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Factors associated with viremia in people living with HIV on antiretroviral therapy in Guatemala

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Abstract

Introduction: Viral suppression prevents HIV transmission and disease progression, but socio-economic and clinical factors can hinder the goal of suppression. We evaluated factors associated with viral non suppression (VNS) and persistent viremia (PV) in people living with HIV (PLHIV) receiving antiretroviral therapy (ART) in Guatemala.

Methods: We conducted a cross sectional analysis using data from an ongoing cohort of PLHIV attending the largest HIV clinic in Guatemala. Univariable and multivariable analyses were conducted between PLHIV with viral suppression and detectable viremia. VNS was defined as most recent HIV RNA ≥ 200 copies/ml and PV as two consecutive HIV RNA ≥ 200 copies/ml.

Results: Of 664 participants, 13.3% had VNS and 7.1% had PV. In univariable analysis disaggregated by gender, low income, poor education, perceived difficulty attending healthcare, and alcohol use were associated with VNS in men while low CD4 at diagnosis, multiple prior ART regimens and treatment interruptions were significant in both genders. Multiple prior ART regimens (adjusted Odds Ratio (aOR) 2.82, [95% confidence interval (CI) 1.59, 4.99], $p < 0.01$), treatment interruptions (aOR 4.51, [95% CI 2.13, 9.58], $p < 0.01$), excessive alcohol consumption (aOR 2.56, [95% CI 1.18, 5.54], $p < 0.05$) perceived difficulty attending healthcare (aOR 2.07, [95% CI 1.25, 3.42], $p < 0.01$) and low CD4 at diagnosis (aOR 2.34, 95% [CI 1.30, 4.20], $p < 0.01$) were independently associated with VNS on multivariable regression.

Conclusions: We conclude that socio-economic and clinical factors influence viral suppression in our cohort and vary between men and women. Gender specific approaches are necessary to achieve the 90% suppression goal.

Keywords: HIV, Treatment outcomes, Health risk behavior, Health services accessibility, Sustained virologic suppression, Gender

Background

Over the last two decades, huge strides have been made in the control of the HIV epidemic. This is widely attributed to the global scale-up in access to antiretroviral therapy (ART). In 2013, the Joint United Nations Programme of HIV/AIDS (UNAIDS) proposed the 90–90–90 goal as a benchmark to contribute to the end of the HIV epidemic. The goal was to diagnose 90% of people living with HIV (PLHIV), provide ART for 90% of those diagnosed and achieve viral suppression in 90% of those receiving ART by 2020 [1, 2]. There has been significant progress towards this goal, mainly driven by the efforts in south and east Africa. However, entire regions

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continue to experience setbacks in the fight against HIV. Such is the case of Latin America, where no countries have reached the 90–90–90 goal, HIV new infections increased by 7% in the past eight years and only 55% of all the diagnosed PLHIV are virally suppressed [2–4].

Viral suppression plays a crucial role in limiting onward transmission of HIV. As HIV prevalence increases, viral suppression must be achieved in order to prevent new infections [5]. Several studies have pointed out that viral suppression decreases the likelihood of HIV transmission in the at-risk and general population and improves overall life quality and life expectancy [6–8]. Individuals failing to achieve viral suppression may progress to persistent viremia, which is associated with double the risk of virologic failure and with higher rates of all-cause mortality [9–11].

The main concern in Latin America is that progress, while steady, is uneven between regions [2]. In Guatemala, the country with the highest number of PLHIV in Central America, 62% of PLHIV know their HIV status, 69% of all linked to care are taking ART and 80% taking ART are virally suppressed. In total, the percentage of all PLHIV in Guatemala with viral suppression is estimated at 34% [2, 3].

Several barriers to viral suppression have been identified and include but are not limited to stigma, difficulty in accessing healthcare because of location or financial status [12, 13], alcohol and substance misuse [2], education [14], pill burden [15], and ART side effects [16]. To our knowledge, a detailed analysis on factors that influence virologic outcomes in PLHIV has not been performed in Guatemala. We aimed to identify associated factors for virologic outcomes in the treatment of PLHIV in this Central American country.

Methods

We used data from baseline interviews obtained as part of an ongoing prospective cohort study on comorbidities in PLHIV attending the Dr. Carlos Rodolfo Mejia Villatoro Infectious Diseases Clinic at Roosevelt Hospital in Guatemala City. The clinic is the largest HIV clinic in the country and provides free care for over 5000 PLHIV nationwide. PLHIV 18 years or older attending the HIV clinic are eligible for enrollment in the cohort. PLHIV were enrolled after providing verbal consent, and data was collected with in-depth interviews, clinical evaluation, and review of clinical files. The study was approved by the institutional review board of Roosevelt Hospital. The baseline interviews, containing questions on demographics, housing, medical conditions, and health risk factors, were conducted in Spanish and took place from July 2019 to February 2020. Study data were collected and managed using REDCap electronic data capture tools hosted at Washington University in Saint Louis [17].

Study design

For the current analysis we included all PLHIV enrolled in the cohort that had been prescribed at least six consecutive months of ART since their initial diagnosis and had a recent viral load. Recent viral load was defined as a HIV viral load taken within three months prior or one month following the enrollment interview for participants with clinic visits every 3-months and viral load taken six months from enrollment at most for participants with 6-months clinic visits. Viral non-suppression (VNS) was defined as a viral load $\geq$ 200 copies/ml and persistent viremia (PV) was defined as two consecutive viral loads $\geq$ 200 copies/ml.

Variable definitions

The continuous variables age, travel time and travel cost to HIV care, individual monthly income, years of education, number of prior ART regimens, CD4 count at diagnosis and days of treatment interruptions were recategorized into binary variables for analysis. Age 50 and below or over 50 years was used to compare younger and older adults, respectively, as defined by the Center for Disease Control and Prevention (CDC) [18]. Travel time to healthcare was defined as commutes within an hour and greater than an hour based on a prior study regarding accessibility in Guatemala [19]. Individual monthly income was evaluated by earning less than or equal to the "Canasta básica alimentaria" (CBA), or national food basket, which is the monthly cost to provide sufficient food for the average Guatemalan household. As of January 2020, the cost was $464 [20]. Education level was divided by PLHIV that achieved above primary education (first six years of formal education) from those with less or no formal education. Travel cost considered whether the round-trip cost to the clinic exceeded the median cost for our study population ($2.6). Multiple-daily dosing refers to more than once-daily dosing of ART. Treatment interruptions were defined as missing seven days or more of ART between changing regimens. Multiple prior ART regimens was defined as having three or more prior ART regimens.

Categorical variables were defined as follows. Excessive alcohol consumption was defined as binge drinking (four or more drinks in one occasion for women and five or more drinks for men) and heavy drinking (eight or more drinks in a week for women and 15 or more drinks in a week for men) within the past month, in accordance with the CDC definitions [21]. Access to basic utilities considered both running water and electricity in the participant's residence. Indigenous participants were

self-identified. Perceived difficulty attending healthcare was defined according to the participant's yes/no response to the question "¿Le parece difícil asistir a la clínica?" Translation: "Do you find it difficult to visit the clinic?". A follow up question gave participants the following reasons to choose from: lack of income, lack of transportation, nobody to take care of children, difficulty getting time off from work, price of transportation, or other reasons (free answer). Comorbidities were reported by participants and verified in the clinical file. Prior AIDS defining illnesses were assessed according to the CDC definitions [22].

Statistical analysis

Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) software version 23. Baseline characteristics were analyzed with respect to frequency and percentage. Normality was evaluated for all numeric variables using Shapiro Wilk test with kurtosis and skewness. Baseline characteristics were compared with the nonparametric Pearson x^2 and Fisher's exact test of independence for categorical variables and Mann–Whitney U test for continuous variables with interquartile range. Binary logistic regression was performed to explore the association between each variable and VNS and PV. Multivariable logistic regression models were fitted with variables at $p \leq 0.05$ to evaluate independent factors associated with VNS and PV.

Results

Of 929 participants enrolled in the cohort, 664 had a recent viral load and had completed at least six months of ART. The median age was 39 years [interquartile range (IQR) 32–48], 356 (53.6%) were male, 493 (74.2%) were heterosexual and 99 (14.9%) self-identified with indigenous ethnicity. Almost half of the participants (49.2%) had less than or equal to primary education and only 60 (9.0%) had a bachelor's degree or higher. A total of 441 (66.4%) participants reported being employed. Out of these, 23.7% (158) were females and 42.6% (283) were males. Five hundred sixty had no income or earned less than the CBA with 211 (31.8%) having to borrow money to cover travel costs. The main transportation used was public buses (606, 91.3%). Travel time varied greatly, but 80 (12%) participants traveled four or more hours to reach healthcare.

Comorbidities were present in 408 (61.4%) and only 21 (3.2%) participants were co-infected with hepatitis B. Median CD4 count and viral load at diagnosis were 178 cells/mm^3 (IQR 57–341) and 77,000 copies/ml (IQR 21,248–252,252) respectively. Current median CD4 count was 473 cells/mm3 (IQR 283–689). A total of 262 (39.5%) of our participants were in their first ART regimen, 402 (60.5%) had at least one prior ART regimen and 105 (15.8%) had multiple prior ART regimens. Other characteristics arranged by virologic status are presented in Table 1. VNS was present in 88 (13.3%) participants on recent HIV viral load testing. Differences between those with viral suppression and VNS are illustrated in Table 1. Of those who were not virally suppressed, 47 (7.1%) had PV.

On univariable analysis, excessive alcohol consumption, perceived difficulty attending healthcare, having no comorbidities, treatment interruptions, multiple prior ART regimens, multiple-daily dosing, low CD4 count at diagnosis, past AIDS-defining illness and sexuality were associated with VNS ($p \leq 0.05$) and were included in the multivariable analysis (Table 2). In the multivariable analysis, treatment interruptions (aOR 4.51, [95% CI 2.13, 9.58], $p < 0.01$), multiple prior ART regimens (aOR 2.82, [95% CI 1.59, 4.99], $p < 0.01$), excessive alcohol consumption (aOR 2.56, [95% CI 1.18, 5.54], $p = 0.017$), low CD4 count at diagnosis (aOR 2.34, [95% CI 1.30, 4.20], $p < 0.01$), bisexual orientation (aOR 4.04, [95% CI 1.33,12.32], $p = 0.014$), and perceived difficulty attending healthcare (aOR 2.07, [95% CI 1.25, 3.42], $p < 0.01$), were all associated with increased risk of VNS. Among those with perceived difficulty, the most commonly reported reasons for such difficulty were difficulty getting time off from work (72, 28.6%) and price of transportation (71, 27.5%) (Additional file 3: Table S3), but no association was found between specific reasons for perceived difficulty attending healthcare and VNS (Additional file 3: Table S3).

Univariable analysis disaggregated by gender (Additional file 1: Table S1 and Additional file 2: Table S2), showed that men's perceived difficulty attending healthcare was associated with VNS (aOR 3.05, [95% CI 1.66, 5.59], $p < 0.01$), but the same association was not seen in women (aOR 1.36, [95% CI 0.68,2.72], $p = 0.371$). Multiple-daily dosing (aOR 4.33, [95% CI 2.33, 8.04], $p < 0.01$), excessive alcohol consumption (aOR 2.19, [95% CI 1.02, 4.67] $p = 0.042$), income below or equal to the CBA (aOR 3.49, [95% CI 1.34,9.10], $p = 0.010$), and primary education or less (aOR 2.01, [95% CI 1.10,3.65], $p = 0.022$) were also significantly associated with VNS in men but not in women. Past AIDS defining illnesses, treatment interruptions, low CD4 count at diagnosis and having multiple prior ART regimens were still significantly associated with VNS in both genders in univariable analysis. In separate multivariable models however, only multiple prior ART regimens was significant in both men and women.

In the univariable analysis for PV as the outcome of interest, past AIDS defining illness, low CD4 count at diagnosis, treatment interruptions, multiple prior ART regimens, multiple-daily dosing, bisexual orientation,

Table 1 Characteristics of 664 virally suppressed and non-suppressed PLHIV on ART in Guatemala

Variable	Total (664)	Viral Suppression (576)	Viral Non-suppression (88)	p-value[a]
Age in years (IQR)	39 [32, 48]	40 [33, 48]	37.5 [34.5,44.5]	0.512
Male *n (%)*	356 (53.6%)	305 (53%)	51 (58%)	0.381
Sexual orientation *n (%)*	653 (98.3%)			0.016
MSM	112 (16.9%)	105 (18%)	7 (8%)	
Bisexual	48 (7.2%)	38 (7%)	10 (11%)	
Heterosexual	493 (74.2%)	425 (74%)	68 (77%)	
Non-indigenous ethnicity *n (%)*	565 (85.1%)	488 (85%)	77 (88%)	0.496
Years of education (IQR)	6 [3, 11]	7 [3, 11]	6 [4, 9]	0.164
Individual monthly income[b] (IQR)	150 [0.375]	182 [0.389]	51 [0.318]	0.058
Working status	441 (66.4%)	391 (67.0%)	50 (56.8%)	0.052
Home owner *n (%)*	422 (63.6%)	362 (63%)	60 (68%)	0.333
Lack of access to basic utilities *n (%)*	80 (12.0%)	67 (12%)	13 (15%)	0.399
Smoking *n (%)*	77 (11.6%)	60 (10%)	17 (19%)	0.015
Excessive alcohol consumption *n (%)*	65 (9.8%)	51 (9%)	14 (16%)	0.038
Prior illicit drug use *n (%)*	70 (10.5%)	57 (10%)	13 (15%)	0.165
Travel time to healthcare in minutes (IQR)	90 [60, 150]	90 [45,150]	90 [60,180]	0.395
Borrows money for transport to care *n (%)*	211 (31.8%)	180 (31%)	31 (35%)	0.455
Round-trip travel cost[b] (IQR)	2.5 [1.25, 7.5]	2.27 [1.3,6.49]	2.66 [1.04,8.04]	0.741
Perceived difficulty attending healthcare *n (%)*	258 (38.9%)	210 (37%)	48 (55%)	0.001
Participants with comorbidities *n (%)*	408 (61.4%)	363 (63%)	45 (51%)	
Dyslipidemia	298 (44.9%)	293 (44%)	5 (5%)	
Hypertension	59 (8.9%)	53 (9%)	6 (7%)	0.030
Diabetes	36 (5.4%)	32 (5.6%)	4 (4.5%)	
Past AIDS-defining illness *n (%)*	221 (33.3%)	178 (31%)	43 (49%)	0.001
Current tuberculosis diagnosis	3 (0.5%)	1 (0.2%)	2 (2.3%)	
CD4 count at diagnosis (IQR)	174 [57, 341]	178 [55,346]	58 [24.5,145.5]	0.000
Treatment interruptions ≥ seven days *n (%)*	42 (6.3%)	26 (5%)	16 (18%)	0.000
Multiple prior ART regimens *n (%)*	105 (15.8%)	74 (13%)	31 (35%)	0.000
Multiple-daily dosing *n (%)*	181 (27.2%)	142 (25%)	39 (44%)	0.001
Integrase inhibitor-based regimen *n (%)*	234 (35.2%)	196 (34%)	38 (43%)	0.094

MSM, men who have sex with men; ART, antiretroviral therapy; IQR, interquartile range

[a] Comparisons were calculated with Chi-squared test for categorical variables and Mann–Whitney U for continuous variables [b]In dollars

perceived difficulty attending healthcare, and having no comorbidities were significantly associated with PV. In the multivariable analysis, participants with multiple prior ART regimens (aOR 4.63, [95% CI 2.36, 9.09], $p<0.01$), treatment interruptions (aOR 4.33, [95% CI 1.72,10.87], $p<0.01$), and low CD4 count at diagnosis (aOR 2.36, [95% CI 1.07,5.22], $p=0.03$) were associated with higher odds of PV, as shown in Table 3. These variables were also significantly associated with VNS.

Discussion

To our knowledge, a detailed analysis on factors that influence virologic outcomes in PLHIV has not been performed in Guatemala. Our study found factors associated with VNS and PV among PLHIV in Guatemala, complementing prior findings about the modifiable and unmodifiable factors associated with detectable viremia in PLHIV on ART [23–28]. Several studies have demonstrated that the risk for negative outcomes such as mortality, virologic failure and AIDS increases for PLHIV at low viremic levels, starting from 50 to 200 copies/ml [24, 29]. Therefore, 200 copies/ml was used in this study as a threshold to identify people with detectable viremia.

Perceived difficulty attending healthcare was one of the variables associated with VNS. Several socio-economic factors have been shown to have a negative impact on perception of HIV care such as quality of services, financial fairness, transportation convenience, perceived negative attitude, and stigma [30]. However, none of the reasons for perceived difficulty in our study was

Table 2 Univariable and multivariable logistic regression of viral non-suppression in 647 PLHIV on ART in Guatemala

Variable	Univariable			Multivariable		
	aOR	95% CI	p-value	aOR	95% CI	p-value
Smoking	2.06	1.14–3.73	0.017	1.73	0.83–3.60	0.141
Excessive alcohol consumption	1.95	1.03–3.69	0.041	2.56	1.18–5.54	0.017
Perceived difficulty attending healthcare	2.09	1.33–3.29	0.001	2.07	1.25–3.42	0.005
No comorbidities	1.63	1.04–2.56	0.034	1.72	1.04–2.84	0.033
Past AIDS defining illness	2.14	1.36–3.36	0.001	1.23	0.72–2.11	0.450
Low CD4 count at diagnosis	2.55	1.54–4.22	0.000	2.34	1.30–4.20	0.004
Treatment interruption ≥ seven days	4.70	2.41–9.18	0.000	4.51	2.13–9.58	0.000
Multiple prior ART regimens	3.69	2.24–6.09	0.000	2.82	1.59–4.99	0.000
Multiple-daily dosing	2.43	1.53–3.86	0.000	1.59	0.92–2.74	0.095
Sexual orientation						
MSM	1.00		0.036	1.00		0.064
Bisexual	3.95	1.4–11.11	0.009	4.04	1.33–12.3	0.014
Heterosexual	2.40	1.07–5.38	0.033	1.61	0.66–3.91	0.298
Age 50 and below	1.11	0.62–1.98	0.723			
Male	1.23	0.78–1.93	0.381			
Not indigenous ethnicity	1.26	0.65–2.47	0.496			
Primary education or less	1.39	0.88–2.19	0.157			
Individual income ≤ CBA[a]	2.00	0.94–4.27	0.074			
Home owner	1.27	0.78–2.05	0.334			
Lack of access to basic utilities	1.32	0.69–2.50	0.400			
Prior illicit drug use	1.58	0.83–3.02	0.168			
Travel time to healthcare > 1 h	1.27	0.79–2.04	0.330			
Borrows money for transport to care	1.20	0.75–1.92	0.456			
Travel cost ≥ $2.6 roundtrip[b]	1.15	0.74–1.81	0.534			
Integrase inhibitor-based regimen	1.47	0.93–2.32	0.095			

MSM men who have sex with men, *ART* antiretroviral therapy, *aOR* adjusted odds ratio, *CI* confidence interval

Significant variables ($p < 0.05$) in univariable analysis were entered into multivariable analysis

[a] Monthly income ≤ *Canasta Básica Alimentaria*, the cost to feed an average Guatemalan household per month

[b] $2.6 was the median cost of transport reported in the cohort

significantly associated with VNS, suggesting that each participant may have individualized difficulties that influence their viral load suppression.

We found that paradoxically, having no comorbidities increases the risk of VNS and PV. Several studies have found no association or a similar association to our study [31–33]. This may be explained by more frequent interactions with healthcare for people with comorbidities, due to their chronic conditions, where they may be encouraged to seek HIV care [34, 35].

In this study, indigenous ethnicity and age did not have an impact on VNS or PV. This differs from other studies where ethnic minorities [36, 37] and younger populations [10, 27, 37, 38] are more likely to experience worse outcomes in HIV care. Our findings may have been influenced by the low frequency of older PLHIV and those who self-identify as indigenous in our cohort, and further studies are needed in these populations.

Gender was also not associated with VNS in the overall population, in keeping with previous research on gender and detectable viremia [39, 40]. However, analysis disaggregated by gender showed important differences (Additional file 1: Table S1 and Additional file 2: Table S2). Lower individual income, low educational attainment, engaging in risk behaviors, bisexual orientation and perceived difficulty attending healthcare exclusively had an impact on viremia in men. Individual income may be less relevant in women due to differences in workforce participation in the cohort (23.7% in women vs 42.6% in men) [41]. Other studies have examined the interplay between gender, HIV and risk behaviors and have observed that the prevalence of heavy alcohol consumption is higher in men with HIV than in women [42], at-risk drinking in men is predictive of virologic failure [43], and MSM who engage in higher risk drinking are more likely to engage in HIV risk behaviors [44]. We emphasize these gender

Table 3 Univariable and multivariable logistic regression of persistent viremia in 647 PLHIV on ART in Guatemala

Variable	Univariable			Multivariable		
	aOR	95% CI	p-value	aOR	95% CI	p-value
Past AIDS-defining illness	2.62	1.43–4.79	0.002	1.46	0.73–2.91	0.281
Low CD4 count at diagnosis	3.21	1.56–6.60	0.001	2.36	1.07–5.22	0.033
Treatment interruption ≥ seven days	5.73	2.55–12.88	0.000	4.33	1.72–10.87	0.002
Multiple prior ART regimens	6.03	3.23–11.25	0.000	4.63	2.36–9.09	0.000
Multiple-daily dosing	2.24	1.22–4.11	0.009	1.39	0.70–2.76	0.335
Perceived difficulty attending healthcare	1.82	1.00–3.31	0.049	1.66	0.85–3.21	0.132
No comorbidities	1.91	1.05–3.48	0.033	1.92	0.99–3.70	0.051
Age 50 and below	1.09	0.51–2.33	0.809			
Male	1.54	0.83–2.85	0.163			
Not indigenous ethnicity	1.54	0.59–4.03	0.370			
Primary education or less	1.39	0.75–2.55	0.284			
Individual income ≤ CBA[a]	2.06	0.72–5.91	0.175			
Home owner	1.37	0.71–2.62	0.341			
No basic utilities access	1.32	0.57–3.09	0.509			
Prior illicit drug use	1.35	0.54–3.34	0.511			
Travel time to healthcare > 1 h	1.19	0.63–2.23	0.584			
Borrows money for transport to care	1.22	0.65–2.27	0.530			
Travel cost ≥ $2.6 roundtrip[b]	1.33	0.72–2.41	0.355			
Integrase inhibitor-based ART	1.22	0.66–2.27	0.514			
Sexual orientation						
MSM	1.00		0.123			
Bisexual	5.74	1.35–24.35	0.018			
Heterosexual	2.71	0.81–8.98	0.103			
Smoking	2.10	0.96–4.57	0.062			
Excessive alcohol consumption	1.51	0.61–3.75	0.371			

MSM men who have sex with men, *ART* antiretroviral therapy, *aOR* adjusted odds ratio, *CI* confidence interval

Significant variables ($p < 0.05$) in univariable analysis were entered into multivariable analysis

[a] monthly income ≤ *Canasta Básica Alimentaria*, the cost to feed an average Guatemalan household per month

[b] $2.6 was the median cost reported in the cohort

differences due to our concern that men are getting left behind in the fight against the HIV epidemic [45] which calls to revise policies regarding men's sexual health services.

Unlike VNS, we found no social or economic variables associated with PV. However, the same variables related to HIV background were significantly associated with both VNS and PV. Having multiple prior ART regimens was independently associated with both outcomes with the highest odds ratio of all relevant variables. Similar findings are reported in South Africa [46], Uganda [47], and the United States [48] where having multiple prior ART regimens or being on 2nd line therapy was significantly associated with PV. We agree with other hypotheses that multiple ART changes are more likely associated with poor adherence, acquired drug resistance mutations, and long-term drug toxicities that influence treatment efficacy and viral suppression [46–48]. Not all studies support this link between the viral suppression and ART history [49], but this finding should encourage further research on reasons for multiple ART changes and HIV outcomes in Guatemala, especially since the HIV treatment guidelines were updated in December 2019 to include integrase inhibitors as first line of therapy [50, 51].

Low CD4 count at diagnosis was another variable significantly associated with VNS and PV, similar to what was found in several cohort studies [23, 52–54]. Progressing to advanced disease before treatment may put patients at higher risk of persistent viremia once treatment is started as a consequence of increased viral reservoir size, but further research is needed to understand this association.

We also demonstrate that treatment interruptions are associated with VNS as well as PV. This result is similar to what is reported from multiple studies where missing any

amount of days of ART is significantly associated with PV [25, 27, 38, 47]. Other studies have related treatment interruptions and poor adherence to poor education, HIV stigma, low socioeconomic status, risk behaviors, treatment fatigue, and young age [55, 56]. These treatment interruptions may occur due to lack of HIV care facilities or treatment support programs in Guatemala, in addition to individual challenges in attending care. This could be a key area of intervention to impact both the percentage of PLHIV taking ART and the proportion of those that are virally suppressed.

There are important limitations in our study. Although all participants were selected randomly, a small number of people declined participation mainly due to insufficient time to conduct an interview. Those that were temporarily lost to follow up in HIV care, hospitalized in-patient, or attending prenatal care were not captured in this cohort. Adolescents were not considered due to health policies regarding age and sexual health consent. Transgender population and sex workers are underrepresented in our cohort due to the lack of public outreach and gender specific programs [2]. We were unable to include HIV subtypes and clades for our participants because this data is not available as standard of care. However, one cohort study previously published from our clinic showed that 98.9% of sequences performed belong to $B_{Pandemic}$ clade [57]. Treatment interruptions were only captured in participants lost to follow up for more than three months or with ART that differed in at least one drug or differed in doses, but not in those that did not change regimen or dosing. During treatment interruptions some participants may share treatment with a partner or split pills. For prior ART switches, we were able to accurately capture reasons for treatment switch due to lack of prior information for some of the files. Household income, which was not available in this data, may be a better measurement of economic status than individual income.

Conclusions

This is the first study, to our knowledge, demonstrating potential social and clinical influences on VNS and PV in PLHIV in Guatemala. In our analysis, we found that social factors such as excessive alcohol consumption, perceived difficulty attending healthcare, and bisexual orientation were significantly associated with VNS in PLHIV in Guatemala. In this cohort low CD4 count at diagnosis, treatment interruptions, multiple prior ART regimens, and multiple-daily dosing were significantly associated with both VNS and PV. This highlights potential areas of improvement to advance towards achieving the goal of 90% suppression. Simplifying regimens when possible, addressing personal barriers, improving access to ART outside of the clinic, and concentrating efforts on groups at greater risk are key interventions to continue improving viral suppression. The strong link between perceived difficulty attending healthcare and VNS warrants further exploration, as PLHIV often need to overcome barriers to optimal care.

Abbreviations

AIDS: Acquired immunodeficiency syndrome; aOR: Adjusted odds ratio; ART : Antiretroviral therapy; CBA: *Canasta básica alimentaria* (In English, national food basket); CDC: Center for Disease Control; CI: Confidence interval; PLHIV: People living with HIV; HIV: Human immunodeficiency virus; IQR: Interquartile range; MSM: Men who have sex with men; PV: Persistent viremia; UNAIDS: Joint United Programme on HIV/AIDS; VNS: Viral non-suppression.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12981-021-00400-9.

Additional file 1: Table S1. Univariable and multivariable logistic regression of viral non-suppression in 308 women† living with HIV on ART in Guatemala.

Additional file 2: Table S2. Univariable and multivariable logistic regression of viral non-suppression in 356 men living with HIV on ART in Guatemala.

Additional file 3: Table S3. Reasons for perceived difficulty attending HIV care in 258 PLHIV on ART in Guatemala.

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Authors' contributions

All authors contributed to the study design and methodology. Material preparation, data collection and data curation: DO, KF and ORS. Conceptualization and methodology: ORS, DO, HM, JO and CM. Formal analysis and first draft: ORS and DO. Review and editing: ORS, DO, HM, JO and CM. Supervision: AS, JM, RP, AS. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are available in the figshare.com repository: https://doi.org/10.6084/M9.FIGSHARE.13218806[58].

Declarations

Ethic approval and consent to participate

Study design and methodology was approved by the Human Research Protection Office at Washington University in St. Louis(May 15, 2019/IRB ID#201905033) and the local Ethics committee at Hospital Roosevelt in Guatemala (February 12, 2019/Form 609, Point 5) in accordance to the International Ethical Guidelines for Health-related Research Involving Humans. A waiver of written consent was granted by the local ethics committee, and informed verbal consent was obtained for all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests
The authors have no financial or proprietary interest in any material discussed in this article.

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