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Original article

Elevated risk of viral rebound on ART in migrants living in France: role of socioeconomic factors

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Background: In Western countries, viral rebound on antiretroviral therapy (ART) appears to occur more frequently in migrants. We aimed to assess the respective roles of socioeconomic factors and migration on viral rebound in people living with HIV (PLHIV) in France.
Methods: We included PLHIV in France, enrolled from 2004 to 2008 in the French ANRS-COPANA cohort, who started a first ART and achieved undetectability (<50 copies/ml) within 1 year. Determinants of viral rebound were assessed using Cox models including geographical origin, HIV transmission group, and clinicobiological and sociodemographic data.
Results: Of 499 included individuals, 288 were born in France, 158 in sub-Saharan Africa (SSA) and 53 in another country. Kaplan–Meier probabilities of viral rebound-free survival were similar for men having sex with men (MSM) and heterosexuals born in France, and lower in migrants from SSA or other countries (P<0.001). The crude hazard ratio (HR) of viral rebound was 2.49 (95% CI, 1.59, 3.90) in migrants from SSA and 1.78 (0.94, 3.88) in migrants from other countries compared with MSM born in France. Educational level, financial difficulties and HIV status disclosure had the biggest impact on the difference between the crude and adjusted HRs for viral rebound in migrants. In multivariable analysis, viral rebound was no longer associated with geographical origin, but with protease inhibitor-containing ART, a VACS index ≥35 as a potential indicator of frailty, poor financial status (difficulties or debts) and non-disclosure to friend(s).
Conclusions: Socioeconomic factors affect outcomes on ART, even in the context of free access to HIV care and treatment. Patient-centred strategies should be encouraged with the intervention of social workers to address basic needs and promote social support for more socially vulnerable individuals.

Introduction

Sustained viral suppression on antiretroviral therapy (ART) is one of the necessary conditions to achieve the 90:90:90 UNAIDS target. In Europe, 85% (interquartile range [IQR] 76–91) of people living with HIV (PLHIV) achieve viral suppression on ART [1] with high disparities between HIV transmission groups [2–5]. In France, the overall rate of viral success is similar to that in Western Europe, and the same disparities are described with lower viral response on first ART in migrants [6–8], possibly due to lower socio-economic conditions or different cultural factors [3,5,9,10].

After a viral response has been obtained on first ART, migrants from sub-Saharan Africa (SSA) also appear to have higher rates of viral rebound than people originating from Northwestern Europe [11], and a possible role of lower sociocultural factors has been suggested [9]. In France, access to health care and treatment is free and universal for people living with HIV, regardless of their

migration status, documented or undocumented. We thus aimed to investigate the respective role of migration status, that is, cultural background, and socioeconomic factors in the risk of viral rebound on first ART in migrants living with HIV in France relative to that of non-migrants after viral control by ART, in the context of free access to health care. We also aimed to investigate the role of the specific geographical origins of the migrants, that is, SSA or other origins.

Methods

Individuals

The French ANRS-INSERM CO9 COPANA study is a prospective cohort conducted in 37 hospitals which enrolled 800 recently diagnosed (<1 year) HIV-1-infected adults, naive to antiretroviral treatment, between 2004 and 2008. Follow-up ended on 30 June 2016. Ethical approval was obtained from the Paris-Cochin Ethics Committee in July 2003. All participants gave their written informed consent. Detailed sociodemographic, clinical and biological data were collected at enrolment and every 6 months thereafter. In addition, individuals were asked to complete a self-administered questionnaire at enrolment and each year about various dimensions of their living conditions and depressive symptoms, as measured by the French version of the Center for Epidemiologic Studies-Depression Scale (CES-D) [12,13]. Help to complete the questionnaire was provided by a non-medical health-care professional when necessary.

Individuals were selected who started a first ART, defined as strategies consisting of at least three antiretroviral drugs with two nucleoside reverse transcriptase inhibitors, plus one boosted protease inhibitor (PI; atazanavir, saquinavir, lopinavir, fosamprenavir, darunavir) or unboosted atazanavir, one non-nucleoside reverse transcriptase inhibitor (nevirapine, efavirenz, etravirine, rilpivirine), one integrase inhibitor (raltegravir, dolutegravir) and/or one entry/fusion inhibitor (maraviroc, enfuvirtide), between 2004–2014, that is, at least 1 year before the last database update, had a pre-ART HIV plasma viral load (pVL) assessment available within the previous 6 months, and subsequently achieved viral suppression (HIV pVL ≤50 copies/ml) within 1 year after ART initiation. Individuals who did not have a subsequent viral assessment after first viral suppression, did not complete the self-administered questionnaire within the 6 months preceding or following the date of first undetectability, or acquired HIV infection through intravenous (IV) drug use (a very small number of individuals) were excluded.

Statistical analysis

Geographical origin, nationality and age at arrival in France were documented at enrolment into the cohort. Participants born outside of France were considered to be migrants if they did not have French nationality or, for those with French nationality, if they arrived in France when they were older than 15 years, that is, after the age limit of compulsory education in France. Geographical origin was subdivided into three groups as follows: French natives, migrants from SSA, or migrants from other countries. Because of different socioeconomic and lifestyle factors between men having sex with men (MSM) and heterosexual HIV-infected individuals born in France, French natives were categorized into two categories according to their HIV-transmission group: MSM born in France and heterosexually infected people (HTR) born in France [14].

Educational level was collected at enrolment. Other social characteristics, such as employment status, self-perceived financial difficulties, housing conditions, partnership, HIV status disclosure and various lifestyle factors were retrieved from the self-administered questionnaire available at the time of first undetectability. In particular, self-perceived financial status was asked for with five levels of answer (you are comfortable/you are okay/it is just, you have to be careful/you get there with difficulty/you cannot do it without debts) and loneliness with four levels of answer (never lonely/occasionally lonely/often lonely/always lonely). Symptoms of depression in the preceding week were considered present if the CES-D score was above 17 for men and above 23 for women, according to the recommended cutoffs [12]. Descriptive statistics are shown as medians and interquartile ranges (IQR) or numbers and percentages with the comparisons based on the Kruskal–Wallis test for continuous variables and the χ^2 test or Fisher exact test for categorical variables.

Viral rebound was defined as one pVL >1,000 copies/ml or two consecutives pVLs between 50 and 1,000 copies/ml after first viral suppression on ART. Time to viral rebound was calculated from the date of first viral suppression to the date of the first pVL >1,000 copies/ml or the second of two consecutive pVLs between 50 and 1,000 copies/ml. Individuals not experiencing viral rebound were censored at the end of follow-up or death. End of follow-up in the database was the date of the last available viral load before 30 June 2016. Loss to follow-up was defined as an interval of more than 18 months between the last follow-up visit and the last database update. Probabilities of rebound-free survival after viral suppression on ART were assessed by Kaplan–Meier curves according to the geographical origin.

Risk factors for viral rebound were assessed using univariable and multivariable Cox models. Potential risk factors were: geographical origin, HIV transmission group, sex, calendar period of ART initiation, type of ART regimen (including PI versus including other), pVL at ART initiation, age, $CD4^+$ T-cell count

and AIDS status at undetectability, the Veterans Aging Cohort Study (VACS) index, alcohol consumption, current tobacco smoking, depression and the social variables previously listed. The VACS index, which sums weighted measures of chronological age, current CD4+ T-cell count, HIV viral load, haemoglobin, liver fibrosis, kidney function and HCV coinfection has been proposed as a measure of frailty for HIV-infected people [15] and is a good predictor of vulnerability and multimorbidity in these individuals [16]. A VACS score cutoff ≥35 was associated with a poorer prognosis in an ART-treated socially vulnerable population [17]. As no study had previously studied the association between the VACS index and viral rebound, we sought to assess the impact of a VACS index of ≥35 as a possible tool to assess frailty, regardless of social conditions. We could not assess viral hepatitis B or C as risk factors, because too few participants were coinfected.

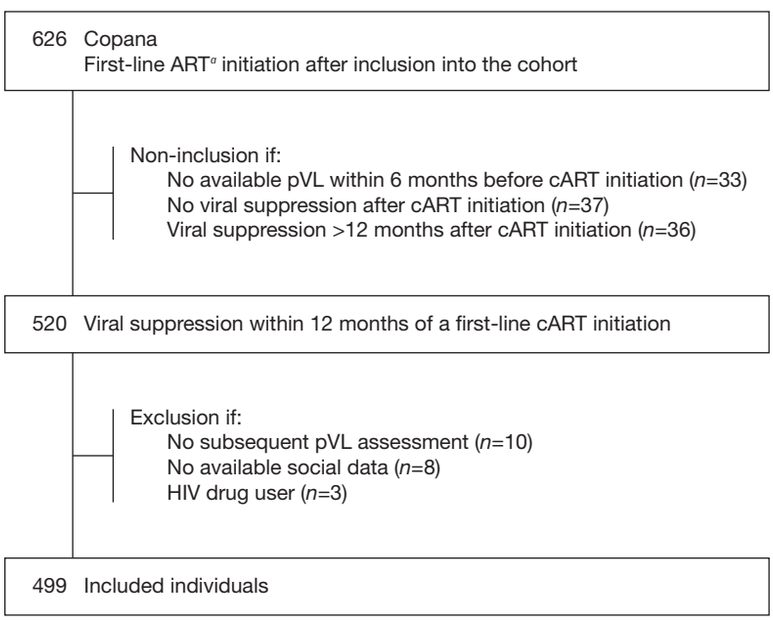
All variables associated with a *P*-value <0.10 in the univariable analysis were considered for the multivariable analyses. To take into account the correlations between some of the social variables and to select the relevant variables for a parsimonious multivariable model, we first used bivariable analyses to identify confounding factors that modified the HR measuring the association between migration and viral rebound by more than 10%. Two multivariable analyses were separately conducted with overall HIV status disclosure included (model 1) or based on the person(s) in the social network to whom HIV status was disclosed (model 2). Sensitivity analyses were also performed with the exclusion of women initiating ART for pregnancy, that is, those who initiated ART between 12 months before and 12 months after a pregnancy date was recorded in the database. Indeed, transient ART was recommended for pregnant women with CD4+ T-cell counts >350/mm^3 until 2013, when national guidelines recommended universal ART, regardless of the CD4+ T-cell count level [18]. Data were analysed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Study population

A total of 499 individuals were included in this analysis (Figure 1), among whom 288 (57.7%) were natives of France, 158 (31.7%) were natives of SSA, either Central Africa (*n*=80), West Africa (*n*=71) or East Africa (*n*=7), and 53 (10.6%) were natives of another country, either Europe (*n*=18), South America (*n*=16), North Africa (*n*=12) or South-East Asia/Middle East (*n*=7). The median (IQR) age at arrival in France was 29 years (25–34) for migrants from SSA (*n*=124) and 27 (24–31)

Figure 1. Flow chart



[a]Antiretroviral therapy (ART) regimens were defined as consisting of at least three drugs, combining two nucleoside reverse transcriptase inhibitors and one boosted protease inhibitor or unboosted atazanavir, one non-nucleoside reverse transcriptase inhibitor (nevirapine, efavirenz, etravirine or rilpivirine), one integrase inhibitor (raltegravir or dolutegravir) and/or one entry/fusion inhibitor. pVL, plasma viral load.

for migrants from other countries (*n*=26), with a length of time in France before HIV diagnosis of 2 (0–5) and 5 (3–14) years, respectively.

Characteristics at the time of ART initiation are described in Table 1. The study included 350 (70.1%) men and the median (IQR) age was 37.9 years (32.0–46.4). Non-migrants were mainly MSM (65.6%) and migrants from SSA were mainly women (63.9%). Although migrants from SSA were the youngest people, they were the most fragile ones as measured by the VACS index. Lower socio-economic conditions were more frequent for migrants, either from SSA or other countries, than for French natives, with a lower educational level, lower rate of employment or in retirement, lower rate of comfortable self-perceived financial status, and a higher rate of unstable living conditions, migrants from SSA experiencing the worst conditions and French natives the best. For example, 79 migrants from SSA were employed or retired (50%), 36 other migrants (68%) and 254 French natives (88%); financial status was perceived as comfortable for 27 migrants from SSA (18%), 19 other migrants (37%) and 162 French natives (56%). Migrants from SSA had more frequent symptoms of depression and less frequent alcohol consumption or tobacco smoking. HIV status was disclosed significantly less frequently by migrants, either from SSA or other countries, and the perception of loneliness was also greater in this group.

Occurrence of viral rebound after achievement of viral suppression on ART

Median follow-up (IQR) after viral suppression on ART was 6.3 (3.7–8.1) years. Viral rebound occurred in 116 individuals during 2,189 person-years (PY) of follow-up (incidence rate: 5.3 cases per 100 PY; 95% confidence interval [CI]: 4.3, 6.3). Viral rebound occurred within a median interval of 1.4 years (IQR 0.7–2.7) after the first undetectable pVL. In individuals enrolled in this analysis, loss to follow-up, defined as an interval of more than 18 months between the last follow-up visit and the last database update, occurred in 133 individuals within a median time of 3.0 years (IQR 1.3–4.6) after undetectability.

Kaplan–Meier curves of rebound-free survival after viral suppression on ART according to the geographical origin are given in Figure 2. Kaplan–Meier probabilities of survival without viral rebound were the highest for French natives MSM and HTR and the lowest for migrants from SSA (P<0.001).

Characteristics associated with viral rebound

Sociodemographic variables

Table 2 shows the HRs of viral rebound associated with geographical origin alone or with geographical origin associated with each studied covariable. In the univariable analyses, HR for viral rebound was 2.5-fold higher among individuals from SSA (HR 2.49; 95% CI 1.59, 3.90) and twofold higher among individuals from other countries (HR 1.78; 95% CI 0.94, 3.88) than among MSM born in France. There was no difference in the risk of viral rebound between HTR born in France and MSM born in France. Viral rebound occurred more frequently for individuals with a lower education status, those unemployed or incapacitated, with a less comfortable financial status, living with others or in an unstable housing situation, or who did not disclose their HIV status. Within the social network, disclosure to the mother and disclosure to friend(s) were associated with a 46% and 59% lower risk of viral rebound than non-disclosure to these persons, respectively, whereas disclosure to sexual partners, other relatives or colleagues were not associated with viral rebound.

After separate adjustment for each significant covariable, only educational level, self-perceived financial status, overall HIV status disclosure and HIV status disclosure to friend(s) modified the relationship between geographical origin and viral rebound by ≥10%.

In multivariable analysis (Table 3), the HR of viral rebound associated with migrant status, either from SSA or other countries, was no longer statistically significant. The only socioeconomic variables which remained significantly associated with viral rebound were self-perceived financial status and HIV status disclosure to friend(s). The adjusted HRs were 1.65 (95% CI 0.97, 2.80) for individuals who reported financial difficulties or debts versus those who found their financial status comfortable, and 0.57 (95% CI 0.35, 0.93) for those who disclosed their HIV status to at least one friend versus those who did not.

HIV and health-related variables

In univariable analysis, type of ART, AIDS status and VACS index ≥35 were associated with viral rebound. In multivariable analyses, individuals initiating PI-containing ART had a 69% (95% CI 10%, 156%) higher risk of viral rebound than those initiating another ART, and those with a VACS index ≥35 had a 50% (95% CI -2%, 128%) higher risk of viral rebound than those with a lower VACS index.

Similar results for all analyses were obtained when women who initiated ART for pregnancy were excluded. Of note, $CD4^+$ T-cell count at cART initiation did not modify the association between geographical origin and viral rebound.

Discussion

Migrants living in France, either from SSA or other countries, had a 2- to 2.5-fold increased risk of viral rebound than individuals born in France in the context

Table 1. Characteristics of the study patients at ART initiation and at the date of viral suppression on ART according to the region of origin (*n*=499)

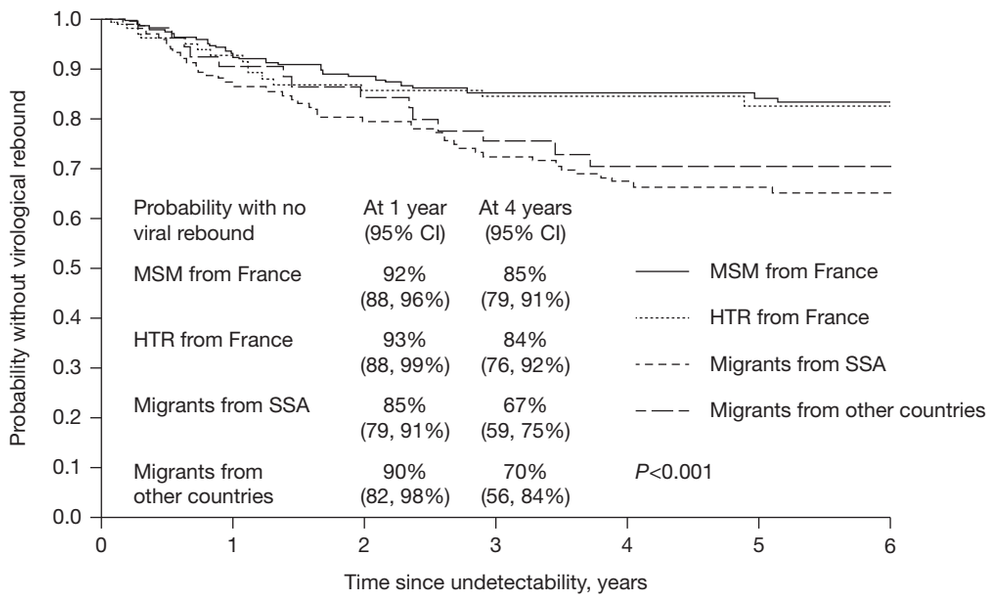
	France (*n*=288)	SSA (*n*=158)	Other (*n*=53)	*P*-value[a]
At ART initiation				
HIV transmission group				
Homosexual men	189 (65.6)	6 (3.8)	28 (52.8)	
Heterosexual men	63 (21.9)	51 (32.3)	13 (24.5)	
Heterosexual women	36 (12.5)	101 (63.9)	12 (22.6)	<0.001
Period				
2004–2007	148 (51.4)	112 (70.9)	34 (64.2)	
2008–2014	140 (48.6)	46 (29.1)	19 (35.8)	<0.001
Type of ART				
2 NRTI + 1 PI	179 (62.1)	101 (64.0)	30 (56.6)	
2 NRTI + 1 NNRTI	88 (30.6)	56 (35.4)	20 (37.7)	
2 NRTI + 1 II/other	21 (7.3)	1 (0.6)	3 (5.7)	0.01
$CD4^+$ T-cell count/mm^3	287 (206–366)	259 (179–372)	258 (156–365)	0.16
Plasma VL, log_{10} copies/ml	4.8 (4.2–5.2)	4.4 (3.8–5.1)	4.7 (4.3–5.1)	0.008
At viral suppression				
Age, years	38.8 (33.0–48.4)	35.9 (30.6–42.3)	40.6 (33.1–46.3)	0.003
Time since ART, months	4.1 (2.8–6.3)	3.7 (2.5–5.8)	5.3 (3.4–6.7)	0.02
$CD4^+$ T-cell count/mm^3	416 (297–517)	364 (259–471)	426 (329–527)	0.03
AIDS status	26 (9.0)	18 (11.4)	18 (13.2)	0.50
HBV/HCV infection[b]	15 (5.2)	15 (9.5)	5 (9.4)	0.15
VACS index ≥35	50 (17.4)	47 (29.8)	11 (20.8)	0.01
Alcohol consumption[c]	29 (10.1)	9 (5.7)	9 (17.0)	0.04
Tobacco smoking[d]	116 (40.3)	23 (14.6)	23 (43.4)	<0.001
Depression[e]	*n*=281	*n*=142	*n*=47	
Yes	88 (31.3)	64 (45.1)	18 (38.3)	0.02
Educational level	*n*=284	*n*=152	*n*=51	
Primary	7 (2.4)	34 (22.4)	7 (13.7)	
Lower secondary	11 (3.9)	25 (16.4)	4 (7.8)	
Upper secondary	126 (44.4)	52 (34.2)	19 (37.3)	
Higher	140 (49.3)	41 (27.0)	21 (41.2)	<0.001
Employment status				
Employed/retired	254 (88.2)	79 (50.0)	36 (67.9)	
Unemployed/incapacitated	34 (11.8)	79 (50.0)	17 (32.1)	<0.001
Self-perceived financial status	*n*=288	*n*=154	*n*=51	
Comfortable	162 (56.3)	27 (17.5)	19 (37.3)	
Just	95 (33.0)	35 (22.7)	14 (27.5)	
Difficult/debts	31 (10.8)	92 (59.7)	18 (35.3)	<0.001
Housing				
Owner/rental	262 (91.0)	80 (50.6)	38 (71.7)	
Living with other/unstable	26 (9.0)	78 (49.4)	15 (28.3)	<0.001
Marital status	*n*=288	*n*=156	*n*=52	
Single	148 (51.4)	74 (47.4)	23 (44.2)	
Married/living together	114 (39.6)	66 (42.3)	23 (44.2)	
Divorced/separate/widower	26 (9.0)	16 (10.3)	6 (11.5)	0.83
Overall HIV status disclosure	261 (90.6)	96 (60.8)	33 (62.3)	<0.001
Disclosure to the steady partner	156 (54.2)	52 (32.9)	18 (34.0)	<0.001
Disclosure to the father	41 (14.2)	4 (2.5)	2 (3.8)	<0.001
Disclosure to the mother	68 (23.6)	10 (6.3)	6 (11.3)	<0.001
Disclosure to the sibling(s)	99 (34.4)	38 (24.1)	5 (9.4)	<0.001
Disclosure to the child(ren)	17 (5.9)	7 (4.4)	3 (5.7)	0.80
Disclosure to other relative(s)	57 (19.8)	16 (10.1)	5 (9.4)	0.01

Data are presented as counts (proportions) and medians (interquartile range). [a]The χ^2 or Fisher exact and Kruskal–Wallis tests were used to compare the demographic, immunovirological and clinical characteristics of the individuals; [b]hepatitis B surface antigen-positive or anti-HCV antibody-positive; [c]alcohol consumption: >2 glasses/day; [d]tobacco smoking: at least 1 cigarette/day; [e]according to the Center for Epidemiologic Studies-Depression (CES-D) score. ART, antiretroviral therapy; II, integrase inhibitor; NNRTI, non-nucleoside reverse transcriptase inhibitor; NRTI, nucleoside reverse transcriptase inhibitor; PI, protease inhibitor; SSA, sub-Saharan Africa; VACS, Veterans Aging Cohort Study; VL, viral load.

Table 1. Continued

	France (*n*=288)	SSA (*n*=158)	Other (*n*=53)	*P*-value[a]
Disclosure to friend(s)	195 (67.7)	30 (19.0)	18 (34.0)	<0.001
Disclosure to colleague(s)	73 (25.4)	3 (1.9)	4 (7.6)	<0.001
Perception of loneliness	*n*=287	*n*=155	*n*=52	
Always/often	57 (19.9)	59 (38.1)	16 (30.8)	<0.001
Occasionally/never	230 (80.1)	96 (61.9)	36 (69.2)	<0.001

Figure 2. Kaplan–Meier curves of the probability of not having a viral rebound, according to geographical origin and HIV transmission group



At risk, *n*	0 years	2 years	4 years	6 years
MSM from France	189	151	115	80
HTR from France	99	71	57	42
Migrants from SSA	158	106	79	55
Migrants from other countries	53	40	26	14

HTR, heterosexual; MSM, men having sex with men; SSA, sub-Saharan Africa.

of universal and free access to health care and treatment for HIV infection. Educational level, HIV status disclosure and financial difficulties contributed the most to the increased risk of viral rebound in migrants. After adjustment for type of ART, VACS index, educational level, self-perceived financial status and HIV status disclosure, geographical origin was no longer associated with the risk of viral rebound. In contrast, the risk of viral rebound was higher in cases of PI-containing ART, frailty with a VACS index ≥35, bad financial status (difficulties or debts) and non-disclosure to friend(s).

This study has some limitations. Individuals lost to follow-up accounted for 27% of the whole population. However, time from undetectability to loss to follow-up was longer than time to viral rebound in this population and bias due to loss to follow-up, if any, should be moderate. In an alternative analysis considering loss to follow-up as a competing risk, the association of the

Table 2. Relative hazards of viral rebound in univariable and bivariable (to identify potential confounders that change the HRs of rebound associated with geographical origin ≥10%) Cox regression models: 116 viral rebounds in 499 patients

	n/total *n* (%)[a]	Univariable analysis, HR (95% CI)	Bivariable analysis including geographical origin[b], HR (95% CI)
At ART initiation			
Geographical origin			
MSM from France	29/189 (15.3)	1.00	
HTR from France	16/99 (16.2)	1.06 (0.58, 1.96; *P*=0.84)	
Migrants from SSA	57/158 (36.1)	2.49 (1.59, 3.90; *P*<0.001)	
Migrants from other countries	14/53 (26.4)	1.78 (0.94, 3.88; *P*=0.08)	
Sex			
Male	69/350 (19.7)	1.00	1.00
Female	47/149 (31.5)	1.68 (1.16, 2.44; *P*=0.006)	1.13 (0.72, 1.76; *P*=0.61)
Geographical origin			
MSM from France			1.00
HTR from France			1.02 (0.54, 1.92; *P*=0.95)
Migrants from SSA			2.31 (1.35, 3.95; *P*=0.002)
Migrants from other countries			1.74 (0.91, 3.32; *P*=0.10)
Period			
2004–2007	80/294 (27.2)	1.00	
2008–2014	36/205 (17.6)	0.78 (0.52, 1.17; *P*=0.23)	
Type of ART			
2 NRTI + PI	84/310 (27.1)	1.00	1.00
2 NRTI + other	32/189 (16.9)	0.58 (0.39, 0.88; *P*=0.009)	0.58 (0.39, 0.87; *P*=0.008)
Geographical origin			
MSM from France			1.00
HTR from France			1.05 (0.57, 1.95; *P*=0.87)
Migrants from SSA			2.49 (1.59, 3.90; *P*<0.001)
Migrants from other countries			1.83 (0.97, 3.47; *P*=0.06)
$CD4^+$ T-cell count			
<200/mm^3	42/132 (31.8)	1.00	1.00
200–350/mm^3	42/212 (19.8)	0.63 (0.41, 0.97; *P*=0.04)	0.66 (0.43, 1.01; *P*=0.06)
≥350/mm^3	32/155 (20.7)	0.72 (0.45, 1.14; *P*=0.15)	0.75 (0.47, 1.20; *P*=0.24)
Geographical origin			
MSM from France			1.00
HTR from France			1.03 (0.56, 1.90; *P*=0.93)
Migrants from SSA			2.45 (1.56, 3.84; *P*<0.001)
Migrants from other countries			1.68 (0.88, 3.19; *P*=0.11)
Plasma VL			
<4 $\log_{10}$ copies/ml	26/119 (21.9)	1.00	
4–5 $\log_{10}$ copies/ml	45/211 (21.3)	0.87 (0.54, 1.41; *P*=0.58)	
≥5 $\log_{10}$ copies/ml	45/169 (26.6)	1.10 (0.67, 1.78; *P*=0.71)	
At undetectability			
Age[c]	–	0.90 (0.75, 1.08; *P*=0.26)	
Time since ART[d]	–	1.00 (0.99, 1.00; *P*=0.96)	
$CD4^+$ T-cell count			
<350/mm^3	41/190 (21.6)	1.00	
350–500/mm^3	43/173 (24.9)	1.22 (0.79, 1.87; *P*=0.37)	
≥500/mm^3	31/129 (24.0)	1.16 (0.73, 1.85; *P*=0.54)	
AIDS status	18/51 (35.3)	1.63 (0.98, 2.69; *P*=0.06)	1.52 (0.92, 2.51; *P*=0.11)
Geographical origin			
MSM from France			1.00
HTR from France			1.06 (0.57, 1.95; *P*=0.86)
Migrants from SSA			2.45 (1.56, 3.84; *P*<0.001)
Migrants from other countries			1.72 (0.91, 3.26; *P*=0.10)

[a]*n* rebound within total *n* people at risk (proportion with viral rebound within the modality); [b]bivariable analyses include geographical origin and each individual variable associated with viral rebound in the univariable analysis (*P*<0.10); [c]hazard ratio (HR) is estimated for 10-year increments; [d]HR is estimated for 1-month increments; [e]variables modifying the viral rebound HR associated with sub-Saharan Africa (SSA) or other origin by ≥10%. ART, antiretroviral therapy; HTR, heterosexual; MSM, men having sex with men; NRTI, nucleoside reverse transcriptase inhibitor; PI, protease inhibitor; VACS, Veterans Aging Cohort Study; VL, viral load.

Table 2. Continued

	n/total *n* (%)[a]	Univariable analysis, HR (95% CI)	Bivariable analysis including geographical origin[b], HR (95% CI)
VACS index ≥35	36/108 (33.3)	1.75 (1.18, 2.59; *P*=0.006)	1.50 (1.00, 2.24; *P*=0.05)
Geographical origin			
MSM from France			1.00
HTR from France			1.02 (0.56, 1.89; *P*=0.94)
Migrants from SSA			2.30 (1.46, 3.63; *P*<0.001)
Migrants from other countries			1.72 (0.91, 3.27; *P*=0.10)
Alcohol consumption	12/47 (25.5)	1.05 (0.58, 1.91; *P*=0.87)	
Tobacco smoking	35/162 (21.6)	0.90 (0.61, 1.34; *P*=0.61)	
Depression	45/170 (26.5)	1.29 (0.88, 1.89; *P*=0.20)	
Educational level			
Primary/lower secondary	28/88 (31.8)	1.00	1.00
Upper secondary	49/197 (24.9)	0.75 (0.47, 1.19; *P*=0.22)	1.05 (0.64, 1.72; *P*=0.85)
Higher	33/202 (16.3)	0.47 (0.29, 0.78; *P*=0.004)	0.68 (0.39, 1.16; *P*=0.17)
Geographical origin			
MSM from France			1.00
HTR from France			0.90 (0.48, 1.70; *P*=0.75)[c]
Migrants from SSA			2.12 (1.30, 3.47; *P*=0.003)[c]
Migrants from other countries			1.58 (0.81, 3.07; *P*=0.18)[c]
Employment status			
Employed/retired	72/369 (19.5)	1.00	1.00
Unemployed/incapacitated	44/130 (33.9)	1.77 (1.22, 2.58; *P*=0.003)	1.25 (0.83, 1.90; *P*=0.29)
Geographical origin			
MSM from France			1.00
HTR from France			1.06 (0.58, 1.96; *P*=0.84)
Migrants from SSA			2.26 (1.39, 3.68; *P*=0.001)
Migrants from other countries			1.69 (0.89, 3.23; *P*=0.11)
Self-perceived financial status			
Comfortable	31/208 (14.9)	1.00	1.00
Just	30/144 (20.8)	1.32 (0.80, 2.18; *P*=0.28)	1.24 (0.75, 2.05; *P*=0.41)
Difficult/debts	54/141 (38.3)	2.61 (1.68, 4.07; *P*<0.001)	1.86 (1.11, 3.10; *P*=0.02)
Geographical origin			
MSM from France			1.00
HTR from France			1.09 (0.59, 2.01; *P*=0.79)
Migrants from SSA			1.90 (1.14, 3.15; *P*=0.01)[c]
Migrants from other countries			1.49 (0.77, 2.90; *P*=0.24)[c]
Housing			
Owner/rental	76/380 (20.0)	1.00	1.00
Living with other/unstable	40/119 (33.6)	1.58 (1.07, 2.32; *P*=0.02)	1.10 (0.73, 1.68; *P*=0.65)
Geographical origin			
MSM from France			1.00
HTR from France			1.06 (0.58, 1.95; *P*=0.85)
Migrants from SSA			2.39 (1.48, 3.87; *P*<0.001)
Migrants from other countries			1.75 (0.92, 3.33; *P*=0.09)
Marital status			
Single	60/245 (24.5)	1.00	
Married/living together	43/203 (21.2)	0.85 (0.58, 1.26; *P*=0.42)	
Divorced/separate/widower	13/48 (27.1)	1.04 (0.57, 1.90; *P*=0.89)	
HIV status disclosure	76/390 (19.5)	0.49 (0.33, 0.72; *P*<0.001)	0.65 (0.43, 0.99; *P*=0.05)
Geographical origin			
MSM from France			1.00
HTR from France			1.07 (0.58, 1.97; *P*=0.84)
Migrants from SSA			2.15 (1.34, 3.46; *P*=0.002)[c]
Migrants from other countries			1.51 (0.78, 2.93; *P*=0.22)[c]
Disclosure to the partner	46/226 (20.4)	0.82 (0.57, 1.19; *P*=0.30)	
Disclosure to the father	7/47 (14.9)	0.65 (0.30, 1.39; *P*=0.27)	

Table 2. Continued

	n/total *n* (%)[a]	Univariable analysis, HR (95% CI)	Bivariable analysis including geographical origin[b], HR (95% CI)
Disclosure to the mother	11/84 (13.1)	0.54 (0.29, 1.01; *P*=0.06)	0.68 (0.36, 1.27; *P*=0.23)
Geographical origin			
MSM from France			1.00
HTR from France			1.04 (0.56, 1.92; *P*=0.91)
Migrants from SSA			2.35 (1.49, 3.71; *P*<0.001)
Migrants from other countries			1.70 (0.89, 3.23; *P*=0.11)
Disclosure to the sibling(s)	28/142 (19.7)	0.77 (0.50, 1.17; *P*=0.22)	
Disclosure to the child(ren)	8/27 (29.6)	1.44 (0.70, 2.95; *P*=0.32)	
Disclosure to other relative(s)	15/78 (19.2)	0.82 (0.48, 1.42; *P*=0.48)	
Disclosure to friend(s)	34/243 (14.0)	0.41 (0.27, 0.61; *P*<0.001)	0.52 (0.33, 0.82; *P*=0.005)
Geographical origin			
MSM from France			1.00
HTR from France			0.94 (0.50, 1.74; *P*=0.83)[c]
Migrants from SSA			1.77 (1.07, 2.92; *P*=0.03)[c]
Migrants from other countries			1.37 (0.71, 2.65; *P*=0.36)[c]
Disclosure to colleague(s)	14/80 (17.5)	0.68 (0.39, 1.19; *P*=0.18)	
Perception of loneliness			
Always/often	34/132 (25.8)	1.00	
Occasionally/never	82/362 (22.7)	0.80 (0.54, 1.19; *P*=0.27)	

Table 3. Relative hazard (95% CI) of viral rebound: univariable and multivariable Cox regression models

	HR (95% CI)	Model 1, aHR (95% CI)	Model 2, aHR (95% CI)
At ART initiation			
Geographical origin			
MSM from France	1.00	1.00	1.00
HTR from France	1.06 (0.58, 1.96)	0.93 (0.49, 1.76; *P*=0.82)	0.87 (0.46, 1.65; *P*=0.68)
Migrants from SSA	2.49 (1.59, 3.90)	1.42 (0.81, 2.50; *P*=0.22)	1.21 (0.68, 2.16; *P*=0.53)
Migrants from other countries	1.78 (0.94, 3.88)	1.18 (0.58, 2.42; *P*=0.65)	1.06 (0.52, 2.18; *P*=0.88)
Type of ART			
2 NRTI + PI	1.00	1.00	1.00
2 NRTI + other	0.58 (0.39, 0.88)	0.59 (0.39, 0.91; *P*=0.02)	0.61 (0.40, 0.93; *P*=0.02)
At undetectability			
VACS index ≥35	1.75 (1.18, 2.59)	1.50 (0.98, 2.28; *P*=0.06)	1.40 (0.92, 2.14; *P*=0.12)
Educational level			
Primary/lower secondary	1.00	1.00	1.00
Upper secondary	0.75 (0.47, 1.19)	0.97 (0.59, 1.60; *P*=0.91)	1.00 (0.61, 1.64; *P*=0.99)
Higher	0.47 (0.29, 0.78)	0.72 (0.42, 1.24; *P*=0.24)	0.76 (0.44, 1.31; *P*=0.33)
Self-perceived financial status			
Comfortable	1.00	1.00	1.00
Just	1.32 (0.80, 2.18)	0.98 (0.57, 1.66; *P*=0.93)	0.94 (0.55, 1.61; *P*=0.83)
Difficult/debts	2.61 (1.68, 4.07)	1.65 (0.97, 2.80; *P*=0.06)	1.61 (0.95, 2.73; *P*=0.08)
HIV status disclosure	0.49 (0.33, 0.72)	0.75 (0.48, 1.19; *P*=0.22)	–
Disclosure to friend(s)	0.41 (0.27, 0.61)	–	0.57 (0.35, 0.93; *P*=0.02)

aHR, adjusted hazard ratio; ART, antiretroviral therapy; HR, hazard ratio; HTR, heterosexual; MSM, men having sex with men; NRTI, nucleoside reverse transcriptase inhibitor; PI, protease inhibitor; SSA, sub-Saharan Africa; VACS, Veterans Aging Cohort Study.

different factors with viral rebound remained similar (data not shown). Illegal migrants could not be included in the COPANA Cohort for regulatory rules. However, overall demographic characteristics, particularly sex, age, percentages of men having sex with men, individuals born in sub-Saharan Africa, and CD4$^+$ T-cell counts were comparable to those recorded in the HIV diagnosis notification data in 2004–2008. We were unable

to categorize migrants according to HIV transmission group and sex due to the low numbers in each category. However, in a model that included only geographical origin and sex, the association between sex and viral rebound disappeared, whereas the association between migration and viral rebound remained statistically significant. Moreover, in a multivariable model including sex and variables associated with viral rebound, but not geographical origin, sex was no longer associated with viral rebound (data not shown). The rate of missing data on socioeconomic variables was very low overall, between 1 and 6%, and well balanced between the groups. We did not have results on baseline genotypic resistance testing. As all subjects had had a rapid response to antiretroviral therapy, the onset of viral rebound was not due to resistance, but much more likely to be due to adherence difficulties. Migrants started their first ART more frequently during the earlier period than other individuals, when only antiretroviral drugs with more side effects and higher pill burden were available. Models were thus adjusted for type of ART. Finally, we had no data on travel abroad, which is more frequent for migrants than non-migrants and associated with an increased risk of viral rebound in migrants born in SSA, at least partly due to a lower adherence during trips [4,19,20]. We might not have adjusted for all potential confounders. However, in the multivariable models, association between migration and viral rebound was lowered and no longer significant. In particular, our results show that non-disclosure may be an intermediate factor that would explain why some migrants from SSA are at higher risk of viral rebound after an initial virological response. The major strengths of our study are its prospective longitudinal design, allowing repeated biological measures and socioclinical data reports, and the availability of a large set of psychosocioeconomic variables, along with HIV-related variables.

Socioeconomic status (education, employment, income/financial status, housing, health insurance, neighbourhood-level socioeconomic factors) influences the response to first ART in European countries with free access to care for HIV [10,21–23], with a lower association after adjustment for non-adherence in several studies. Although most of these studies were adjusted for HIV-related factors and ethnic or geographical origin, none could assess the impact of socioeconomic variables on the association between ethnic origin or migrant status and viral response. After a first viral response, geographical origin is associated with viral rebound [11]. Our study clearly suggests that crude association between geographical origin and viral rebound was driven by socioeconomic factors, that is, bad financial status and non-disclosure to friends.

Viral rebound on ART was also assessed in one cross-sectional study with a longitudinal sub-analysis in the United Kingdom, showing an association between financial hardship, non-employment, unstable housing, non-university education, and self-reported ART non-adherence or viral non-suppression [9]. In this study, the questionnaire response rate was only 64%, and socioeconomic factors and viral outcome on ART were unknown for individuals who did not answer the questionnaire. Both individuals on first-line or subsequent-line regimens with possible previous viral failure or rebounds were included and no adjustment for the type of ART was performed. A French cross-sectional study showed that, even after adjustment for self-reported adherence, socioeconomic factors, such as unemployment or lower education level, were associated with viral replication on ART [24]. Here, we had the opportunity to assess factors associated with a first viral rebound in individuals with previous viral suppression on a first-line regimen in a longitudinal cohort study with a high rate of questionnaire responses. Lower socio-economic status, regardless of the condition, was more frequent for migrants than non-migrants. It is well known that the level of hardship is high after immigration [25,26] and that migrants are at higher risk for late HIV diagnosis, delayed ART initiation and lower virological response on cART than non-migrants in European countries [27,28]. After adjustment, only a bad financial status was associated with viral rebound among the various assessed socioeconomic variables. Lower financial status among migrants may explain lower treatment compliance due to other socioeconomic priorities than HIV care.

In addition, higher crude rates of viral replication on ART or subsequent viral rebound in non-White individuals or migrants relative to natives were no longer observed after adjustment for socioeconomic factors in these two cross-sectional studies [9,24]. We also found that migration status, either from SSA or another country, was no longer associated with viral rebound after adjustment for various socioeconomic factors. After separate adjustment for each covariable, only educational level, financial status and HIV status disclosure modified the relationship between geographical origin and viral outcome, thus explaining the crude association found in our study. Overall, non-disclosure of HIV status, which was more frequent in migrants, was associated with viral rebound. Among the various components of disclosure, only disclosure to friend(s) was associated with a lower risk of viral rebound. Individuals living alone appeared to more frequently reveal their HIV status to their social network beyond their sexual partner. HIV status disclosure by these individuals may reveal a need for psychological social support [29,30]. This should thus be encouraged, as it is associated with

higher levels of social support, infrequent discrimination and better adherence [19,30,31]. A stronger or more supportive social network was also associated with less viral replication in previous studies [9,24].

We had the opportunity to assess other factors, such as lifestyle (tobacco smoking or alcohol consumption) and psychological factors (depression or perception of loneliness) and marital status, none of which were found to be associated with viral rebound in our study. PI-containing ART, less tolerable than other regimens, was predictive of viral rebound, as previously shown [32]. VACS index, a composite score including various variables associated with vulnerability and comorbidities, was associated with viral rebound; VACS index can be considered as a surrogate marker of vulnerability and lower adherence as previously shown [33].

In conclusion, a high rate of viral rebound occurred after viral suppression on ART in our study. Socioeconomic factors affect outcomes on ART, even in the context of a high-income country with free access to HIV care and treatment. Patient-centred strategies to improve adherence should be encouraged, with the participation of social workers to address basic needs and intercultural mediators to promote social support in more socially vulnerable individuals, such as migrants. Educational interventions would help to lower health inequalities in people infected with HIV by reducing fear of stigmatization and improving linkage to care and adherence to cART after HIV diagnosis. Augmentation of the social network and HIV disclosure should be promoted as it is associated with better adherence levels. Public health policies should aim to reduce the socioeconomic insecurity experienced by some migrants, more particularly the most recently arrived ones.

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Conceptualization: SA, MRM; data curation: MG; formal analysis: SA, MRM; investigation: SA, MRM, RS, MG, SM, GP, CG, LM; methodology: SA, MRM, LM; supervision: SA, LM; writing original draft: SA, MRM; writing review and editing: SA, MRM, RS, MG, SM, GP, CG, LM. All authors have read and approved the final manuscript.
A list of the ANRS CO9-COPANA study group members can be found in Additional file 1.

Disclosure statement

The authors declare no competing interests.

Additional file

Additional file 1: A list of the ANRS CO9-COPANA study group members can be found at https://www.intmedpress.com/uploads/documents/AVT-19-OA-4554_Abgrall_Addfile1.pdf

References

1. Gourlay A, Noori T, Pharris A, *et al*. The human immunodeficiency virus continuum of care in European Union countries in 2013: data and challenges. *Clin Infect Dis* 2017; **64:**1644–1656.
2. Monge S, Alejos B, Dronda F, *et al*. Inequalities in HIV disease management and progression in migrants from Latin America and sub-Saharan Africa living in Spain. *HIV Med* 2013; **14:**273–283.
3. Saracino A, Lorenzini P, Lo Caputo S, *et al*. Increased risk of virologic failure to the first antiretroviral regimen in HIV-infected migrants compared to natives: data from the ICONA cohort. *Clin Microbiol Infect* 2016; **22:**288.e1–288.e8.
4. Gebreselassie HM, Kraus D, Fux CA, *et al*. Ethnicity predicts viral rebound after travel to the tropics in HIV-infected travelers to the tropics in the Swiss HIV Cohort Study. *HIV Med* 2017; **18:**564–572.
5. Monge S, Mocroft A, Sabin A, *et al*. Immunological and virological response to antiretroviral treatment in migrant and native men and women in Western Europe; is benefit equal for all? *HIV Med* 2018; **19:**42–48.
6. Dray-Spira R, Spire B, Heard I, Lert F, VESPA Study Group. Heterogeneous response to HAART across a diverse population of people living with HIV: results from the ANRS-EN12-VESPA Study. *AIDS* 2007; **21 Suppl 1:**S5–S12.
7. Supervie V, Marty L, Lacombe JM, Dray-Spira R, Costagliola D, FHDH-ANRS CO4 study group. Looking beyond the cascade of HIV care to end the AIDS epidemic: estimation of the time interval from HIV infection to viral suppression. *J Acquir Immune Defic Syndr* 2016; **73:**348–355.
8. de Monteynard LA, Matheron S, Gilquin J, *et al*. Influence of geographic origin, sex and HIV transmission group on the outcome of first-line combined antiretroviral therapy in France. *AIDS* 2016; **30:**2235–2246.
9. Burch LS, Smith CJ, Anderson J, *et al*. Socioeconomic status and treatment outcomes for individuals with HIV on antiretroviral treatment in the UK: cross-sectional and longitudinal analyses. *Lancet Public Health* 2016; **1:**e26–e36.
10. Del Amo J, Lodi S, Dray-Spira R, *et al*. Inequalities by educational level in response to combination antiretroviral treatment and survival in HIV-positive men and women in Europe. *AIDS* 2017; **31:**253–262.
11. Staehelin C, Keiser O, Calmy A, *et al*. Longer term clinical and virological outcome of sub-Saharan African participants on antiretroviral treatment in the Swiss HIV Cohort Study. *J Acquir Immune Defic Syndr* 2012; **59:**79–85.
12. Fuhrer R, Rouillon F. [The French version of the CES-D (Center for Epidemiologic Studies-Depression) Scale. Description and translation of the self-evaluation scale]. *Psychiatr Psychobiol* 1989; **4:**163–166. French.
13. Seng R, Ghislain M, Girard PM, *et al*. Sub-Saharan Africa migrants have slower initial CD4 cell recovery after cART initiation than French natives, regardless of living conditions. *AIDS* 2017; **31:**1323–1332.
14. Lert F, Annequin M, Tron L, *et al*. [Socioeconomic status of people living with HIV followed in hospitals in metropolitan France in 2011. First results of the ANRS-Vespa2 Survey]. *Bull Epidemiol Hebd (Paris)* 2013; **26–27:**293–299. French.
15. Escota GV, Patel P, Brooks JT, *et al*. Short communication: the Veterans Aging Cohort Study Index in an effective tool to assess baseline frailty status in a contemporary cohort of HIV-infected persons. *AIDS Res Hum Retroviruses* 2015; **31:**313–317.

16. Guaraldi G, Brothers TD, Zona S, *et al*. A frailty index predicts survival and incident multimorbidity independent of markers of HIV disease severity. *AIDS* 2015; **29:**1633–1641.
17. Cohen MH, Hotton AL, Hershow RC, *et al*. Gender-related risk factors improves mortality predictive ability of VACS index among HIV-infected women. *J Acquir Immune Defic Syndr* 2015; **70:**538–544.
18. Morlat P and the expert group on HIV infection. [Medical care for people infected with HIV]. Paris: Flammarion médecine-sciences. 2013. French. (Accessed 23 July 2018.) Available from http://www.sante.gouv.fr/IMG/pdf/Rapport_Morlat_2013_Mise_en_ligne.pdf
19. Abgrall S, Fugon L, Lélé N, *et al*. Visiting one's native country: the risks of nonadherence in HIV-infected sub-Saharan migrants – ANRS VIHVO Study. *J Int Assoc Provid AIDS Care* 2013; **12:**407–413.
20. Kankou JM, Bouchaud O, Lele N, *et al*. Factors associated with virological rebound in HIV-positive sub-Saharan migrants living in France after traveling back to their native country. *J Immigr Minor Health* 2019; **21:**1342–1348.
21. Sobrino-Vegas P, Rodriguez-Urrego J, Berenguer J, *et al*. Educational gradient in HIV diagnosis delay, mortality, antiretroviral treatment and response in a country with universal healthcare. *Antivir Ther* 2012; **17:**1–8.
22. Rosin C, Elzi L, Thumheer C, *et al*. Gender inequalities in the response to combination antiretroviral therapy over time: the Swiss HIV Cohort Study. *HIV Med* 2015; **16:**319–325.
23. Gueler A, Schoeni-Affolter F, Moser A, *et al*. Neighbourhood socio-economic position, late presentation and outcomes in people living with HIV in Switzerland. *AIDS* 2015; **29:**231–238.
24. D'Almeida KW, Lert F, Spire B, Dray-Spira R. Determinants of virological response to antiretroviral therapy: socio-economic status still plays a role in the era of cART. Results from the ANRS-VESPA 2 study, France. *Antivir Ther* 2016; **21:**661–670.
25. Desgrees-du-Lou A, Pannetier J, Ravalihasy A, *et al*. Is hardship during migration a determinant of HIV infection? Results from the ANRS PARCOURS study of sub-Saharan African migrants in France. *AIDS* 2016; **30:**645–656.
26. Ridolfo AL, Oreni L, Vassalini P, *et al*. Effect of legal status on the early treatment outcomes of migrants beginning combined antiretroviral therapy at an outpatient clinic in Milan, Italy. *J Acquir Immune Defic Syndr* 2017; **75:**315–321.
27. Conway AS, Esteve A, Fernandez-Quevedo M, Casabona J, PISCIS Study Group. Determinants and outcomes of late presentation of HIV infection in migrants in Catalonia, Spain: PISCIS Cohort 2004-2016. *J Immigr Minor Health* 2019; **21:**920–930.
28. Gatey C, Brun A, Hamet G, *et al*. Does region of origin influence the timing and outcome of first-line antiretroviral therapy in France? *HIV Med* 2019; **20:**175–181.
29. Kankou JM, Bouchaud O, Lele N, *et al*. Factors associated with HIV status disclosure in HIV-infected sub-Saharan migrants living in France and successfully treated with antiretroviral therapy: results from the ANRS-VIHVO study. *J Immigr Minor Health* 2017; **19:**843–850.
30. Marcellin F, Suzan-Monti M, Vilotitch A, *et al*. Disclosure of HIV status beyond sexual partners by people living with HIV in France: a call for help? Results from the National Cross-Sectional Survey ANRS-VESPA2. *AIDS Behav* 2017; **21:**196–206.
31. Bouillon K, Lert F, Sitta R, Schmauss A, Spire B, Dray-Spira R. Factors correlated with disclosure of HIV infection in the French Antilles and French Guiana: results from the ANRS-EN13-VESPA-DFA study. *AIDS* 2007; **21 Suppl 1:**S89–S94.
32. Raffi F, Hanf M, Ferry T, *et al*. Impact of baseline plasma HIV-1 RNA and time to virological suppression on virological rebound according to first-line antiretroviral therapy. *J Antimicrob Chemother* 2017; **72:**3425–3434.
33. John MD, Greene M, Hessol NA, *et al*. Geriatric assessments and association with VACS index among HIV-infected older adults in San Francisco. *J Acquir Immune Defic Syndr* 2016; **72:**534–541.

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