to have an MPR of zero.

Exposures of Interest

Gender and Sexual Orientation Sex assigned at birth, self-reported gender identity, and sexual orientation were used to group participants by gender and sexual orientation: cisgender women (CisW), cisgender men who have sex with men (CisMSM), cisgender men who have sex with women

(CisMSW), cisgender men of unknown sexual orientation (CisMSU), and transgender women (TGW).

Race/Skin Color Race/skin color was self-reported at enrollment according to the Brazilian Institute of Geography and Statistics' racial categories of white, *pardo*, black, Indigenous, or Asian [18].

Other Exposure Variables

Age at start of the pre-pandemic year was calculated by subtracting the participant's date of birth from the start of pre-pandemic year, and categorized into the following groups 18–24, 25–29, 30–39, and 40+ years. Educational level was classified as either 9 years or more of school (more than elementary school), 8 years or less of schooling (completed elementary school or less), or unknown. ART duration from the start of the pre-pandemic year was calculated according to ART start date and classified as: less than or equal to 12 months on ART, or greater than 12 months on ART.

Statistical Methods

Study population characteristics are described as medians [and interquartile range (IQR)] or as absolute frequencies (and percentages) for continuous and categorical variables, respectively.

The percentages of participants meeting the definition of each care indicator were calculated for pre- and post-pandemic periods. We also estimated the percentages of participants meeting the definition of each care indicator by gender and sexual orientation, and by race in pre- and post-pandemic periods. These estimates were compared using paired t-tests for continuous outcomes and chi-square tests for categorical outcomes, assuming a significance of $p < 0.05$.

Finally, unadjusted and adjusted logistic regression models with generalized estimating equations (GEE, which accounts for repeated observations for the same participant, i.e. pre and post-pandemic measures) were used to quantify the association of factors with the outcome "having adequate care visits" (1 = yes, 0 = no) [19]. We aimed to quantify the association of gender and sexual orientation with the outcome "adequate care visits" while adjusting for period (pre- and post-pandemic) and other covariates (age, race, education level, and ART duration). Participants of Asian (n = 7) and Indigenous (n = 3) race as well as those with missing information on race (n = 19) and educational level (n = 12) were excluded from the regression models, given the small numbers involved and thus our inability to adequately speak of the groups. Data analysis was performed using R software (R version 4.1.1) [20].

Ethical Approval

Written informed consent for enrolment in the cohort was obtained from all patients at the initial visit. Retrospective analysis of previously collected data delinked from personal identifying information was considered exempt from review by the University of California Los Angeles IRB.

Results

There were 906 PLWH included in the analysis in the pre-pandemic period and 904 PLWH in the post-pandemic period (Supplementary Fig. 1).

The median age at the start of the pre-pandemic year was 32 years (IQR 27–40) (Table 1). Most participants were *pardo* (44.0%), compared to 27.9% white, 24.8% black, 0.8% Asian, and 0.3% Indigenous. Most participants were CisMSM (48.3%), while 16.8% were CisMSW, 15.7% were CisW, 15.5% were TGW and 3.8% were CisMSU. The majority had greater than 9 years of school (61.6%), while 37.1% had less than 8 years of school. Median ART duration by the start of the pre-pandemic year was 35 months (IQR 24–49).

Pre-pandemic to post-pandemic year, the median number of care visits decreased from 5 (IQR 2–8) to 3 (IQR 1–5; $p < 0.001$) as the percentage of participants with at least one care visit decreased from 86.4 to 80.1% ($p < 0.001$) and adequate care visits decreased from 77.0 to 55.1% ($p < 0.001$) (Table 2). Similarly, the median number of viral load monitoring was 1 (IQR 0–2) pre-pandemic compared to 0 (IQR 0,1; $p < 0.001$) post-pandemic. Pre-pandemic, 73.6% of the participants had at least one viral load monitoring, and 36.6% had adequate viral load monitoring compared to only 37.9% ($p < 0.001$) and 11.6% ($p < 0.001$) in the post-pandemic period, respectively. Of those with at least one viral load monitoring event (n = 667 pre-pandemic; n = 343 post-pandemic), there were no statistically significant changes in consistent viral suppression pre- to post-pandemic (81.0% and 85.7%, respectively). The majority never had a viral load over 1000 copies/mL pre-pandemic (90.4%) or post-pandemic (91.5%) periods. Most participants with viral load monitoring in pre-pandemic (89.2%) and post-pandemic (88.3%) years achieved or maintained viral suppression at their last viral load test during each period. Of the 906 and 904 participants included in the pre- and post-pandemic periods, 760 (83.9%) and 715 (79.1%) had at least one ART pharmacy pickup, respectively. The median number of ART pharmacy pickups was 6 (IQR 3–8) pre-pandemic and 5 (IQR 2–6; $p < 0.001$) post-pandemic. Pre-pandemic, the median MPR was 80% (IQR 30–100%) and 25.5% had optimal MPR. The median post-pandemic MPR was 90%

Table 1 Sociodemographic and clinical characteristics of a cohort of PLWH in Rio de Janeiro, Brazil, 2019–2021

	Total 906
Age at start of pre-pandemic year (years)	
Median (IQR)	32 (27,40)
Age at start of pre-pandemic year by category	
18–24	132 (14.6)
25–29	219 (24.2)
30–39	310 (34.2)
40+	245 (27)
Race/skin color	
White	253 (27.9)
Pardo (mixed)	399 (44)
Black	225 (24.8)
Asian	7 (0.8)
Indigenous	3 (0.3)
Unknown	19 (2.1)
Gender and sexual orientation	
Cisgender heterosexual women (CisW)	142 (15.7)
Cisgender men who have sex with men (CisMSM)	438 (48.3)
Cisgender men who have sex with women (CisMSW)	152 (16.8)
Cisgender men of unknown sexual behavior (CisMSU)	34 (3.8)
Transgender women (TGW)	140 (15.5)
Education	
9 or more years of school	558 (61.6)
8 or less years of school	336 (37.1)
Unknown	12 (1.3)
ART duration at start of pre-pandemic year (months)	
Median (IQR)	35 (24,49)
ART duration at start of pre-pandemic year by category (months)	
Less than or equal to 12 months	238 (26.3)
Greater than 12 months	668 (73.7)

IQR interquartile range, *ART* antiretroviral therapy

(IQR 20–100%; $p < 0.001$) and 40.0% had optimal MPR ($p < 0.001$).

Comparing indicators among categories of gender and sexual orientation, TGW consistently had worse levels of care visits, viral load monitoring and MPR both pre-pandemic and post-pandemic (Fig. 1). The proportion of adequate care visits decreased from 60.7 to 35.7% ($p < 0.001$) for TGW, 79.2 to 57.1% ($p < 0.001$) for CisMSM, 80.3 to 62.5% ($p < 0.001$) for CisMSW, and 85.9 to 60.3% ($p < 0.001$) for CisW; the change in adequate care visits from 64.7 to 54.5% for CisMSU was not significant ($p = 0.397$). Adequate viral load monitoring significantly decreased among all gender and sexual orientation groups: 28.6–5.0% ($p < 0.001$) for TGW, 37.4–12.1% ($p < 0.001$) among CisMSM, 37.5–15.8% ($p < 0.001$) for CisMSW, 39.4–11.3% ($p < 0.001$) among CisW, and 44.1–15.2% ($p = 0.010$) among CisMSU. While CisW had the lowest proportion of consistent viral suppression pre- (74.1%) and post-pandemic (76.8%, $p = 0.705$), the change in consistent viral suppression was only significant among CisMSW (pre-viral suppression: 78.6%, post-viral suppression: 83.3%, $p = 0.04$). Optimal MPR significantly increased among all groups except CisMSU (26.5% vs. 36.4%, $p = 0.383$): TGW (11.4% vs. 21.4%, $p = 0.024$), CisW (23.9% vs. 36.9%, $p = 0.018$), CisMSM (28.3% vs. 45.9%, $p < 0.001$), and CisMSW (31.6% vs. 44.1%, $p = 0.025$).

When comparing indicators by race/skin color groups, there was no observed statistical difference between racial groups within pre- or post-pandemic periods (Supplementary Tables 3, 4). Proportion of adequate care visits among white, *pardo*, and black participants were 75.9%, 78.2%, and 78.7% pre-pandemic compared to 53.8% ($p < 0.001$), 55.8% ($p < 0.001$), and 55.8% ($p < 0.001$) post-pandemic, respectively (Fig. 2). For adequate viral load monitoring, there was a decrease from 36.0 to 11.9% ($p < 0.001$) among whites, 38.6 to 10.8% ($p < 0.001$) among *pardo*, and 33.8 to 12.5% ($p < 0.001$) among blacks. Of those with viral load

Table 2 Comparing pre-pandemic and post-pandemic HIV care indicators for a cohort of PLWH in Rio de Janeiro, Brazil, 2019–1021

Care cascade indicator	Pre-pandemic year	Post-pandemic year	Stat test	p value
Number of participants	906	904		
HIV care visits	N = 906	N = 904		
Number of HIV care visits			Ranksum test	< 0.001
Median (IQR)	5 (2,8)	3 (1,5)		
Had any number of HIV care visits?			Chisq. (1 df) = 13.03	< 0.001
No	123 (13.6)	180 (19.9)		
Yes	783 (86.4)	724 (80.1)		
Had more than 1 HIV care visit?			Chisq. (1 df) = 53.79	< 0.001
No	156 (17.2)	291 (32.2)		
Yes	750 (82.8)	613 (67.8)		
Had two HIV care visits ≥ 90 days apart?			Chisq. (1 df) = 97.29	< 0.001
No	208 (23)	406 (44.9)		
Yes	698 (77)	498 (55.1)		
Viral load monitoring	N = 906	N = 904		
Number of viral load monitoring events			Ranksum test	< 0.001
Median (IQR)	1 (0,2)	0 (0,1)		
Had any viral load monitoring events?			Chisq. (1 df) = 233.54	< 0.001
No	239 (26.4)	561 (62.1)		
Yes	667 (73.6)	343 (37.9)		
Had more than 1 viral load monitoring events?			Chisq. (1 df) = 194.47	< 0.001
No	526 (58.1)	789 (87.3)		
Yes	380 (41.9)	115 (12.7)		
Had two viral load monitoring events ≥ 90 days apart?			Chisq. (1 df) = 154.79	< 0.001
No	574 (63.4)	799 (88.4)		
Yes	332 (36.6)	105 (11.6)		
Viral suppression	N = 667	N = 343		
Had the maximum viral load < 1000 copies/mL?			Chisq. (1 df) = 0.35	0.553
No	64 (9.6)	29 (8.5)		
Yes	603 (90.4)	314 (91.5)		
Had consistent viral suppression?			Chisq. (1 df) = 3.56	0.059
No	127 (19)	49 (14.3)		
Yes	540 (81)	294 (85.7)		
Had viral suppression at the last viral load monitoring event?			Chisq. (1 df) = 0.17	0.678
No	72 (10.8)	40 (11.7)		
Yes	595 (89.2)	303 (88.3)		
Medication possession ratio (MPR)	N = 906	N = 904		
Number of ART pharmacy pickups?			Ranksum test	< 0.001
Median (IQR)	6 (3,8)	5 (2,6)		
MPR			Ranksum test	< 0.001
Median (IQR)	0.8 (0.3,1)	0.9 (0.2,1)		
Categorical MPR			Chisq. (5 df) = 78.2	< 0.001
0% (had no pharmacy pick-ups)	146 (16.1)	189 (20.9)		
< 50%	157 (17.3)	104 (11.5)		
50–79%	132 (14.6)	110 (12.2)		
80–89%	102 (11.3)	44 (4.9)		
90–94%	138 (15.2)	95 (10.5)		
≥ 95%	231 (25.5)	362 (40.0)		

IQR interquartile range, *MPR* medication possession ratio, *ART* antiretroviral therapy

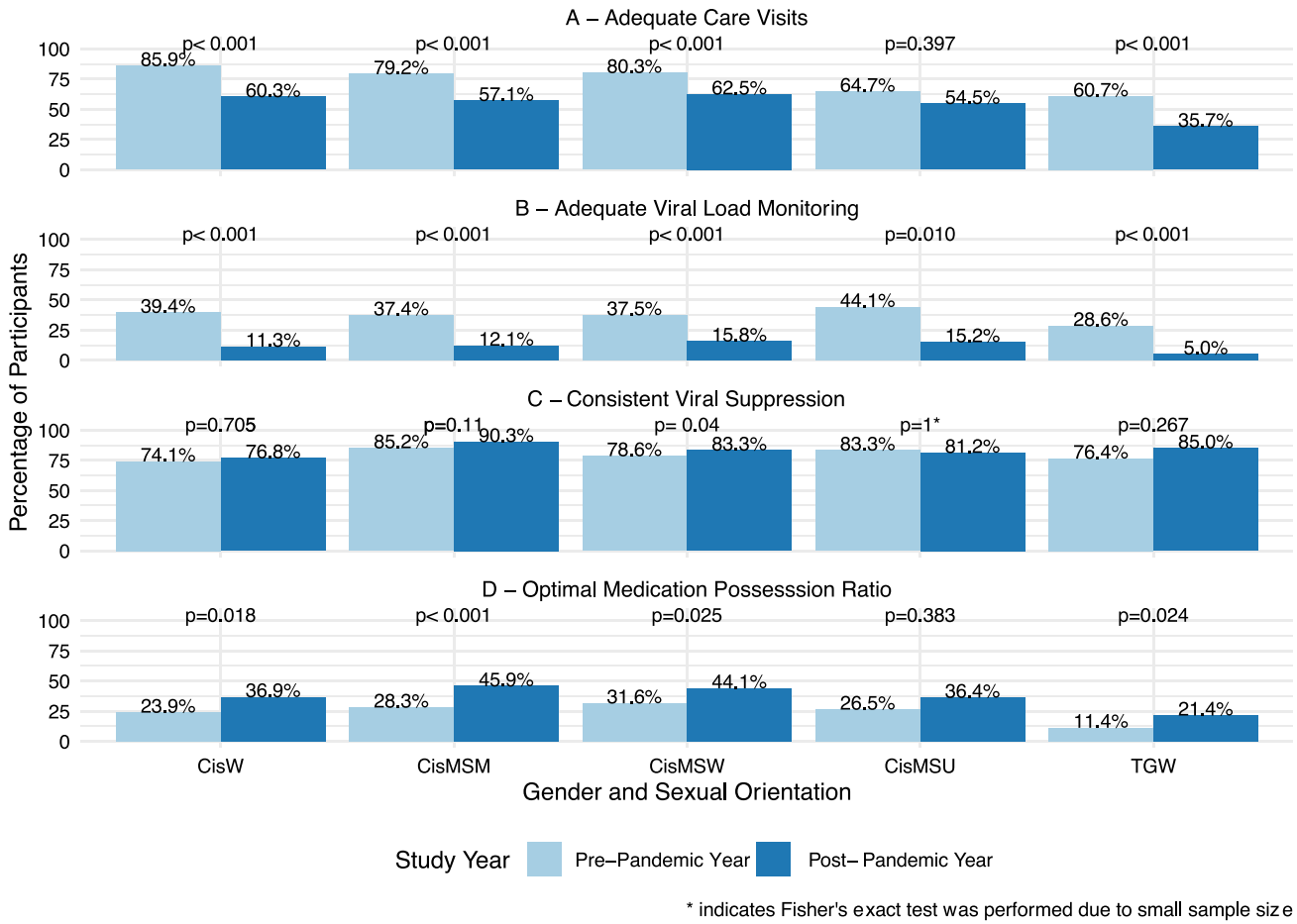

Fig. 1 Comparing HIV pre-pandemic and post-pandemic care indicators by gender and sexual orientation. *CisW* cisgender women, *CisMSM* cisgender men who have sex with men, *CisMSW* cisgender men who have sex with women, *CisMSU* cisgender men of unknown sexual partners, *TGW* transgender women

monitoring, there was no significant change in consistent viral suppression pre-pandemic to post-pandemic among any racial groups (white: pre: 81.5%, post: 87.8%, p = 0.176; *pardo*: pre: 80.7%, post: 86.1%, p = 0.169; black: pre: 83.6%, post: 83.8%, p = 0.964). Those with optimal MPR increased from 25.3 to 41.1% for whites (p < 0.001), 26.3 to 40.7% for *pardo* (p < 0.001), and 25.3 to 40.2% for blacks (p < 0.001).

Table 3 presents logistic regression models' estimated odds ratios (OR) of adequate care visits. The odds of adequate care visits were lower in the post-pandemic period [adjusted(a) OR 0.33, 95% confidence interval (CI) 0.28–0.40] relative to the pre-pandemic period. Compared to CisW, TGW (aOR 0.34, 95% CI 0.22–0.53) and CisMSU (aOR 0.49, 95% CI 0.25–0.97) had lower odds of adequate care visits, though the small number of CisMSU suggests caution when interpreting the results for this group. Compared with participants aged 30–39, younger age was also associated with decreased odds of adequate care visits among 18–24-year-olds (aOR 0.67, 95% CI 0.45–0.97). Those using ART for less than or equal to 12 months had greater odds of adequate care visits (aOR 1.52, 95% CI 1.15–2.01). Race/skin color and education level were not associated with change in odds of adequate care visits.

Discussion

In this study, we found evidence of an impact of the COVID-19 pandemic on most HIV care indicators. When comparing pre- to post-pandemic, adequate care visits and viral load monitoring decreased, while consistent viral suppression remained unchanged and optimal MPR improved. Disparities in care indicators were observed by gender and sexual orientation, with worse care indicators for TGW in both periods. In contrast, we did not observe disparities in HIV care indicators by race/skin color. Finally, results from the regression models suggested that even when evaluated jointly, both COVID-19 pandemic period and gender and

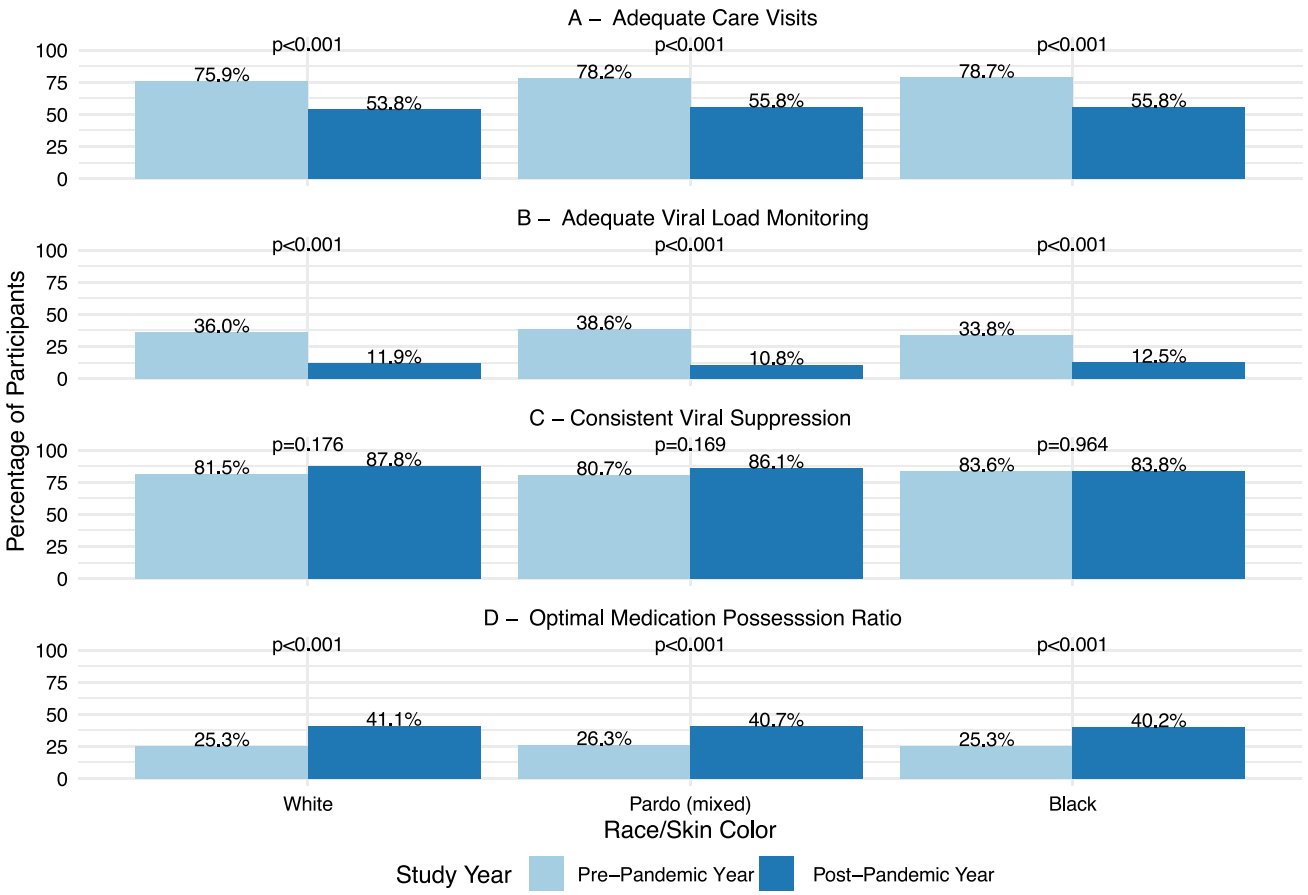

Fig. 2 Comparing HIV pre-pandemic and post-pandemic care indicators by race/skin color

sexual orientation were associated with care visits, with worse odds of adequate care visits in the post-pandemic period for TGW.

When considering our study population, we found that the COVID-19 pandemic impacted most HIV care continuum indicators. Access to in-person care events, such as care visits and viral load monitoring, was disrupted during the pandemic year across all gender and sexual orientation groups and races. Even when considering other factors in our regression models, we found lower odds of having adequate care visits in the post-pandemic year compared to the pre-pandemic year. These findings may be attributed to societal level changes such as social distancing requirements, fear of exposure to COVID-19, transportation difficulties, clinic closures, and staffing shortages. Our findings parallel results from other studies in Korea [21], Italy [22], and the United States [23] showing that the COVID-19 pandemic disrupted the HIV care continuum through decreases in clinic visits and viral load testing, and negatively affected ART use. Furthermore, a multi-continent study of the impact of COVID-19 on HIV care provisions found a reduction in the number of in-person care events and a decrease in linkage to care despite the increase in positive HIV tests [24]. A survey-based study of 773 PLWH at 6 North American cohort sites from May 2020 to February 2021 found that socioeconomic factors such as unstable housing, food insecurity, low resiliency, and disruptions to access to mental health care were associated with both missed care visits and missed ART doses during the pandemic [25]. Changes in care recommendations, as proposed by the World Health Organization (WHO), could help explain changes in care utilization. For instance, mid-pandemic WHO recommended longer dispensing of ART per pharmacy pickup and reduced frequency of viral load monitoring to every 12 months for PLWH stable on ART [26]. However, INI did not offer telemedicine visits for care visits nor change its guidelines for viral load monitoring frequency.

Our results showed that consistent viral suppression remained unchanged. The literature has demonstrated inconsistent results for maintaining viral suppression during the COVID-19 pandemic. While Norwood et al. found that the proportion of PLWH with virologic suppression decreased among a cohort in the United States as viral load monitoring decreased [23], Izzo et al. concluded that viral suppression improved during the first 3 months of the pandemic with stable viral load monitoring among 3537 patients at

Table 3 Crude and adjusted odds ratio of having adequate care visits as a function of sociodemographic and clinical factors in a cohort of PLWH in Rio de Janeiro, Brazil, 2019–2021

Predictors	Adequate care visits					
	Crude OR	CI	*p*	Adjusted OR	CI	*p*
Period						
Pre-pandemic year	Ref.					
Post-pandemic year	0.35	0.30–0.41	< 0.001	0.33	0.28–0.40	< 0.001
Age at start of pre-pandemic						
30–39	Ref.					
18–24	0.68	0.49–0.95	0.025	0.67	0.45–0.97	0.035
25–29	0.71	0.53–0.96	0.025	0.77	0.56–1.05	0.102
40+	1.05	0.78–1.42	0.731	1.01	0.73–1.41	0.929
Race/skin color						
White	Ref.					
Pardo/mixed	1.09	0.84–1.42	0.518	1.13	0.85–1.49	0.405
Black	1.13	0.84–1.52	0.432	1.16	0.83–1.60	0.385
Gender and sexual orientation						
CisW	Ref.					
CisMSM	0.76	0.54–1.08	0.127	0.77	0.52–1.13	0.176
CisMSW	0.91	0.60–1.40	0.675	0.91	0.58–1.43	0.683
CisMSU	0.53	0.28–1.00	0.049	0.49	0.25–0.97	0.039
TGW	0.33	0.22–0.49	< 0.001	0.34	0.22–0.53	< 0.001
Education level						
9 or more years of school	Ref.					
Less than 8 years of school	0.81	0.64–1.02	0.070	0.85	0.65–1.11	0.240
ART duration						
Greater than 12 months	Ref.					
Less than or equal to 12 months	1.44	1.11–1.85	0.005	1.52	1.15–2.01	0.003

OR odds ratio, *CI* 95% confidence interval, *Ref.* reference value, *CisW* cisgender women, *CisMSM* cisgender men who have sex with men, *CisMSW* cisgender men who have sex with women, *CisMSU* cisgender men of unknown sexual partners, *TGW* transgender women, *ART* antiretroviral therapy

an outpatient clinic in Italy [27]. Noteworthy, in our study, a large proportion of participants had no viral monitoring in either period, and the prevalence of viral suppression among these participants is uncertain. Therefore, the interpretation of viral suppression estimates should take into consideration the potential bias from not at random missing data.

While some studies [21, 22, 28] observed an interruption in ART supply in different countries, our study showed that the proportion of participants with any pharmacy pickups decreased from 83.9 to 79.1% but optimal MPR among those with pickups actually improved. Norwood et al. observed an increase in HIV medication refills [23]. A 2020 web-based survey of Brazilian MSM and TGW found that only 18.2% of respondents reported poor ART adherence and 17.2% reported impact of social distancing on ART refill due to fear of COVID-19 exposure, transportation difficulties, and healthcare unit closure [29]. The increase in MPR pre-to-post COVID-19 in our study was likely related to changes in guidelines for ART dispensing at INI. Starting in April 2020, these changes included an increase in the standard refill of ART from 30-days to a 3-month supply, pharmacy pickups permitted without an appointment, and regular phone calls by INI staff to check if participants had an adequate ART supply. A longer supply of ART, fewer pharmacy visits, and more convenient pharmacy pickup schedules are likely to have resulted in the improved ART adherence observed in our cohort.

Our results highlight an important disparity in HIV care for TGW. Compared to all other gender and sexual orientation groups, TGW had lower levels of adequate care visits, adequate viral load monitoring, and optimal MPR in both periods. Studies have shown that TGW have lower rates of linkage to care, ART usage, and virologic suppression and especially for TGW who are black, of lower income, or experiencing unstable housing [2, 4]. Factors associated with barriers to accessing care for TGW include transphobia, stigma, socioeconomic instability, and lack of awareness of available services [2, 30].

Moreover, TGW living with HIV have been shown to face higher rates of unemployment, income disparity, stigma, and violence [31], which the pandemic could have exacerbated. TGW reported aggravation of socioeconomic

vulnerabilities due the pandemic as compared to MSM due to the pandemic, especially in terms of food and housing insecurity as well as accessing medical care for hormone therapy, medical issues, mental health and medication refills [29]. Social isolation, fear of COVID-19 exposure, financial woes, and intimate partner violence may have worsened mental health rates among TGW thereby worsening HIV care outcomes [29, 32, 33]. Social factors, such as mental health and stigma, have also been shown to affect access to care and are associated with more missed health care visits and worse HIV outcomes [25]. Despite ongoing efforts by INI staff to overcome barriers to engagement and retention in care for TGW by using preferred names and pronouns, promoting a trans-friendly space with gender-neutral accommodations, offering trans specific transportation, providing legal assistance, and having trans staff members working in the clinic, the indicators were still worse for TGW [34]. The social, economic and psychologic impact of the COVID-19 pandemic affecting the TGW population may have further burdened access to HIV care continuum and contributed to worse outcomes for this group within our cohort.

The HIV epidemic in Brazil has disproportionately affected socioeconomically vulnerable populations, and COVID-19-related disruptions to care threatened to worsen disparities along the HIV care continuum [9, 35]. While we observed sociodemographic disparities within each period, our results showed that the pandemic affected all PLWH despite gender and sexual orientation, age, race, and education. Nonetheless, it was important to evaluate care indicators by race given Brazil's longstanding history of racial inequality, whereby race can be used as a proxy for socioeconomic status. The country's legacy of slavery has entrenched a cycle of political, economic, and discriminatory forces perpetuating sociopolitical and economic exclusion, exploitation, disinvestment, and racial stigmatization that have permeated all aspects of life [36]. These factors have contributed to socioeconomic disadvantage and worse health outcomes, including high infant and maternal mortality, low life expectancy, poor health, and social infrastructure [36]. Further, the COVID-19 pandemic has been shown to disproportionately impact racial minorities in other countries, and health care inequalities for black and *pardo* groups in Brazil have been shown typically parallel those of racial and ethnic minorities in the United States, China, and the United Kingdom [37]. For instance, a study of 101 black Americans living with HIV in California showed that those who had more negative impacts from COVID-19 demonstrated lower ART adherence [38]. A study at the Johns Hopkins HIV Clinical Cohort in Baltimore found that, among virally suppressed individuals, there was a greater delay in resuming viral load monitoring for PLWH who were black, had non-private insurance or had recent substance abuse [39]. This highlights the potential disproportionate impact of social vulnerability on disruption to HIV care continuum. Despite prior studies demonstrating racial disparities in retention in care for PLWH by race/skin color in Brazil [6], the prevalence of adequate care by each indicator were relatively equivalent among race/skin color groups in both periods in this study. However, each race/skin color group experienced significant decreases in care visits and viral load monitoring and an increase in MPR. Our results are consistent with other studies such as Norwood et al. which also did not observe a difference in COVID-19 related impact on number of medical encounters by race with a 31% decrease among whites, 31% decrease among blacks, and 23% decrease among Hispanics [23].

Of note, our cohort had a median age of 32 at the start of the pre-pandemic year, which is younger than other cohort studies estimating a median age of PLWH on ART to be 50 years-old in the US [40]. While young people represent the majority of new HIV diagnoses globally and in Brazil, improved survival for PLWH on ART has contributed to an increase in modal age of PLWH globally from 1990 to 2017 [41]. In our study, younger PLWH had lower odds of having adequate care visits. In addition, younger age has been linked to higher attrition rates [6], not being on ART and not being virologically suppressed [5]. With COVID-19 onset, younger PLWH may have been less able to adhere to social distancing requirements and more likely to need to go to work. Spinelli et al. found that retention in care improved among younger individuals (although viral suppression did not) with more telehealth visits suggesting a potential targeted intervention to improve retention in care among these individuals [42].

On the other hand, older PLWH were more at risk of COVID-19 related mortality [10] and less likely to adopt alternatives to in-person care events [43]. While the literature has suggested that those with lower education have worse health outcomes for HIV (linkage to care, ART uptake, viral suppression, retention in care, mortality [5, 6, 42, 43]) and COVID-19 (exposure and severity [44], mortality [10]), our results did not show statistically significant lower odds of adequate care visits among those with less than 8 years of schooling compared to those with 9 or more years of schooling. Finally, we found that those who were on ART for less than or equal to 12 months by the start of the pre-pandemic year had a higher odds of adequate care visits.

We found worrisome HIV care indicators in the pre-pandemic period. The ongoing economic crisis in Brazil that worsened since 2016 marked by increased unemployment, food and housing insecurity and poverty [44, 45] as well as political decisions to cut public funding for HIV/AIDS awareness, prevention and treatment [46] may have impacted the feasibility to meet adequate care standards pre-pandemic for participants in our cohort. Similarly, the prevalence of those meeting adequate care standards in our

cohort is comparable to Brazilian reports of 74% of PLWH retained in care, 69% on ART treatment, and 60% virally suppressed in 2019 [47]. Overall, this highlights the intrinsic link between HIV care continuum and socioeconomic vulnerability as the HIV care continuum is highly susceptible to rapid macro-level societal and economic changes.

Our study has several limitations. First, the Clinical Cohort at INI is a longitudinal cohort of PLWH and therefore does not collect data on HIV care continuum indicators before enrollment (i.e., percent of individuals tested; percent of individuals diagnosed and linked to care). Nonetheless, it allows for reliable estimates of endpoints after cohort enrollment, such as clinical visits, viral load monitoring, and pharmacy pickups. Second, those cared for at INI comprise a convenience sample of PLWH that may not be representative of the entire PLWH population in Rio de Janeiro or Brazil [48]. Third, for MPR calculation, we used INI's pharmacy records as the data source for pharmacy pick-ups and number of dispensed medications and it is possible that those without any pharmacy pick-ups at INI could have been picking up medication at a different pharmacy. Indeed, Brazil has a national system that registers all antiretroviral dispensations in the country (Logistics Control System for Medicines, SICLOM in Portuguese). Future studies could take advantage of this technology to conduct a study similar to ours without the limitation of changes of pick-up locations by an individual. Fourth, our calculation for MPR is limited to total days-supply over a 1-year period. This method may underestimate the calculation for those who had pharmacy pick-ups just prior to the start of each year. However, while this may underestimate the calculation for participants who died, only two died during the pre-pandemic year, and thus the impact on MPR is considered minimal. Overall, this effect on calculation for MPR is consistent between periods thereby minimizing the amount of error produced in comparison between the two periods. Fifth, it is worth mentioning that we have chosen care visits as the outcome for regression models to study the effect of pandemic on HIV care indicators because participants were less likely to have modified their place of treatment or have medical consultations elsewhere compared to other indicators such as viral load monitoring and MPR. Additionally, while Brazilian Ministry of Health recommends these studies definitions of adequate care visits and viral load monitoring for those stably on ART and almost a quarter of the study participants were on ART < 12 months by the start of the pre-pandemic year, those individuals would likely be engaging with care more frequently than the study's conservative definition of adequate HIV care.

Finally, COVID-19 infection and mitigation strategies may have influenced access to HIV care. While the rate of COVID-19 infection and hospitalization rates in our cohort is beyond the scope of this study, if a participant came to the clinic or hospital due to COVID-19 or another infectious illness, this event would have been classified equally as a care visit. As such, it is possible that cohort participants with COVID-19 would have been more likely to be classified as having adequate medical visits than the ones who did not present for COVID-19 care. However, at the beginning of the pandemic, INI and media outlets typically instructed patients with mild COVID-19 symptoms to stay at home and monitor their symptoms. So, if any, our data is more likely to include moderate to severe COVID-19 cases. On the other hand, for those who did not come to a medical visit during the pandemic, we might not have information on COVID-19 diagnosis. The potential bias introduced on number of care visits is limited by the 1-year window to achieve adequate care visits, i.e., even if a patient had had COVID-19 and skipped a scheduled medical visit, they would likely have had time to reschedule another visit.

While INI has successfully implemented telemedicine for PrEP services [49, 50], it has not been used for HIV services. According to the Brazilian Ministry of Health, telehealth was not widely utilized for HIV care in Brazil and there was no negative effect on the number of people treated for HIV in Brazil as of September 2020 [51]. Furthermore, while telemedicine provides potential to reduce barriers in access to care—including transportation costs, stigma, and convenience [52]—some of the most marginalized populations may be less likely to benefit from it. Studies from our prevention cohort at INI have shown that TGW and those of lower education have less access to good internet connection and lack adequate privacy in their homes to conduct clinical visits remotely [49, 50, 53].

Conclusions

In conclusion, COVID-19 pandemic disrupted access to HIV care for PLWH with disproportionate impact for TGW. In this way, the socioeconomic disruption affected the HIV care continuum especially for TGW and younger PLWH. This highlights the need for targeted interventions to support some of the more socially vulnerable individuals during public health emergencies to ensure continued access to HIV-related care. Following the COVID-19 pandemic disruption in HIV care, strategies to re-engage PLWH, focusing on the most impacted groups, are essential to avoid long-term negative outcomes.

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Data Availability Data was obtained from the HIV Clinical Cohort of Evandro Chagas National Institute of Infectious Diseases (INI) of the Oswaldo Cruz Foundation (FIOCRUZ) in Rio de Janeiro, Brazil. Derived data supporting the study findings are available from the corresponding author (AEB) upon request.

Declarations

Competing Interests The authors have no competing interests to declare.

Ethical Approval Retrospective analysis of previously collected data delinked from personal identifying information was considered exempt from review by the University of California Los Angeles IRB.

Informed Consent Written informed consent for enrolment in the cohort was obtained from all patients at the initial visit.

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