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Factors associated with HIV RNA viral loads in ART-naïve patients: implications for treatment as prevention in concentrated epidemics

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Abstract

Background: Limited data are available on factors associated with HIV-RNA viral load (VL) among antiretroviral treatment (ART)-naïve key populations in concentrated epidemics.

Methods: We conducted a cross-sectional survey of 1211 adult ART-naïve patients at 19 HIV clinics in Ho Chi Minh City (HCMC), Vietnam. Data collection included a standardised questionnaire, routine laboratory testing, hepatitis serology and HIV VL. Correlation between CD4 cell count and VL was assessed across all participants. In 904 participants not meeting Vietnam criteria for ART (CD4 cell count >350 cells/mm^3, WHO clinical stage 1 or 2 and not pregnant), multivariate analyses were conducted to assess factors associated with HIV VL.

Results: Pre-ART patients had a median age of 31 years and 54% were male. Median CD4 cell count was 533 cells/mm^3. Median HIV VL was 17,378 copies/mL; 60% had VL greater than 10,000 copies/mL and 16% had VL above 100,000 copies/mL. Although declining CD4 cell count was correlated with rising VL across all CD4 cell counts, correlation of VL with CD4 cell counts between 351 and 500 cell/mm^3 was not significant. On multivariate linear regression, higher HIV VL was independently associated with male sex, men who have sex with men (MSM), CD4 cell count 351–500, HIV diagnosis within the previous 6 months, and hepatitis B (HBV). Lower HIV VL was independently associated with hepatitis C (HCV).

Conclusions: The majority of HIV patients who were not eligible for ART in HCMC in 2014 had HIV VL greater than 10,000 copies/mL. These data support expanded eligibility of ART to all HIV patients with the goal of treatment as prevention. This study is also among the first to demonstrate that MSM had a higher VL than women and heterosexual men and highlights the need for improved outreach and linkages to HIV care for this high-risk group.

Keywords: HIV, ART naïve, treatment as prevention, HIV viral load, Vietnam

Introduction

Numerous case–control, cohort and modelling studies have concluded that the strongest predictor of per exposure HIV transmission risk is HIV-RNA viral load (VL) of the HIV-infected person [1–7]. The Rakai Project Study Group in Uganda found that transmission to heterosexual partners increased with VL strata in the infected partner and that more than 75% of infections were transmitted from individuals with VL>10,000 copies/mL [4]. Another African study concluded that 90% of new HIV infections could be eliminated by treating only people living with HIV (PLHIV) with HIV VL>10,000 copies/mL [3].

Various factors have been associated with HIV VL. A number of studies have found 35–50% lower HIV VL among females relative to males [7–12]. Acute HIV infection is characterised by very high VL and increased transmission risk [7,13–17].

Studies examining HIV viral load among persons who inject drugs (PWID) are conflicting. One study in France demonstrated a small but statistically significant 0.35–0.60 $\log_{10}$ increase in HIV VL among active PWID relative to former PWID not on ART [18]. However, another study among female PWID in New York City did not find a correlation between HIV VL and use of cocaine, methadone or injecting heroin [19].

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Genital ulcer disease increases HIV VL and rates of HIV transmission [2,4,6,7,20]. A meta-analysis on treatment of co-infections found a small but significant inverse relationship between syphilis treatment and HIV viral load [21]. In addition, one retrospective analysis found untreated primary or secondary syphilis increased HIV VL on average by 66% and decreased CD4 cell count on average by 62 cells/mm^3 [22].

In Vietnam, the HIV epidemic is concentrated among men who have sex with men (MSM), PWID and female sex workers (FSW). The majority of PLHIV in Vietnam are not yet on ART and many continue to engage in risky behaviour, presenting a significant risk for HIV transmission. Targeted combined prevention strategies, including expanded treatment to members of key populations not currently eligible for ART, could potentially decrease HIV transmission in the community. The purpose of this study was to determine HIV VL and to identify clinical, biological, behavioural and demographic factors associated with HIV VL among pre-ART patients in Vietnam.

Methods

Brief overview of study setting

Ho Chi Minh City (HCMC) is the largest city in Vietnam, with a population of 8 million inhabitants [23]. The province has a large population of PLHIV, largely concentrated among PWID, MSM and FSW. The reported 2013 prevalence of HIV infection among these three key populations was 18%, 5% and 15%, respectively [24].

As of September 2013, there were 26,249 PLHIV enrolled in HIV care, with 24,115 on ART and 2134 designated as pre-ART [25].

Study population, recruitment and entry criteria

This was a cross-sectional assessment of all pre-ART patients in all 19 district-based HIV outpatient clinics (OPCs) in HCMC operating at the time of the study. No sampling or randomisation was employed; all pre-ART patients at each OPC who met the inclusion criteria and gave informed consent were enrolled in the evaluation.

Enrolment was conducted between November 2013 and July 2014 during routine visits when routine blood work was scheduled. The inclusion criteria were that individuals be 18 years of age or older, with documented HIV infection, enrolled in pre-ART care, and not known to be eligible for ART based on Vietnam Ministry of Health guidelines. Exclusion criteria were for individuals to be unable or unwilling to give informed consent, or any previous or current use of ART. Criteria for ART initiation in the Vietnam national treatment program at that time was a CD4 cell count ≤350 cells/mm^3 or WHO clinical stage 3 or 4. Pregnant and breast-feeding women in Vietnam were eligible for antiretroviral-based prevention of mother-to-child transmission.

Ethics

This research study was reviewed by FHI 360 Office of International Research Ethics, Protection of Human Subjects Committee and the Ho Chi Minh City Provincial AIDS Committee Institutional Review Board.

Data collection

After providing informed consent, participants were guided through a structured questionnaire by trained clinic staff. The questionnaire included demographics, HIV status of primary sex partner, symptoms of upper respiratory (URI) or viral infections, symptoms of STIs, injection drug use history, and sexual behaviour. Other information extracted from the medical record included HIV transmission risk-group category and the date of the first HIV-positive test.

Routine laboratory investigations included complete blood count, liver function and CD4 cell count. If not performed within the previous 1 year, testing was carried out for HBsAg, anti-HCV antibody and syphilis serology (VDRL, RPR and/or TPHA). An additional 6 mL of blood was taken for an HIV viral load test.

Routine blood tests were performed at the local laboratory in each district using standard commercial assays. All viral load testing was performed at the Pasteur Institute in HCMC using a validated and external quality-controlled real-time reverse transcriptase PCR assay (generic HIV viral load assay, Biocentric, Bandol, France), which had a level of detection of 250 copies/mL [26,27].

Data analysis

Viral load was analysed both as a continuous variable and as a dichotomous categorical variable. The two categories for dichotomous HIV viral load were less than and greater than or equal to 10,000 (4.0 $\log_{10}$) copies/mL. This cut-off value was based on previous studies showing a higher risk for HIV transmission above 10,000 copies/mL in patients not taking ART.

'Recent HIV diagnosis' was defined as first positive HIV test within the previous 6 months. 'Sexually active' was defined as having any sex during the previous 30 days. 'Multiple sex partners' was defined as having two or more sex partners within the previous 30 days. STI symptoms included any one or more of genital ulcer, dysuria, urethral discharge (men) or vaginal discharge (women). 'URI or viral symptoms' was defined as report of any three or more of the following symptoms: headache, fever, chills, cough, sputum, nasal congestion, throat pain, muscle aches, swollen lymph nodes, fatigue and rash. 'Syphilis serology' was defined as the result of TPHA, VDRL and/or RPR testing. Access to VDRL and RPR testing was limited in some clinics.

The analysis population was pre-ART subjects, defined as those who did not meet Vietnam MOH criteria for ART at the time of the study. Because current CD4 cell count could not be determined prior to enrolment, several subjects initially included in the evaluation were subsequently found to meet criteria for ART after the results of the CD4 cell count were known and were excluded from the bivariate and multivariate analyses of associations with HIV VL.

Associations between categorical variables and dichotomous HIV VL were evaluated using the Chi-squared test or Fisher's exact test. Comparisons of continuous variables between HIV VL groups were assessed using *t*-test and ANOVA tests. The non-parametric versions of these tests (i.e. Mann–Whitney or Kruskal–Wallis tests) were used if normality assumptions were not met.

For testing the association between categorical and continuous $\log_{10}$ transformed VL, we used *t*-tests or ANOVA tests. The non-parametric versions of these tests (i.e. Mann–Whitney, Kruskal–Wallis tests) were used if normality assumptions were not met. For assessing the association between $\log_{10}$ HIV VL and continuous variables, we used Spearman correlation coefficients with 95% confidence intervals.

Multivariate logistic regression was used to evaluate predictors for the dichotomous variable of HIV VL>10,000 copies/mL. A second log–linear regression model was used to evaluate predictors for $\log_{10}$ transformed HIV VL as a continuous variable. Age, WHO clinical stage, injection-drug user (IDU) status, gender, sexual orientation, HBsAg and anti-HCV were included in both models. Additional variables significant at $P<0.10$ in respective bivariate analyses were included using a backward selection process. Final tests were assessed for significance at the 5% level with two-sided comparisons.

Results

Participant characteristics

A total of 1231 patients gave informed consent and enrolled in the study representing 58% of pre-ART patients registered in public OPCs at the start of the study. Data on number of refusals to participate was not systematically reported, but refusals were less than 5% at those sites that reported these data. Of those patients enrolled, 20 patients were missing either VL or CD4 data, or had previous CD4 cell count ≤350 cells/mm^3, and were excluded from analysis. Another 307 patients had a CD4 count ≤350 cells/mm^3 at the time of enrolment and therefore met criteria for ART. These patients were excluded from the outcome analysis but were included in the CD4 cell count versus VL correlation testing. The final analysis population size was 904 for the bivariate and multivariate analyses and 1211 for the CD4 cell count versus VL correlation analysis.

Characteristics of the study population are shown in Table 1. The median age was 31 (range 18–64). The majority were male (54%), aged 26–35 (55%), married (57%), and WHO clinical stage 1 (89%).

The ranges of CD4 cell count and HIV VL are shown in Figure 1. The median CD4 was 533 cells/mm^3 (interquartile range [IQR] 439–681). The majority (58%) had CD4>500 cells/mm^3. A small proportion (12%) had VL below 1000 copies/mL, 27% had VL 1000–9999 copies/mL, and 61% had VL>10,000 copies/mL, a

Table 1. Characteristics of pre-ART study participants (*n*=904)

	Total *n* (%)
HIV WHO clinical stage	
Stage 1	804 (88.9)
Stage 2	100 (11.1)
Province of residence	
HCMC	732 (81.0)
Other	172 (19.0)
Sex	
Male	487 (53.9)
Female	417 (46.1)
Age	
18–25	152 (16.8)
26–35	497 (55.0)
36–64	255 (28.2)
Highest education level	
No schooling	27 (3.0)
Primary (1–5)	157 (17.4)
Secondary (6–9)	346 (38.3)
High school (10–12)	238 (26.3)
College/University	136 (15.0)
Marital status	
Married	514 (56.9)
Divorced/widowed	125 (13.8)
Single	265 (29.3)
Currently lives with other people	
Alone	87 (9.6)
With other people	817 (90.4)

level associated with higher risk for onward HIV transmission [3,4]. Of note, 16% had VL above 100,000 copies/mL. Lower CD4 cell count was associated with higher VL (P<0.0001). Overall, CD4 cell count and HIV VL were significantly and negatively correlated, such that as CD4 cell count declined, HIV VL increased (Figure 1a). In CD4 cell count ranges below 350 and above 500 cells/mm^3 the negative correlation with HIV VL was statistically significant (P<0.0001 and P<0.0001, respectively). However, within the 351–500 cells/mm^3 range the correlation between CD4 cell count and viral load was not significant (Figure 1b). Differences in linear trends by gender can also be seen in Figure 1.

Risk behaviour

Risk behaviour disaggregated by sexual orientation and gender is presented in Table 2. MSM represented 17% of the total sample and approximately one-third (31%) of all males in the study population. Among those diagnosed with HIV in the previous 6 months, 40% were MSM, 30% were non-MSM males, and 30% were female (P<0.001). MSM had significantly higher HIV VL: 80% of MSM had HIV VL ≥10,000 copies/mL while only 64% of non-MSM males and 51% of females had HIV VL in that range (P<0.0001). Mean HIV VL was 0.51 $\log_{10}$ copies/mL higher in MSM when compared to females, or an average of 30,199 copies/mL in MSM versus 9332 copies/mL in females. Non-MSM males had a mean HIV viral load of 15,849 copies/mL.

One-quarter (n=222) of the sample had a history of injection-drug use. Non-MSM males (55%) were much more likely to have IDU history than MSM (10%) and females (6%). Only 32 (14%) of PWID reported injecting in the previous 7 days and only three of these reported sharing needles. Only 28 (13%) were on methadone maintenance treatment (MMT). PWID were more likely than others to be diagnosed for more than 3 years (54% *vs* 36%, P<0.0001) and to have hepatitis C infection (85% *vs* 10%, P<0.0001).

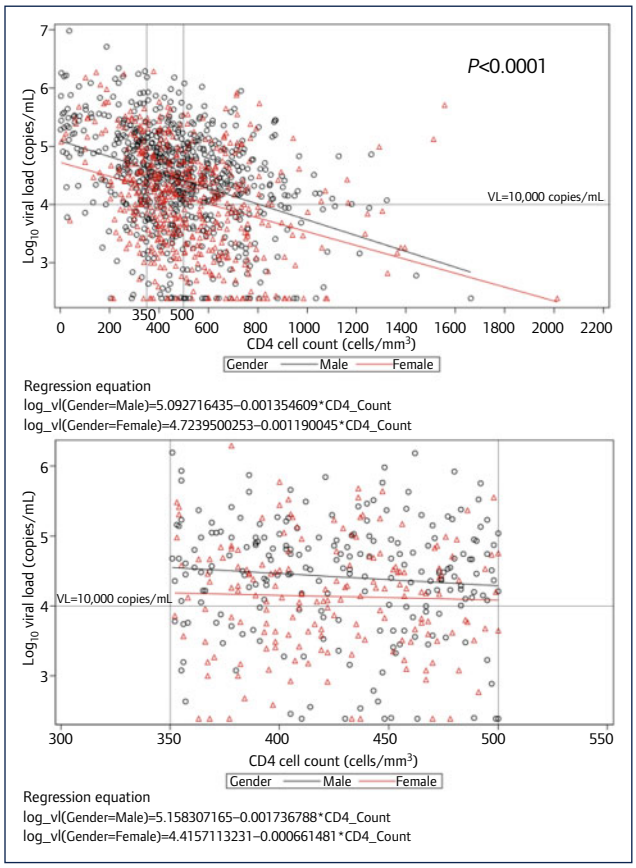

Figure 1. Scatterplot of CD4 *vs* HIV VL in (a) total population (n=1211), and (b) patients with CD4 cell counts 351–500 cells/mm^3

Predictors of HIV viral load

Bivariate analysis between categorical variables and HIV VL greater than 10,000 copies/mL is presented in Table 3. Results of the multivariate models are shown in Table 4. Factors independently associated with $\log_{10}$ transformed HIV VL and HIV VL>10,000 copies/mL were MSM, non-MSM male, CD4 351–500 cells/mm^3, recent HIV diagnosis and HBsAg. Positive anti-HCV was associated with lower HIV VL. When hepatitis C was replaced with PWID in the multivariate analyses, we found that injection-drug use was also negatively associated with viral load ≥10,000 copies/mL (odds ratio [OR] 0.65, 95% confidence interval [CI] 0.44–0.97) and did not significantly change the level of association of the other independent variables with HIV VL (data not shown).

Discussion

These results reveal a large proportion of participants with elevated HIV viral load among pre-ART patients in HCMC. More than 60% of the pre-ART population had VL above 10,000 copies/mL and 16% had viral loads above 100,000 copies/mL. This is significantly higher than the 34% of patients with CD4 cell counts >350 cells/mm^3 found to have HIV viral load greater than 10,000 copies/mL in a recent study in South Africa [28].

We found that a majority of pre-ART patients had WHO clinical stage 1 and CD4>500 cells/mm^3. The low number of patients with clinical stage 2 may be due to underreporting of clinical symptoms perceived by patients and doctors to be minor and not meeting criteria for ART. It is also possible that some patients with CD4 cell counts in the range 350–500 cells/mm^3 were diagnosed with clinical stage 3 or 4 conditions, such as oral thrush, weight loss or pulmonary TB, which are commonly reported among PLHIV in Vietnam and would make them eligible for ART.

Table 2. Sexual behaviour, STI, hepatitis serology and IDU by sexual orientation and gender.

	MSM (*N*=153) *n (%)*	Non-MSM male (*N*=334) *n (%)*	Female (*N*=417) *n (%)*	Total (*N*=904)[2] *n (%)*	*P*-value
HIV status of regular sex partner					
Positive	32 (26.4)	106 (37.7)	266 (68.7)	404 (51.2)	<0.001
Negative/unknown	89 (73.6)	175 (62.3)	121 (31.3)	385 (48.8)	
Multiple sex partners in last 30 days[1]					
Yes	20 (29.9)	5 (2.8)	7 (2.6)	32 (6.2)	<0.001
No	47 (70.1)	175 (97.2)	260 (97.4)	482 (93.8)	
Received money for sex in last 30 days[1]					
Yes	3 (4.5)	0 (0.0)	2 (0.7)	5 (1.0)	0.0146
No	64 (95.5)	182 (100)	267 (99.3)	513 (99.0)	
Any STI symptoms					
Yes	9 (5.9)	22 (6.6)	94 (22.5)	125 (13.8)	<0.001
No	144 (94.1)	312 (93.4)	323 (77.5)	779 (86.2)	
History of IDU					
Yes	15 (9.8)	182 (54.5)	25 (6.0)	222 (24.6)	<0.001
No	138 (90.2)	152 (45.5)	392 (94.0)	682 (75.4)	
Syphilis serology					
Positive	31 (20.3)	22 (6.7)	6 (1.5)	59 (6.6)	<0.001
Negative	122 (79.7)	306 (93.3)	407 (98.5)	835 (93.4)	
HBsAg					
Positive	20 (13.2)	50 (15.1)	31 (7.5)	101 (11.3)	0.004
Negative	131 (86.8)	282 (84.9)	383 (92.5)	796 (88.7)	
Anti-HCV					
Positive	18 (11.9)	183 (55.3)	53 (12.8)	254 (28.3)	<0.001
Negative	133 (88.1)	148 (44.7)	361 (87.2)	642 (71.7)	
HIV viral load (copies/mL)					
0–999	7 (4.6)	39 (11.7)	60 (14.4)	106 (11.7)	<0.001
1000–9999	23 (15.0)	81 (24.3)	144 (34.5)	248 (27.4)	
10,000–99,999	92 (60.1)	154 (46.1)	163 (39.1)	409 (45.2)	
≥100,000	31 (20.3)	60 (18.0)	50 (12.0)	141 (15.6)	
Recently diagnosed HIV infection					
Yes	64 (41.8)	49 (14.7)	48 (11.5)	161 (17.8)	<0.001
No	89 (58.2)	285 (85.3)	369 (88.5)	743 (82.2)	

STI: sexually transmitted infections; IDU: injection drug use; MSM: men who have sex with men.
[1] Among those who reported sex in last 30 days. Some participants did not answer all risk-behaviour questions.
[2] Some factors have lower totals due to missing data.

Almost half (46%) of our study participants were female. This proportion may not be representative of the HIV population in the community as women in Vietnam are more likely to enrol in care earlier and have greater retention in care [29,30]. However, our data also suggest that women may be a low-risk group for HIV transmission. Women had significantly lower VL than men and among the 417 women enrolled in our study, 98% reported having no or one regular sex partner, 63% reported that their regular sex partner was already HIV-infected, 6% reported ever injection drug use, and only 0.5% reported sex work. This suggests that most of the women enrolled acquired HIV from their husbands or male partners, had few other sex partners, and had low potential for transmitting the virus to others.

Similar to previous studies, we found higher HIV VL in men versus women [8–10,31]. It is not clear why MSM had higher VL than non-MSM males. The fact that MSM represented 40% of the participants with recent HIV diagnosis but only 17% of the entire sample is an indication of the changing epidemiology of HIV infection in Vietnam; and recent HIV diagnosis was independently associated with higher VL. However, in the multivariate analyses MSM was significantly associated with elevated HIV VL even after controlling for recent HIV diagnosis.

This study is the first known to us to identify higher VL among HBV co-infected patients. Based on our study results, earlier expanded treatment for those PLHIV co-infected with HBV would be likely to have significant long-term benefits to individual patients as well as the potential for reduced transmission of both HIV and HBV in the community. The preferred first-line ART regimen in Vietnam includes the drugs tenofovir and lamivudine, which are also effective against hepatitis B. Indeed, the most recent Vietnam HIV treatment guidelines revised in 2015 recommend early treatment of patients with HBV or HCV co-infection [32].

This study is also one of the first to show lower VL among persons co-infected with hepatitis C, a finding also reported in the RESINA Cohort in Germany [33]. However, the biological mechanism for this phenomenon has not been elucidated. The majority (86%) of PWID were positive for anti-HCV, suggesting that anti-HCV may be a surrogate marker for injection drug use among PLHIV. PWID were more likely to be diagnosed for longer periods of time, suggesting that as a risk group they were infected and identified in the more distant past.

Our study has a number of limitations not previously mentioned. The cross-sectional nature of the study could not assess when patients acquired HIV infection or how VL evolves over time. We cannot exclude the possibility that VL varies over time within individuals. Very few participants reported high-risk behaviour including active drug use, sex work and other high-risk sexual behaviour. These behaviours may have been underreported because

Table 3. Summary of bivariate analyses

	HIV viral load ≥10,000 copies/mL (*N*=550) *n (%)*	HIV viral load <10,000 copies/mL (*N*=354) *n (%)*	Total (*N*=904)[2] *n (%)*	*P*-value
HIV WHO clinical stage				
Stage 1	479 (87.1)	325 (91.8)	804 (88.9)	0.0273
Stage 2	71 (12.9)	29 (8.2)	100 (11.1)	
Sex				
Male	337 (61.3)	150 (42.4)	487 (53.9)	<0.0001
Female	213 (38.7)	204 (57.6)	417 (46.1)	
Age				
18–25	107 (19.5)	45 (12.7)	152 (16.8)	0.0199
26–35	287 (52.2)	210 (59.3)	497 (55.0)	
36–64	156 (28.4)	99 (28.0)	255 (28.2)	
Highest education level				
No school	13 (2.4)	14 (4.0)	27 (3.0)	0.0175
Primary (1–5)	90 (16.4)	67 (18.9)	157 (17.4)	
Secondary (6–9)	201 (36.5)	145 (41.0)	346 (38.3)	
High (10–12)	147 (26.7)	91 (25.7)	238 (26.3)	
College/university	99 (18.0)	37 (10.5)	136 (15.0)	
Marital status				
Married	287 (52.2)	227 (64.1)	514 (56.9)	<0.0001
Divorced/Widowed	72 (13.1)	53 (15.0)	125 (13.8)	
Single	191 (34.7)	74 (20.9)	265 (29.3)	
Recently diagnosed HIV infection				
Yes	124 (22.5)	37 (10.5)	161 (17.8)	<0.0001
No	426 (77.5)	317 (89.5)	743 (82.2)	
URI/viral symptoms				
Yes	179 (32.5)	87 (24.7)	266 (29.5)	0.0119
No	371 (67.5)	265 (75.3)	636 (70.5)	
Any STI symptoms				
Yes	73 (13.3)	52 (14.7)	125 (13.8)	0.5470
No	477 (86.7)	302 (85.3)	779 (86.2)	
MSM (males only)				
Yes	123 (36.5)	30 (20.0)	153 (31.4)	0.0003
No	214 (63.5)	120 (80.0)	334 (68.6)	
Multiple sex partners in last 30 days[1]				
Yes	24 (8.0)	8 (3.7)	32 (6.2)	0.0463
No	275 (92.0)	207 (96.3)	482 (93.8)	
Received money for sex in last 30 days[1]				
Yes	3 (1.0)	2 (0.9)	5 (1.0)	1.0000
No	300 (99.0)	213 (99.1)	513 (99.0)	
History of IDU				
Yes	127 (23.1)	95 (26.8)	222 (24.6)	0.2016
No	423 (76.9)	259 (73.2)	682 (75.4)	
Current CD4 count (cells/mm^3)				
351–500	256 (46.5)	128 (36.2)	384 (42.5)	0.0020
>500	294 (53.5)	226 (63.8)	520 (57.5)	
Syphilis test result				
Positive	44 (8.1)	15 (4.3)	59 (6.6)	0.0254
Negative	500 (91.9)	335 (95.7)	835 (93.4)	
HBsAg				
Positive	72 (13.2)	29 (8.3)	101 (11.3)	0.0228
Negative	474 (86.8)	322 (91.7)	796 (88.7)	
Anti-HCV				
Positive	142 (26.1)	112 (31.9)	254 (28.3)	0.0577
Negative	403 (73.9)	239 (68.1)	642 (71.7)	

[1] Among those who reported sex in last 30 days. Some participants did not answer all risk-behaviour questions.
[2] Some factors have lower totals due to missing data.

they are stigmatised and we relied on patient self-report in a survey conducted by clinic staff. Similar to HIV epidemics in other countries, MSM in HCMC constitute both an increasing proportion of new HIV transmissions and a long-underserved population [34–40]. Compared to PWID, MSM in HCMC were significantly more likely to have been recently diagnosed with HIV, suggesting a shifting trend in HIV transmission in HCMC from injection drug use to homosexual sex. Increasing HIV transmission among MSM in Vietnam would also

Table 4. Results of multivariate analysis

	Logistic regression for HIV VL ≥10,000 copies/mL		Linear regression for log_{10} HIV VL	
	Adjusted OR (95% CI)	***P*-value**	**Parameter estimates (95% CI)**	***P*-value**
WHO clinical stage				
Stage 1	Reference		Reference	
Stage 2	1.5 (0.93–2.42)	0.0962	0.06 (–0.11–0.24)	0.4913
Gender/MSM				
MSM	3.08 (1.91–4.95)	<0.0001	0.38 (0.22–0.55)	<0.0001
Male (Non-MSM)	1.98 (1.4–2.8)	0.0001	0.26 (0.12–0.39)	0.0002
Female	Reference		Reference	
Age				
18–25	1.1 (0.69–1.77)	0.688	0.06 (-0.12–0.24)	0.5163
26–35	1 (0.72–1.38)	0.9861	-0.04 (-0.17–0.09)	0.5386
36–64	Reference		Reference	
Current CD4 cell count (cells/mm^3)				
351–500	1.46 (1.09–1.94)	0.0106	0.24 (0.13–0.35)	<0.0001
>500	Reference		Reference	
Recently diagnosed HIV infection				
Yes	1.82 (1.2–2.78)	0.0053	0.21 (0.06–0.37)	0.0051
No	Reference		Reference	
URI/viral symptoms				
Yes	1.4 (1.02–1.92)	0.0375	0.11 (-0.02–0.23)	0.0863
No	Reference		Reference	
HBsAg				
Positive	1.64 (1.02–2.65)	0.0414	0.19 (0.01–0.36)	0.0348
Negative	Reference		Reference	
Anti-HCV				
Positive	0.64 (0.45–0.91)	0.0132	-0.15 (-0.28–-0.01)	0.0362
Negative	Reference		Reference	

support the implementation of other biomedical HIV prevention strategies such as pre-exposure prophylaxis (PrEP).

The Vietnam Ministry of Health revised the national HIV treatment guidelines in 2015 to expand ART eligibility to include CD4 cell counts less than 500 cells/mm^3 as well as groups at high-risk for HIV transmission, such as PWID, FSW, MSM and those with HIV-uninfected sex partners [32]. Our findings support implementation of the 2015 revised ART guidelines within the goal of treatment as prevention. However, in order to reduce HIV transmission in the community, expanded eligibility for ART needs to be combined with outreach and improved services for those most likely to transmit HIV [14]. Our study underscores the need for updated service delivery models that target groups with higher VL and higher levels of risk behaviour, especially MSM. Effectively addressing the HIV epidemic among MSM in HCMC will require improved provision and access to MSM-friendly HIV prevention and care services [41]. PWID will need greater access to harm-reduction methods including opioid substitution therapy and needle exchange programs. Only then will the goals of treatment as prevention be truly achievable.

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Conflict of interests

All authors report no conflict of interests.

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