High levels of postmigration HIV acquisition within nine European countries

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Objective: We aimed to estimate the proportion of postmigration HIV acquisition among HIV-positive migrants in Europe.

Design: To reach HIV-positive migrants, we designed a cross-sectional study performed in HIV clinics.

Methods: The study was conducted from July 2013 to July 2015 in 57 clinics (nine European countries), targeting individuals over 18 years diagnosed in the preceding 5 years and born abroad. Electronic questionnaires supplemented with clinical data were completed in any of 15 languages. Postmigration HIV acquisition was estimated through Bayesian approaches combining extensive information on migration and patients' characteristics. $CD4^+$ cell counts and HIV-RNA trajectories from seroconversion were estimated by bivariate linear mixed models fitted to natural history data. Postmigration acquisition risk factors were investigated with weighted logistic regression.

Results: Of 2009 participants, 46% were MSM and a third originated from sub-Saharan Africa and Latin America & Caribbean, respectively. Median time in host countries was 8 years. Postmigration HIV acquisition was 63% (95% confidence interval: 57–67%); 72% among MSM, 58 and 51% in heterosexual men and women, respectively. Postmigration HIV acquisition was 71% for Latin America and Caribbean migrants and 45% for people from sub-Saharan Africa. Factors associated with postmigration HIV acquisition among heterosexual women and MSM were age at migration, length of stay in host country and HIV diagnosis year and among heterosexual men, length of stay in host country and HIV diagnosis year.

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Conclusion: A substantial proportion of HIV-positive migrants living in Europe acquired HIV postmigration. This has important implications for European public health policies.

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Introduction

Migrants most typically encompass a selected population of healthy young people [1] whose drivers are largely labour and education markets. Migration is also fuelled by economic and political instability [2]. Despite this, compared with native populations, migrants are at increased risk of many diseases, including HIV infection [3,4]. This is attributable to individual behaviours, structural factors and social inequalities [3,4] which increase the vulnerabilities of migrant populations through limited access to HIV prevention, testing and care [3,5].

In 2015, 29 747 new HIV diagnoses were reported in the European Union (EU) and the European Economic Area (EEA); information on geographical origin was available for 25 785, and of these, 9347 (37%) were in people from outside of the reporting country, migrants, and 3768 (15%) from countries with generalized HIV epidemics [6]. Most EU countries consider migrants as a priority population in their national response to HIV [7]. In the past, most HIV infections in migrants in Europe, particularly among those from sub-Saharan African (SSA), were assumed to have been imported [8,9]. There is mounting evidence that HIV infections in migrants are being increasingly acquired postmigration [10–15]. This concerns the two populations most affected by HIV in Europe, African communities and MSM from different geographical regions, but hardly any data are available from migrant MSM [16]. Knowing whether HIV acquisition occurs premigration or postmigration is critical in designing adequate HIV prevention and testing strategies. Obtaining reliable estimates, though, requires a combination of behavioural and clinical data, as well as detailed information of migratory paths which is hard to implement on routine bases. There is no consensus on how to best determine timing of HIV infection and different methodologies have adopted [12–15]. Further, all published studies to date have been confined to one city or one country and most have addressed heterosexually transmitted HIV among people from SSA [12,15,17].

In this article, we estimate the proportion of postmigration HIV acquisition, and factors associated with it, among HIV-positive migrants diagnosed with HIV in the preceding 5 years from different geographic origins living in any of the nine EU/EEA countries participating in the aMASE (Advancing Migrant Access to Health Services in Europe) study [18].

Methods

Study design, setting and participants

We designed a multicenter cross-sectional study whose full methodology has been described elsewhere [18]. Participants' were over 18 years old, diagnosed with HIV in the preceding 5 years (to minimize recall bias), living outside their country of birth and residing in one of the nine following countries for at least 6 months: Belgium, Germany, Greece, Italy, The Netherlands, Portugal, Spain, Switzerland and the United Kingdom. Patients had to consent to participate and be able to complete alone or assisted an electronic survey in any of the 15 languages (Amharic, Arabic, Dutch, English, French, German, Greek, Italian, Polish, Portuguese, Russian, Turkish, Tigrinya, Spanish and Somali). In Switzerland, migrants from neighbouring Austria, France, Germany and Italy were excluded. A convenience sample was recruited within 57 HIV clinics (Appendix 1, http://links.lww.com/QAD/B119) across the EuroCoord European Network of Excellence on HIV Research (www.eurocoord.net). Data collection took place July 2013–2015.

Sample size calculation

Sample size calculations were estimated for the proportion of patients with previous HIV-negative tests, as described in the methodology article by the aMASE study group [18]. The target sample size was 2000 HIV-positive migrants who were recruited from a minimum of two clinics in each country, with each clinic forming a discrete cluster. Within cluster correlation was estimated to be relatively weak (e.g. 0.005) [18]. This sample size ($n = 2000$) was sufficient for the question addressed in this article as the assumed proportion of postmigration HIV acquisition was 50% with a precision of 5–10%.

Variables and definitions

A questionnaire was designed in collaboration with community partners to gather the following information: socio-economic and clinical data; sexual and drug use behaviour; migratory trajectories, including dates of arrival into the host country; and residency status. Whenever possible, items were adapted from existing

survey instruments [18]. The survey was delivered using a computer assisted self-interview or personal-interview using a tablet or personal computer available online and offline to minimize interviewer and interviewee bias, supplemented with clinical data from patient records within the participating clinics. Clinical data included: previous HIV tests, $CD4^+$ cell counts, viral load determinations, HIV-1 subtypes, clinical events and antiretroviral therapy (ART) initiation. For the current analyses, our outcome of interest was the time of HIV-acquisition (premigration or postmigration).

Statistical analyses

The probability of premigration or postmigration infection was estimated through a Bayesian approach that combined information on migration history, risk factors and patients' characteristics, including $CD4^+$ cell count and HIV-RNA measurements. Full statistical methods were presented elsewhere [19] and in the Web appendix (refer to Text, Supplemental Digital Content 1, http://links.lww.com/QAD/B120). We assumed patients could have not been infected with HIV before the age of 10 years (since patients in this analysis were not vertically infected); 1 January 1980 and the date of a documented HIV negative test. Starting from a uniform prior distribution for the seroconversion date over time at risk, we incorporated information from available $CD4^+$ cells counts and HIV-RNA levels measurements before AIDS development and ART initiation. $CD4^+$ cell counts and HIV-RNA trajectories from HIV seroconversion were estimated by a bivariate linear mixed model (LMM) fitted to natural history data from the CASCADE collaboration [20]. CASCADE comprises data of over 30 000 HIV-positive persons with documented dates of HIV seroconversion from 29 cohorts across Europe, Canada and Australia. Demographic covariates such as sex, current age, mode of infection and region of birth along with calendar year of seroconversion were incorporated in the model as virulence may increase over the epidemic's course [21]. For individuals participating in aMASE, we derived the posterior distribution of the time between HIV seroconversion and HIV diagnosis applying the Bayes' rule assuming parameters obtained by the bivariate LMM as known (refer to Text, Supplemental Digital Content 1, http://links.lww.com/QAD/B120). We further extended this method by considering absence or presence of AIDS at diagnosis, incorporating the distribution of time to AIDS obtained from CASCADE data (censored at 1996 due to the introduction of ART). In addition, behavioural data were also considered by assigning prior probabilities of HIV acquisition premigration or postmigration based on expert' opinion (HIV researchers with more than 15 years' experience in HIV epidemiology). Table 1 summarizes the assigned premigration or postmigration probabilities for sexual and drug use behaviour data. In case of no agreement between experts, the figures closest to 0.5 (i.e. the less informative) were considered (bold in Table 1). Analyses were also done removing these prior probabilities. The posterior probabilities of premigration or postmigration infection were obtained through numerical integration over the posterior distribution of the time between HIV seroconversion and diagnosis dates (refer to Text, Supplemental Digital Content 1, http://links.lww.com/QAD/B120). For patients who were known to have been infected premigration or postmigration (through a documented or self-reported HIV positive test premigration or a documented HIV negative test after migration followed by a positive one, respectively), the aforementioned Bayesian method was not applied but they were included in the final analysis assigning to them premigration or postmigration probability equal to one as appropriate. The combination of behavioural, documented seroconversion and inferences from joint $CD4^+$ and viral load modelling, allowed classifying 95% of all HIV infections as premigration or postmigration acquisitions. To investigate the validity of our approach, we applied it to individuals known to be infected premigration or postmigration (based on their HIV testing history). The results of this analysis showed that our method was able to correctly identify postmigration and premigration infections (e.g. individuals with an estimated probability of postmigration infection >0.5 were classified as infected postmigration), in about 85% of the cases.

Uncertainty in the estimation of the date of HIV seroconversion (and the resulting uncertainty in the classification of HIV acquisition as premigration or postmigration) was taken into account using a multiple imputations approach. More specifically, after deriving the posterior distribution of unknown seroconversion time for each individual, 50 random samples were drawn for each participant (using rejection sampling). In each one of the resulting datasets ($n = 50$), patients were classified as being infected premigration or postmigration based on the imputed seroconversion time. Results for all subsequent analyses were based on the combination of results from the imputed datasets according to Rubin's [22] rules. Potential clinics and/or countries clustering effects were investigated and taken into account through multilevel logistic regression models. Initially, three-level logistic models (i.e. participants nested within clinics nested within countries) were fitted. However, the variance of the countries' random effects was approximately zero and nonsignificant given other significant prognostic factors. Thus, all subsequent analyses were based on two-level random effects logistic regression models with clinics as the clustering variable. Associated P values were derived using Wald type tests.

The probabilities of postmigration HIV acquisition, and their 95% confidence intervals (CIs), were estimated by geographical origin, transmission categories and destination country. Separate analyses were conducted for HIV transmitted heterosexually in men and in women (only

Table 1. Assigned premigration and postmigration prior probabilities based on behavioural data as evaluated by five members of the research team.

	Condition	Probability of premigration HIV acquisition (%)	Probability of postmigration HIV acquisition (%)
1	Has an AIDS diagnosis within 3 months of HIV diagnosis and arrived in the same year of diagnosis and has no evidence of seroconversion	**70**	**30**
		80	20
		80	20
		70	30
		80	20
2	Has not had sex in the country of destination and has never injected drugs	65	35
		60	**40**
		70	20
		85	15
		85	15
3	Has only injected drugs in country of origin	**80**	**20**
		80	20
		80	20
		80	20
		80	20
4	Patient with negative self-reported HIV test after year of arrival	20	80
		20	80
		20	80
		30	**70**
		20	80
5	Has only injected drugs in country of destination	20	80
		20	80
		20	80
		25	**75**
		25	75
6	Has had unprotected sex only in country of destination and has never injected drugs	35	65
		40	**60**
		30	60
		30	70
		40	60

Bold indicates the prior probabilities applied in data.

reported heterosexual sex and never injected drugs), for MSM (MSM who never injected drugs) and for people who inject drugs (PWID). Socio-demographic factors associated with postmigration HIV acquisition were investigated for each transmission category through multivariable random effects logistic regression as described above. We specified the following a priori variables which could be associated with postmigration HIV acquisition: age at arrival to host country, age at HIV diagnosis, geographical origin (Europe, SSA, Latin-America & The Caribbean and others), length of stay in host country (<6, 6–10 and >10 years), residency status (EU/EEA nationals/with residency permit, visa/asylum/refugee status and uncertain/unknown status), civil status (married/living with couple, single and divorced/separated/widowed), has children (yes/no), educational level (primary or less, secondary and university), employment status (working, unemployed, not allowed to work due to immigration reasons, student, retired/long term disability, family care/voluntary work and unknown) and salary (less that minimum wage, does not earn his/her own wage, above or similar to minimum wage, rather not say). The final model was constructed through a backward stepwise procedure with the removal P value equal to 0.15, whereas area of origin was included irrespective of its significance due to its importance in the specific study.

Statistical analyses were performed by using Stata software (Version 13.1; College Station, Texas, USA) and R (Version 3.4.0; R Foundation for Statistical Computing, Vienna, Austria)

Ethics

Ethical approval for aMASE was received separately in each country [18].

Results

Of 3794 patients registered on enrolment logs, 3251 HIV-positive migrants were invited to participate, of whom 3152 were eligible and 2209 (70%) accepted and completed the survey. Participation was higher in men (74%) than in women (62%), decreased with age (83% in people aged 18–24 years and 70% in those aged 55–64 years) and was higher in migrants from Latin America (86%) and Eastern Europe (82%) and lower in those from SSA (59%). Out of these 2209, 2117 (96%) had supplementary clinical data. Recruitment was as follows: Belgium (256), Germany (31), Greece (175), Italy (64), The Netherlands (119), Portugal (182), Spain (710), Switzerland (178) and United Kingdom (402).

Table 2. Socio-demographic characteristics of the study population ($n = 2117$).

Sample characteristics	HET female, $n = 643$	HET male, $n = 344$	MSM, $n = 967$	PWID, $n = 98$	Other/unknown, $n = 65$
Geographical area of origin					
European migrants	98 (15%)	58 (17%)	335 (35%)	49 (50%)	7 (11%)
Sub-Saharan African	401 (62%)	204 (59%)	59 (6%)	9 (9%)	26 (40%)
Latin America & Caribbean	119 (19%)	49 (14%)	453 (47%)	17 (17%)	28 (43%)
Other	25 (4%)	33 (10%)	120 (12%)	23 (23%)	4 (6%)
Sex					
Female	643 (100%)	–	–	11 (11%)	4 (6%)
Male	–	344 (100%)	967 (100%)	86 (88%)	38 (58%)
Transgender male	–	–	–	1 (1%)	18 (28%)
Transgender female	–	–	–	–	5 (8%)
Age at interview					
18–30 years old	162 (25%)	39 (11%)	304 (31%)	19 (19%)	18 (28%)
31–50 years old	401 (62%)	240 (70%)	595 (62%)	70 (71%)	39 (60%)
51 and more years old	80 (12%)	65 (19%)	68 (7%)	9 (9%)	8 (12%)
Educational level					
Primary education or less	207 (32%)	110 (32%)	81 (8%)	14 (14%)	23 (35%)
Secondary education	279 (43%)	145 (42%)	347 (36%)	38 (39%)	33 (51%)
University degree	157 (24%)	89 (26%)	539 (56%)	46 (47%)	9 (14%)
Administrative status					
EU nationals/with residence permit	470 (73%)	263 (76%)	855 (88%)	78 (80%)	44 (68%)
In temporary visa/asylum/refugee status	74 (12%)	42 (12%)	44 (5%)	10 (10%)	10 (15%)
Uncertain status and unknown	99 (15%)	39 (11%)	68 (7%)	10 (10%)	11 (17%)
Employment					
Working (full and part time)	269 (42%)	170 (49%)	641 (66%)	57 (58%)	35 (54%)
Unemployed	200 (31%)	120 (35%)	204 (21%)	26 (27%)	16 (25%)
Other	174 (27%)	54 (16%)	122 (13%)	15 (15%)	14 (22%)
Salary					
Less than MW	210 (33%)	99 (29%)	191 (20%)	16 (16%)	21 (32%)
Do not earn his/her own wage	230 (36%)	115 (33%)	137 (14%)	33 (34%)	14 (22%)
More/about the same MW	144 (22%)	101 (29%)	576 (60%)	44 (45%)	19 (29%)
Rather not say	59 (9%)	29 (8%)	63 (7%)	5 (5%)	11 (17%)
Civil status					
Married or living as a couple	292 (45%)	200 (58%)	367 (38%)	35 (36%)	33 (51%)
Single	221 (34%)	96 (28%)	513 (53%)	48 (49%)	23 (35%)
Divorced/separated/widowed	130 (20%)	48 (14%)	87 (9%)	15 (15%)	9 (14%)
Has a child/children					
Yes	461 (72%)	253 (74%)	106 (11%)	26 (27%)	26 (40%)
No	178 (28%)	84 (24%)	854 (88%)	71 (72%)	34 (52%)
Rather not say	4 (1%)	7 (2%)	7 (1%)	1 (1%)	5 (8%)
Age at arrival					
Duration of residence in host country					
5 years or less	263 (41%)	95 (28%)	312 (32%)	27 (28%)	19 (29%)
Between 6 and 10 years	175 (27%)	92 (27%)	282 (29%)	34 (35%)	18 (28%)
More than 10 years	205 (32%)	157 (46%)	373 (39%)	37 (38%)	28 (43%)
Year of HIV diagnosis					
2008–2009	95 (15%)	58 (17%)	105 (11%)	16 (16%)	11 (17%)
2010–2012	359 (56%)	174 (51%)	464 (48%)	48 (49%)	34 (52%)
2013–2015	189 (29%)	112 (33%)	398 (41%)	34 (35%)	20 (31%)
Total	643 (100%)	344 (100%)	967 (100%)	98 (100%)	65 (100%)

HET, heterosexuals; MW, minimum wage; PWID, people who inject drugs.

Overall, 68% were men, the proportion of transgender men or women was low (1%, $n = 24$). Median age was 36 years (interquartile range: 30–44). A third were from SSA and Latin America & Caribbean (LAC), respectively, followed by Western (11%), Central (10%) and Eastern (5%). Almost half of participants were MSM (46%). The median time in host countries was 8 years (interquartile range: 4–13). Heterosexually transmitted cases were largely from SSA (61%), the proportion of women was 65%, educational level was the lowest (32% with primary education or less) and 26% did not have permanent resident status. MSM were mainly from LAC (47%) and Europe (35%) and their socio-economic profile was more favourable than heterosexually transmitted cases. PWID were largely from Europe (50%) and predominantly men (88%) (Table 2).

Of the 2117 study participants with clinical data, 2009 (95%) had enough information to estimate time of HIV acquisition. Of them, 129 (6.4%) and 624 (31.1%) were classified as definitely infected premigration or postmigration through a documented or self-reported HIV positive test premigration or a documented HIV negative test after migration, respectively. Taking into account all

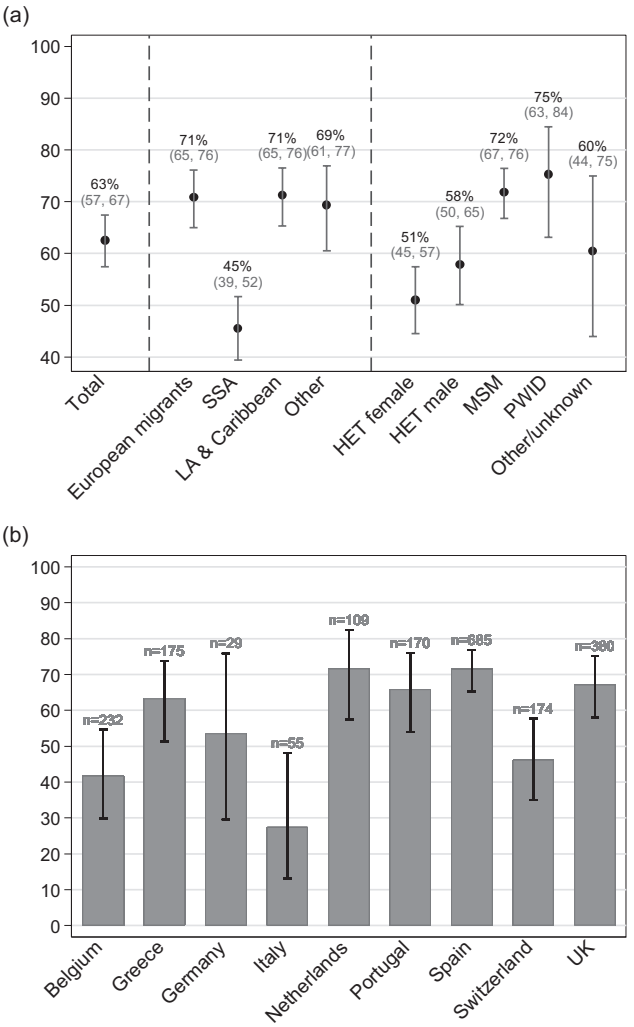

Fig. 1. Estimated postmigration HIV acquisition probability (95% confidence interval) by (a) mode of transmission and geographical origin and (b) destination country (numbers on top of bars denote sample size per country).

available data, the overall proportion of postmigration HIV acquisition was 63% (95% CI: 57–67%). Postmigration HIV acquisition was higher among MSM (72%) and PWID (75%) compared with heterosexual men (58%) and women (51%). Postmigration HIV acquisition was higher in migrants from Europe (71%) and LAC (71%) compared with migrants from SSA (45%) (Fig. 1a). Estimated probabilities of postmigration HIV acquisition in the nine participating countries are shown in Fig. 1b with The Netherlands, Spain and United Kingdom having the highest ones (72, 71 and 67%, respectively) and Italy, Belgium and Switzerland the lowest estimates (27, 42 and 46%, respectively). Overall differences by country were statistically significant ($P < 0.001$) but became nonsignificant after adjustment for transmission category and length of stay ($P = 0.430$). Analyses without assigning prior probabilities yielded similar results: the estimated overall probability (95% CI) of postmigration infection became 61% (56, 65) instead of 63% (57, 67). Similar differences were observed when estimating the same probability by region of origin [e.g. European migrants 69% (63, 74) instead of 71% (65, 76), SSA migrants 44% (38, 50) instead of 45% (39, 52)].

Table 3 shows the percentages of postmigration HIV acquisition (i.e. the proportion of individuals with an estimated probability of postmigration infection >0.5) by mode of transmission for each socio-demographic characteristic. In the multivariate regression analyses, among heterosexual women and among MSM, the factors associated with the probability of acquiring HIV postmigration were length of stay and age at arrival in the host country and year of HIV diagnosis (Table 4). For heterosexual men, factors associated with postmigration HIV acquisition were length of stay in the host country and the year of HIV diagnosis (Table 4). In addition, among MSMs, those in visa/asylum or refugee status and those with unknown status were less likely to be infected postmigration compared with those of EU nationalities or with residence permit. Geographical region of origin did not remain a significant risk factor in the multivariate analyses apart from some weak indications for lower probabilities of postmigration HIV acquisition in heterosexual men from SSA compared with migrants from Europe [odds ratio: 0.4 (95% CI: 0.1–1.4); $P = 0.144$].

Numbers were too low to perform multivariate analyses in PWID.

Discussion

Our study suggests that 63% of HIV-positive migrants in aMASE – who were diagnosed within the preceding 5 years – acquired HIV after migrating into Europe. The proportion of postmigration HIV acquisition varies by patients' origin which is closely linked to the mode of HIV transmission. LAC MSM appear to be particularly at risk, 79% of all HIV infections in this group were acquired most likely postmigration. Among heterosexual migrants from SSA more than 40% of all HIV infections seem to be acquired postmigration. Although numbers are considerably lower among PWID, the probability of postmigration HIV acquisition exceeded 74% for all geographical origins. Length of stay and age at arrival in the host country were associated with postmigration HIV acquisition of sexually transmitted HIV; the longer the duration of residence and the younger the age at migration, the higher the probability of becoming HIV infected after migration. Postmigration HIV acquisition was more common in recent periods for the sexually transmitted cases and only for MSM was commoner for those with secure immigration status.

Migrants included in this study are not representative of migrants living with HIV in the nine participating

Table 3. Postmigration HIV acquisition by mode of HIV transmission, sex and socio-economic characteristics.

Characteristics	HET female, $N=588$	HET male, $N=326$	MSM, $N=938$	PWID, $N=94$	Other/unknown, $N=63$
Area of origin					
European migrants	53/92 (58%)	47/57 (82%)	242/324 (75%)	35/47 (74%)	6/7 (86%)
Sub-Saharan African	145/360 (40%)	82/188 (44%)	30/58 (52%)	8/9 (89%)	8/24 (33%)
Latin America & Caribbean	75/112 (67%)	31/48 (65%)	349/442 (79%)	12/16 (75%)	20/28 (71%)
Other	11/24 (46%)	22/33 (67%)	82/114 (72%)	20/22 (91%)	4/4 (100%)
Sex					
Female	284/588 (48%)	–	–	8/10 (80%)	1/4 (25%)
Male	–	182/326 (56%)	703/938 (75%)	67/83 (81%)	21/36 (58%)
Transgender male	–	–	–	0/1 (0%)	12/18 (67%)
Transgender female	–	–	–	–	4/5 (80%)
Age					
18–30 years old	62/146 (42%)	18/37 (49%)	184/293 (63%)	12/19 (63%)	9/18 (50%)
31–50 years old	175/369 (47%)	120/227 (53%)	460/578 (80%)	56/67 (84%)	23/38 (61%)
51 and more years old	47/73 (64%)	44/62 (71%)	59/67 (88%)	7/8 (88%)	6/7 (86%)
Educational level					
Primary education or less	83/186 (45%)	54/105 (51%)	50/81 (62%)	10/14 (71%)	12/23 (52%)
Secondary education	126/253 (50%)	82/137 (60%)	265/335 (79%)	26/35 (74%)	20/31 (65%)
University degree	75/149 (50%)	46/84 (55%)	388/522 (74%)	39/45 (87%)	6/9 (67%)
Legal status					
EU nationals/with residence permit	237/436 (54%)	159/252 (63%)	650/829 (78%)	62/75 (83%)	31/43 (72%)
In visa/asylum/refugee status	15/63 (24%)	9/38 (24%)	18/43 (42%)	6/9 (67%)	2/9 (22%)
Uncertain status and unknown	32/89 (36%)	14/36 (39%)	35/66 (53%)	7/10 (70%)	5/11 (45%)
Employment					
Working	145/253 (57%)	95/165 (58%)	482/624 (77%)	50/56 (89%)	22/35 (63%)
Unemployed	83/177 (47%)	68/110 (62%)	151/196 (77%)	15/24 (63%)	9/16 (56%)
Other	56/158 (35%)	19/51 (37%)	70/118 (59%)	10/14 (71%)	7/12 (58%)
Salary					
Less than MW	99/193 (51%)	53/97 (55%)	125/185 (68%)	10/15 (67%)	13/21 (62%)
Do not earn his/her own wage	73/205 (36%)	45/104 (43%)	82/132 (62%)	25/32 (78%)	7/13 (54%)
More/about the same MW	86/135 (64%)	69/97 (71%)	457/561 (81%)	39/43 (91%)	14/18 (78%)
Rather not say	26/55 (47%)	15/28 (54%)	39/60 (65%)	1/4 (25%)	4/11 (36%)
Civil status					
Married or living with a couple	124/267 (46%)	112/191 (59%)	253/358 (71%)	27/34 (79%)	19/32 (59%)
Single	97/200 (49%)	46/90 (51%)	383/495 (77%)	35/46 (76%)	15/23 (65%)
Divorced/separated/widow	63/121 (52%)	24/45 (53%)	67/85 (79%)	13/14 (93%)	4/8 (50%)
Has child					
Yes	207/421 (49%)	139/238 (58%)	78/102 (76%)	18/25 (72%)	11/24 (46%)
No	74/163 (45%)	40/81 (49%)	619/829 (75%)	56/68 (82%)	25/34 (74%)
Rather not say	3/4 (75%)	3/7 (43%)	6/7 (86%)	1/1 (100%)	2/5 (40%)
Age at arrival					
36 and more years old	41/124 (33%)	38/100 (38%)	68/114 (60%)	9/14 (64%)	4/11 (36%)
26–35 years old	107/260 (41%)	67/127 (53%)	258/371 (70%)	27/37 (73%)	17/25 (68%)
18–25 years old	85/149 (57%)	58/80 (73%)	276/350 (79%)	30/34 (88%)	12/22 (55%)
17 years old or less	51/55 (93%)	19/19 (100%)	101/103 (98%)	9/9 (100%)	5/5 (100%)
Length of stay					
5 years or less	21/228 (9%)	6/85 (7%)	111/290 (38%)	11/24 (46%)	3/18 (17%)
Between 6 and 10 years	89/164 (54%)	42/91 (46%)	228/279 (82%)	29/34 (85%)	11/18 (61%)
More than 10 years	174/196 (89%)	134/150 (89%)	364/369 (99%)	35/36 (97%)	24/27 (89%)
Year of HIV diagnosis					
2008–2009	36/85 (42%)	25/54 (46%)	69/103 (67%)	12/15 (80%)	4/11 (36%)
2010–2012	150/329 (46%)	89/164 (54%)	323/452 (71%)	34/46 (74%)	21/32 (66%)
2013–2015	98/174 (56%)	68/108 (63%)	311/383 (81%)	29/33 (88%)	13/20 (65%)

HET, heterosexuals; MW, minimum wage; *n*/*N* (%), *n* number of participants with estimated probability of postmigration infection >0.5; *N*, total number of participants; PWID, people who inject drugs.

countries, but rather a convenience sample from large HIV testing sites of migrants diagnosed with HIV in the preceding 5 years. Indeed, this selection bias needs to be taken into account when comparing our findings with other studies. Whereas the restriction to HIV diagnoses within preceding 5 years may hamper comparisons with other studies, this was a deliberate decision to minimize recall bias given the extensive information on migration and risk behaviour history we aimed to collect.

Our results are consistent with previous publications but provide new information to guide public health policy and practice. Fakoya *et al.* [13] described in a systematic review that HIV acquisition after migration could range from 2% in Switzerland among people from countries with a generalized epidemic [23] to 62% among migrant black Caribbean MSM in the United Kingdom [24]. Overall differences between countries were highly significant, but after adjustment for differences in the

Table 4. Factors associated with HIV postmigration acquisition by mode of transmission and sex: results from mixed-effects logistic regression analyses [adjusted odds ratio (95% confidence intervals)]

	Heterosexual women $N = 588$ aOR (95% CI)	Heterosexual men $N = 326$ aOR (95% CI)	MSM $N = 938$ aOR (95% CI)
Area of origin	$P^* = 0.611$	$P^* = 0.390$	$P^* = 0.728$
European migrants	Referent	Referent	Referent
Sub-Saharan African	1.0 (0.5–2.2)	0.4 (0.1–1.4)	0.6 (0.2–1.6)
Latin America & Caribbean	1.7 (0.6–4.3)	0.7 (0.2–2.8)	1.0 (0.6–1.8)
Other	1.0 (0.2–4.7)	0.5 (0.1–2.4)	0.9 (0.4–1.9)
Length of stay	$P^* < 0.001$	$P^* < 0.001$	$P^* < 0.001$
5 years or less	Referent	Referent	Referent
Between 6 and 10 years	7.5 (3.7–15.4)	6.4 (2.2–18.1)	7.4 (4.2–13.2)
More than 10 years	34.7 (15.7–76.8)	47.0 (14.0–157.6)	54.3 (21.6–136.6)
Age at arrival	$P^* = 0.117$		$P^* = 0.121$
36 and more years old	Referent		Referent
26–35 years old	1.3 (0.6–2.6)		1.5 (0.8–2.9)
18–25 years old	1.6 (0.7–3.5)		2.1 (1.0–4.4)
17 years old or less	4.9 (1.2–20.2)		4.0 (0.7–21.8)
Year of HIV diagnosis	$P^* = 0.032$	$P^* = 0.046$	$P^* < 0.001$
2008–2009	Referent	Referent	Referent
2010–2012	1.8 (0.8–4.0)	2.3 (0.8–6.4)	2.3 (1.1–4.7)
2013–2015	3.4 (1.3–9.1)	4.2 (1.4–12.9)	6.9 (3.0–15.7)
Legal status			$P^* = 0.056$
EU nationals/with residence permit			1
In visa/asylum/refugee status			0.4 (0.2–1.1)
Uncertain status and unknown			0.4 (0.2–1.1)

Results, including confidence intervals and *P* values, based on multiple imputations ($n = 50$) of unknown HIV infection times. aOR, adjusted odds ratio; CI, confidence interval.
*P values from global Wald tests.

distribution of transmission category and length of stay, differences became clearly nonsignificant.

Rice *et al.* [15] estimated that 31% of HIV-positive black Africans reported through national surveillance had become infected after arrival to the United Kingdom between 2004 and 2010. Desgrees-du-Lou *et al.* [12] in the PARCOUR study which looked at a representative sample of SSAs in the Paris Area from 2012 to 2013 published that from one-third to half (depending on the assumptions made) of HIV-positive Africans were infected postmigration. Brannstrom *et al.* [10] showed that 19% of those diagnosed with HIV-1 infection in the period 1983–2013 acquired HIV after migrate to Sweden. Migrants can suffer an increased risk of acquiring HIV in destination countries related to the socio-economic and structural inequalities they may have to endure [25,26]. The probability of postmigration HIV acquisition increased overtime for migrant MSM and for men and women from SSA and this is consistent with the dynamics of sexually transmitted infections and the convergence of health patterns of migrant populations with those of native populations from host countries. Similar trends have been observed in HIV reports from surveillance data from United Kingdom [15] and in a random sample of migrants from SSA in France [12].

Our study shows that postmigration HIV acquisition in Europe in migrant MSM is very frequent, irrespective of their geographical origin even if our estimates are not population-based. Many MSM migrate to be able to live in less homophobic environments [27]; this can place them at higher risk of HIV as many EU cities have higher HIV prevalence among MSM than the reported for MSM in their countries of origin [28,29]. Further, many migrant MSM have to deal with deep-rooted stigma and some studies show that migrant MSM are reluctant to disclose their sexual orientation to members of their communities [30]. Consequently, many live their sexuality under cover, creating challenges for preventive interventions. The process of migration itself can influence sexual behaviours with data suggesting disconnection from the traditional systems of social control and a greater frequentation of gay venues which results in increased sexual activity, particularly in the first phases of migration [27]. Sexual mixing, the use of commercial sex and changing perceptions of risk behaviours in origin versus destination countries are all contributing factors to high-risk behaviours. Our data are concordant with Diez *et al.* [16] in Spain and Dougan *et al.* [24] in United Kingdom and highlight the need to develop specific health promotion interventions targeting MSM from all migrant groups, soon after arrival to Europe, as previously stated by Elford *et al.* [31].

Among heterosexuals in aMASE, postmigration HIV acquisition is less common in people from SSA compared with people from other regions. It accounts, nevertheless, for more than 40% of all HIV infections and highlights prevention gaps in the migrant group with the largest burden of HIV in Europe [15,19,21]. Length of stay in the host country, age at arrival and year of HIV diagnosis

confounded associations observed in univariate analyses and after taking these into account geographical origin was no longer a risk factor for postmigration acquisition. Postmigration HIV acquisition among PWID was also high irrespective of geographical origin. Similar to previous analyses, the younger the age at migration and the longer the duration of stay in the host country, the higher was the probability of having become HIV infected after migration. However, contrary to sexually transmitted HIV, statistical significance of differences seen in PWID, according to the year of HIV diagnosis, could not be determined in a multivariable analysis.

Our study has a number of limitations to acknowledge. The most important one stems from the lack of a clear sampling frame for the HIV-positive migrant population within the nine EU/EEA participating countries leading to a potential selection bias of our convenience sample. Because response rates were lower in women and migrants from SSA, where the probability of postmigration HIV acquisition is lower, the proportion of postmigration HIV acquisition in the study may be overestimated. However, the distribution of the HIV-positive migrants participating in aMASE is consistent with the epidemiology of new HIV diagnoses in each of the nine countries thus supporting the external validity of our findings. Among most relevant differences is the larger proportion of migrant MSM in our study due to the nature of the participating clinics; migrant and gay friendly sites [18]. We collected data only from people followed-up in HIV clinics therefore selecting those who have been linked to and retained in care, thus excluding those migrants who are not within the health system. Though most of the postmigration HIV acquisition is likely to have occurred in the host country, we cannot exclude that circular migrations or visits to travel countries may account for some of these [32].

To our knowledge, this is the first pan-European study that has estimated the proportion of postmigration HIV acquisition among people diagnosed in the preceding 5 years across all transmission categories and irrespective of geographical origin. The high level of postmigration HIV acquisition provides strong evidence of inadequate HIV prevention for migrants across Europe and helps to further identify which subgroups are more at risk. Interventions – soon after migration into host countries – need to tackle migrants' vulnerabilities to HIV infection and recognise them as a priority group within primary and secondary HIV prevention strategies.

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Conflicts of interest

There are no conflicts of interest.

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