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ORIGINAL ARTICLE

Dual cross-sectional and longitudinal perspective on the continuum of HIV care to disentangle natural epidemic evolution from real progress, Belgium 2014–2022

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Abstract

Introduction: This study provides a comprehensive overview of HIV care by combining cross-sectional and longitudinal continuum of care (CoC) analyses.

Methods: Using national surveillance data 2014–2022, a five-stage cross-sectional CoC was calculated among people living with HIV (incl. undiagnosed): diagnosed, linked to care, retained in care, on antiretroviral therapy (ART) and virally suppressed. For the longitudinal CoC, cumulative incidences (CI) were calculated for each transition.

Results: The study included 26 191 people living with HIV. By the end of 2022, an estimated 18 302 persons were living with HIV in Belgium. Of these, 92.1% were diagnosed, 90.9% linked to care, 89.2% retained in care, 87.9% on ART and 85.6% virally suppressed. One-year post-infection diagnosis rates were 38% (2014–2016), 33% (2017–2019) and 31% (2020–2022), with differences disappearing after correction for immigration timing. Time from diagnosis to care entry remained stable at 82% within 3 months. Time to ART initiation and to viral load suppression reduced substantially, with 3-month CIs rising from 69% and 71%, respectively (2014–2016), to 91% and 77% (2020–2022). Transitions

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between all stages of care were the fastest among Belgian men who have sex with men. People who inject drugs had the lowest CI for care entry and viral suppression. Cumulative incidences of ART initiation increased substantially for all key populations, exceeding 90% within 3 months in 2020–2022, except for non-Belgian heterosexuals (87%).

Conclusion: A steady improvement in the CoC places Belgium close to the joint united nations programme on HIV/AIDS 95-95-95 targets, although populations like people who inject drugs and migrants still face significant barriers to care. Timely diagnosis by supporting existing and innovative testing strategies should be prioritized.

KEYWORDS

Belgium, care cascade, continuum of care, cross-sectional, HIV, key population, longitudinal

INTRODUCTION

Today, human immunodeficiency virus (HIV) is considered a chronic disease and people living with HIV on antiretroviral therapy (ART) enjoy a life expectancy close to that of the general population [1]. Furthermore, adherence to ART allows for achieving an undetectable viral load, which prevents the transmission of the infection to others. However, long-term HIV management involves a lifelong commitment to regular care and uninterrupted ART.

In Belgium, access to HIV services is provided through the compulsory national health insurance, which fully covers the cost of ART. People living with HIV have access to multidisciplinary care including psychological, social, sexual and dietary consultations at the HIV reference centres (HRCs)—specialized tertiary care structures that cover more than 80% of people living with HIV in care. Alternatively, people living with HIV may receive medical follow-up in other hospitals or in primary care settings. Undocumented migrants do not have access to the national health insurance, but they may access essential health care, including HIV care, through a procedure called Urgent Medical Aid covering preventive and curative health care, delivered either in hospital or in ambulatory settings, as well as drug prescription.

To study engagement and maintenance in care and therapy of people living with HIV, the framework of the continuum of care (CoC) analysis is widely used. This analysis is usually based on a cross-sectional approach to estimate at a given time the distribution of people living with HIV between consecutive stages of HIV care: numbers of persons including those unaware of their serostatus, of persons diagnosed, of persons linked to and retained in care, of persons on ART and virally suppressed [2]. This approach highlights the critical stages of engagement in care and thereby provides key information for prioritizing and targeting HIV strategies. Furthermore, such analysis by subpopulation allows the identification by stage of care of the most vulnerable groups [3].

To improve their individual prognosis and reduce the risk of transmission to others, the progression of people living with HIV from infection to viral suppression should be as fast as possible. A longitudinal analysis measuring the time spent in each stage of care allows the estimation of this progression, bringing complementary information to the findings from the cross-sectional analysis. Various methods of longitudinal analyses have been described [4, 5]. Touloumi et al. proposed a combined approach incorporating time spent between stages [6].

This study aimed at providing a comprehensive picture of HIV care in Belgium by integrating cross-sectional and longitudinal analyses of the HIV CoC for all people living with HIV and key populations.

METHODS

Study population and data sources

In the frame of the national HIV surveillance, individual data on all HIV diagnoses and viral loads (VL) performed in Belgium, including demographic information, are collected annually from the AIDS Reference Laboratories (ARL). This allows for a national exhaustive HIV surveillance covering all people diagnosed with HIV and all those in HIV care. Additionally, routine individual demographic, medical, ART and laboratory data on more than 80% of people living with HIV in care in Belgium are reported by the HRCs. One unique pseudonymized person identifier is used across all data collections in the context of HIV surveillance, allowing the integration of these various data sources.

The HIV surveillance data from 1 January 2014 to 31 December 2022 were used for this analysis.

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Key populations

The following key populations, defined by a combination of grouped nationalities and modes of HIV acquisition, were selected according to their prevalence in the Belgian HIV epidemic and specific vulnerability factors: Belgian men who have sex with men (BMSM); European MSM (EMSM); non-European MSM (other MSM, OMSM); heterosexual men and women of Belgian nationality (Belgian heterosexuals, BH); sub-Saharan African nationality (sub-Saharan African heterosexuals, SSAH) and other nationalities (other heterosexuals, OH); and people who inject drugs.

Statistical analyses

Dataset

All analyses for the cross-sectional and longitudinal continua were performed on a single dataset comprising all individuals in the Belgian HIV surveillance data. This dataset contained time-fixed variables (demographics, probable mode of acquisition), variables obtained at diagnosis (acute stage of the infection according to detection of p24 antigen or plasma viral RNA in combination with a negative or indeterminate immuno-assay result, clinical stage according to the diagnosing physician, reason of testing, CD4 and VL values, last negative HIV test) and time-varying variables (dates and values of measurements of CD4 and VL and ART prescriptions, dates of medical visits and diagnoses of AIDS-defining events).

Missing values and multiple imputation

Missing values in selected fixed covariates were 20-fold multiply imputed with the fully conditional specification method [7] using a nonparametric classification and regression tree. All subsequent analyses for the continua were done within each imputed dataset and then pooled using Rubin's rule.

Cross-sectional continuum of care

The method for the cross-sectional CoC (CsCoC) analysis has been described previously [8]. Given that a straightforward yearly count of diagnosed people living with HIV who live in Belgium is not possible due to the lack of direct data on the emigration of people living with HIV after diagnosis, this number was instead estimated starting from the number of people living with HIV retained in care yearly, which is directly measured as part of surveillance. To this, were added the estimates of individuals who had been diagnosed but were not yet linked to HIV care and of those who were not retained in care, after the subtraction of the estimated number of people who had emigrated after diagnosis or linkage to care. Antiretroviral therapy coverage was calculated among all people living with HIV in care in the HRCs at the end of each year, and VL suppression (<200 copies/mL [9]) was calculated among all people living with HIV, using the last VL measure of the year. We estimated the number of undiagnosed people living with HIV at the end of each year using the CD4-based back-calculation model (corrected for probable place of infection) implemented in the ECDC hivPlatform R package [10]. The estimates of diagnosed and undiagnosed people living with HIV were summed to obtain the total of people living with HIV living in Belgium each year.

Longitudinal continuum of care

We analysed time-to-event using cumulative incidence (CI) functions for each of the following transitions in the longitudinal CoC (LCoC): (1) infection to diagnosis, (2) diagnosis to linkage to HIV care, (3) linkage to HIV care to ART initiation and (4) ART initiation to VL suppression (VL <200 copies/mL). The method to estimate time from infection to diagnosis uses the model described by Pantazis et al. [11] and is detailed in Supporting Information—Annex 1. The date of entry in care was defined as the earliest date at which a patient had a CD4 measurement or a medical visit in an HRC, or a measurement of VL (outside the diagnosis process). For Transitions 2–4, death prior to the event of interest was treated as a competing risk, and loss-to-follow-up was used as an additional competing risk for Transitions 3 and 4 [6]. The date of loss to follow-up was defined as the date on which the patient was last seen if this occurred more than 1 year prior to the date of censoring. We present the CI of diagnosis 1 year after infection (Transition 1) and the CI at 3 months for the following transitions. For each transition, comparisons were performed between key populations and periods of its initial event using Cox proportional hazard models (Transition 1) and Fine–Gray competing risk models (Transitions 2–4). The comparison periods were defined as 2014–2016 (in view of the authorization of reimbursement of ART for all people living with HIV unconditionally from the CD4 value from 1 December 2016), 2017–2019 (pre-COVID period) and 2020–2022 (COVID and post-COVID periods). Individuals were censored at the end of their respective periods to ensure equal maximum follow-up time [6]. Analyses of Transitions 3 and 4 were restricted to people living with HIV who were

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TABLE 1 Descriptive statistics of people living with HIV included in the study.

	***N* = 26 191**
Sex	
Male	17 056 (65.3%)
Female	9077 (34.7%)
Unknown	58
Age at diagnosis	
Median (interquartile range)	35 (28–44)
Unknown	89
Year of HIV diagnosis	
<1990	621 (2.4%)
1990–1999	3159 (12.1%)
2000–2013	13 657 (52.0%)
2014–2016	3240 (12.4%)
2017–2019	2906 (11.1%)
2020–2022	2608 (10.0%)
Key populations by nationality and mode of HIV acquisition	
Belgian MSM (BMSM)	5802 (26.7%)
European MSM (EMSM)	1553 (7.2%)
Other MSM (OMSM)	1668 (7.7%)
Belgian heterosexuals (BH)	2940 (13.5%)
Sub-Saharan African heterosexuals (SSAH)	6508 (30.0%)
Other heterosexuals (OH)	1933 (8.9%)
People who inject drugs	548 (2.5%)
Other mode of HIV acquisition	752 (3.5%)
Unknown	4487

linked to care in an HRC—representing 83% of those in care in Belgium during the study period—as ART data are only recorded by the HRC. A sensitivity analysis was conducted on the first transition, from infection to diagnosis, considering that for people who acquired HIV abroad, the time of migration marks the start of possible access to testing in Belgium. This analysis started from the most recent of two dates: the estimated date of infection or the date of immigration to Belgium.

RESULTS

Population description

A total of 26 191 people living with HIV were included in the study. Socio-demographic characteristics are presented in Table 1. Among those with available information on nationality and probable mode of HIV acquisition (17.1% missing values), key populations were distributed as follows: 26.7% were BMSM, 7.2% EMSM, 7.7% OMSM, 13.5% BH, 30.0% SSAH, 8.9% OH, 2.5% people who inject drugs and 3.5% other (perinatal acquisition, transfusion and haemophilia).

Cross-sectional continuum of care

Based on the CsCoC analysis, an estimated 18 302 (95% CI [17 923; 18 843]) persons were living with HIV in Belgium at the end of 2022. Of these, 92.1% [89.5; 94.1] were diagnosed, 90.9% [88.3; 92.9] had entered HIV care, 89.2% [86.6; 91.0] were retained in HIV care, 87.9% [85.4; 89.8] were on ART, and 85.6% [83.1; 87.4] had a suppressed VL. All stages of care have improved over the years (Figure 1). These estimates positioned Belgium at 92-95-97 relative to joint united nations programme on HIV/AIDS (UNAIDS) '95-95-95' targets [12].

Viral suppression was reached at the end of 2022 for 92.6% (95% CI [89.3; 94.5]) of BMSM, 89.3% [82.2; 91.5] of EMSM, 84.0% [81.5; 86.1] of OMSM, 81.8% [77.4; 84.5] of BH, 84.9% [82.3; 86.8] of SSAH, 77.0% [71.7; 81.1] of OH and 77.0% [70.4; 81.9] of people who inject drugs living with HIV. In all key populations, the results of the CsCoC have overall improved since 2014 (Figure 2).

Longitudinal continuum of care

The CIs for diagnosis at 1 year after HIV infection were 38% (95% CI [33; 44]), 33% [29; 38] and 31% [26; 37] for the diagnosis periods 2014–2016, 2017–2019 and 2020–2022, respectively. This CI was significantly higher in 2014–2016 than in 2017–2019 ($p = 0.023$) (Figure 3 and Table 2). The sensitivity analysis with time to diagnosis corrected for the timing of migration shows CIs at 1 year of 52% [48; 57], 50% [45; 54] and 50% [45; 54] for the three periods, respectively, and no statistically significant difference between periods was found (Table 3).

Time from HIV diagnosis to linkage to care remained stable with a CI at 3 months of 83% [81; 84], 82% [80; 83] and 81% [79; 83] for those diagnosed in 2014–2016, 2017–2019 and 2020–2022, respectively. Time from linkage to HIV care to ART initiation and from ART initiation to VL suppression has substantially reduced over time, with a CI at 3 months of 91% [89; 92] for ART initiation and 77% [74; 79] for VL suppression in 2020–2022, compared with 69% ([67; 71]; $p < 0.001$) and 71% ([69; 72]; $p < 0.001$), respectively, in 2014–2016. The rate of loss to follow-up (LTFU) between linkage to care and ART

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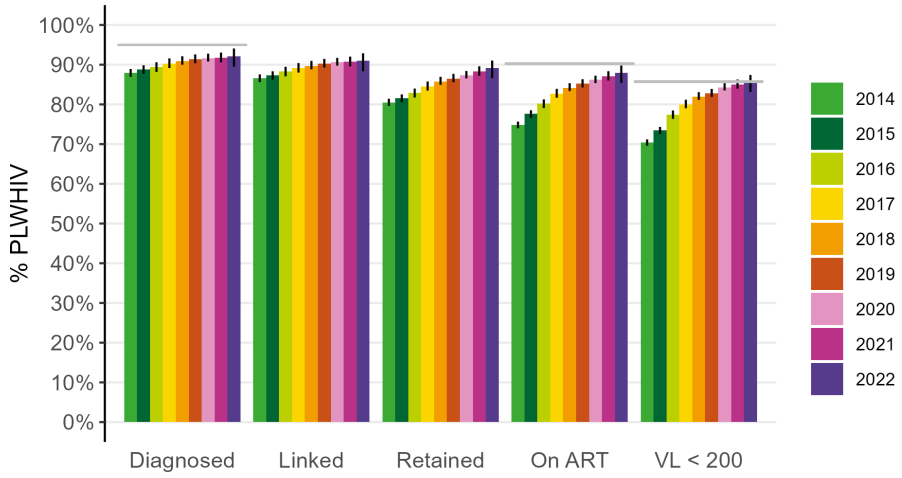

FIGURE 1 Cross-sectional continuum of care of people living with HIV (PLWHIV), Belgium, 2014–2022 (95% CI). The grey horizontal lines are the UNAIDS 95-95-95 targets. ART, antiretroviral therapy.

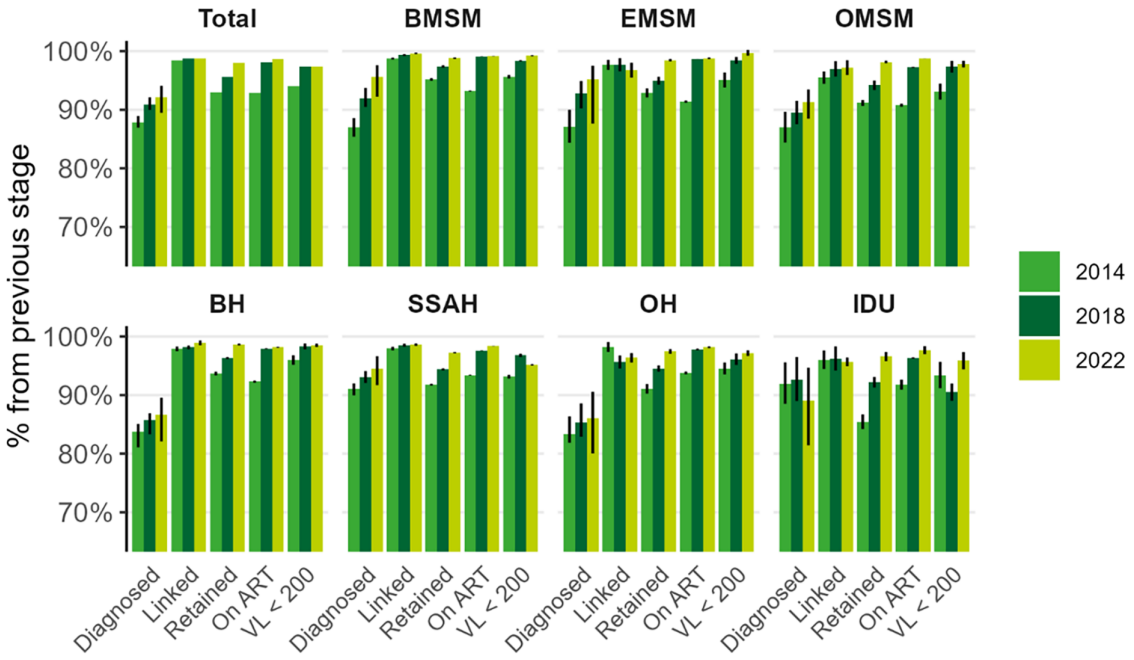

FIGURE 2 Trends in cross-sectional continuum of care results by key populations on selected years, presented as % of previous stage (95% CI), Belgium, 2014–2022. ART, antiretroviral therapy; BH, Belgian heterosexuals; BMSM, Belgian MSM; EMSM, European MSM; OH, other heterosexuals; OMSM, Other MSM; SSAH, sub-Saharan African heterosexuals.

initiation was significantly lower in 2020–2022 than in 2017–2019, with respective 1-year CIs of 1% [1; 2] and 3% [2; 4].

Transitions between all successive stages of care were the fastest among BMSM (Table 2). In the period 2020–2022, 49% (95% CI [42; 56]) of BMSM were diagnosed within 1 year following HIV infection, while the delay of diagnosis was the longest for SSAH (17% [11; 25]) and OH (20% [13; 30]). In the sensitivity analysis, taking into account the migration date for those estimated to be infected before migration, no difference or even a shorter time to diagnosis was observed for all non-Belgian key populations (Table 3). People who inject drugs showed the lowest CIs for linkage to care after diagnosis and for VL suppression after ART initiation, as well as the highest incidence of loss to follow-up after linkage to care. Cumulative incidences of ART initiation have increased substantially over the study period for all key

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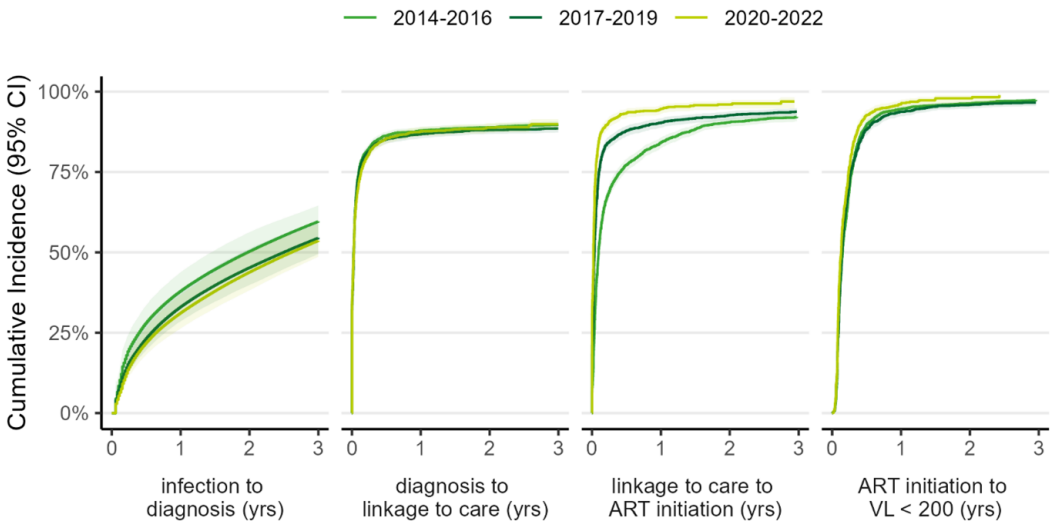

FIGURE 3 Cumulative incidence curves for all transitions for the total population by periods of diagnosis (first two transitions), period of linkage to care (third transition) and period of antiretroviral therapy (ART) initiation (fourth transition).

populations, reaching at least 90% within 3 months following linkage to care in 2020–2022, except for SSAH and OH (both 87%).

DISCUSSION

By combining cross-sectional and longitudinal methods, this approach overcomes their individual limitations and provides a comprehensive view of the care situation of people living with HIV. Overall, the CsCoC results show a steady improvement in HIV care over the years. Belgium is closely approaching the UNAIDS 95-95-95 targets with an achievement of 92-95-97, in line with the Western European average 92-95-93 [9]. This is a natural consequence of the low mortality among people living with HIV in modern times combined with the passage of time. As a result, the number of people living with HIV who have been in medical care for long has increased, making them the majority of people living with HIV in Belgium. Most of these individuals have already achieved long-term viral suppression, and their significant numbers have a major impact on the CsCoC estimates [6].

The LCoC analysis provides some nuances to this positive picture by showing an increase over time in the estimated time between infection and diagnosis. However, when this analysis is adjusted to account for immigrants infected abroad, this adverse trend disappears. Hence, from the point when individuals can benefit from national HIV testing strategies, the situation regarding time to diagnosis appears stable over time. The time to diagnosis of 50% diagnosed within 1 year of infection/immigration is relatively short in Belgium compared with other European countries such as Greece, with 22.9% diagnosed within 1 year of infection [6] and the Netherlands, with a median time to diagnosis of 3.5 years (interquartile range: 1.7–6.4) [13]. However, with half of people living with HIV taking more than 1 year before diagnosis, this stage of the continuum remains the one that contributes most to the delay between HIV infection and the achievement of viral suppression. Furthermore, the risk of unknown onward transmission is the highest at this stage, particularly from those recently infected [14, 15]. Hence, timely testing and early diagnosis for all must remain a strategic priority, supported by maintaining a diversified range of testing options. This includes promoting HIV screening at the initiative of the healthcare provider and facilitating access for the most vulnerable people to free and anonymous service and community-based testing. Further improvements will require innovative strategies such as those proposed in an Amsterdam study, where increased awareness of acute HIV infection, targeted point-of-care testing and same-day care linkage significantly reduced the time to viral suppression [16]. Additionally, studies have highlighted the effectiveness of electronic prompts in primary health care to facilitate HIV testing based on clinical criteria such as the presence of indicator conditions [17, 18] and the value of opt-out screening at emergency departments within HIV high-prevalence areas [19, 20]. Another complementary strategy involves proactively supporting people living with HIV or those at high risk of acquiring HIV to engage their social networks by encouraging their

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TABLE 2 Cumulative incidences (95% CI) at selected time points of interest for each transition, by key population and period, and results of adjusted time-to-event models.

		Total	BMSM	EMSM	OMSM	BH	SSAH	OH	PWID
Infection to diagnosis[a] 1-year CI	2014–2016	0.38 [0.33; 0.44] $p = 0.023$[b]	0.52 [0.46; 0.59] $p = 0.2$[c]	0.46 [0.36; 0.56] $p = 0.2$[c]	0.44 [0.35; 0.54] $p = 0.6$[c]	0.33 [0.26; 0.42] $p = 0.13$[c]	0.23 [0.16; 0.31] $p = 0.5$[c]	0.24 [0.16; 0.33] $p = 0.7$[c]	0.30 [0.16; 0.51] $p > 0.9$[c]
	2017–2019	0.33 [0.29; 0.38] [ref]	0.49 [0.43; 0.55]	0.39 [0.29; 0.50]	0.38 [0.29; 0.47]	0.28 [0.22; 0.36]	0.21 [0.16; 0.28]	0.23 [0.16; 0.32]	0.28 [0.14; 0.50]
	2020–2022	0.31 [0.26; 0.37] $p = 0.60$[b]	0.49 [0.42; 0.56] $p = 0.7$[c]	0.39 [0.29; 0.51] $p = 0.9$[c]	0.38 [0.30; 0.47] $p > 0.9$[c]	0.26 [0.18; 0.35] $p = 0.8$[c]	0.17 [0.11; 0.25] $p = 0.6$[c]	0.20 [0.13; 0.30] $p = 0.5$[c]	0.25 [0.12; 0.47] $p > 0.9$[c]
	p-value[d]		[ref]	0.005	0.080	<0.001	<0.001	<0.001	<0.001
Diagnosis to linkage to care[e] 3-month CI	2014–2016	0.83 [0.81; 0.84] $p = 0.8$[b]	0.90 [0.88; 0.93] $p = 0.057$[c]	0.84 [0.79; 0.87] $p = 0.5$[c]	0.82 [0.76; 0.86] $p = 0.9$[c]	0.84 [0.79; 0.88] $p = 0.7$[c]	0.77 [0.74; 0.80] $p = 0.9$[c]	0.77 [0.71; 0.82] $p = 0.14$[c]	0.63 [0.47; 0.76] $p = 0.023$[c]
	2017–2019	0.82 [0.80; 0.83] [ref]	0.93 [0.90; 0.95]	0.82 [0.75; 0.87]	0.82 [0.78; 0.86]	0.83 [0.78; 0.87]	0.78 [0.74; 0.82]	0.71 [0.64; 0.76]	0.76 [0.62; 0.86]
	2020–2022	0.81 [0.79; 0.83] $p = 0.6$[b]	0.90 [0.86; 0.93] $p = 0.3$[c]	0.76 [0.69; 0.81] $p = 0.14$[c]	0.80 [0.75; 0.84] $p = 0.5$[c]	0.85 [0.79; 0.89] $p = 0.8$[c]	0.77 [0.72; 0.81] $p = 0.6$[c]	0.80 [0.76; 0.84] $p = 0.019$[c]	0.71 [0.57; 0.82] $p = 0.4$[c]
	p-value[d]		[ref]	0.005	<0.001	0.002	<0.001	<0.001	<0.001
Linkage to care to ART initiation[f] 3-month CI	2014–2016	0.69 [0.67; 0.71] $p < 0.001$[b]	0.74 [0.71; 0.77] $p < 0.001$[c]	0.67 [0.60; 0.74] $p < 0.001$[c]	0.64 [0.56; 0.70] $p < 0.001$[c]	0.68 [0.62; 0.73] $p < 0.001$[c]	0.68 [0.63; 0.72] $p = 0.002$[c]	0.68 [0.60; 0.75] $p = 0.012$[c]	0.37 [0.18; 0.57] $p = 0.2$[c]
	2017–2019	0.84 [0.82; 0.86] [ref]	0.90 [0.87; 0.93]	0.85 [0.77; 0.90]	0.82 [0.75; 0.87]	0.90 [0.85; 0.93]	0.77 [0.72; 0.81]	0.81 [0.74; 0.87]	0.77 [0.57; 0.88]
	2020–2022	0.91 [0.89; 0.92] $p < 0.001$[b]	0.95 [0.92; 0.97] $p < 0.001$[c]	0.90 [0.82; 0.95] $p = 0.4$[c]	0.90 [0.85; 0.93] $p = 0.003$[c]	0.94 [0.89; 0.97] $p < 0.001$[c]	0.87 [0.82; 0.91] $p < 0.001$[c]	0.87 [0.81; 0.91] $p = 0.013$[c]	0.96 [0.68; 1.00] $p = 0.021$[c]
	p-value[d]		[ref]	<0.001	<0.001	0.01	<0.001	<0.001	<0.001
ART initiation to VL < 200[g] 3-month CI	2014–2016	0.71 [0.69; 0.72] $p = 0.2$[b]	0.75 [0.71; 0.77] $p = 0.7$[c]	0.71 [0.65; 0.77] $p = 0.9$[c]	0.68 [0.61; 0.74] $p = 0.7$[c]	0.67 [0.62; 0.72] $p = 0.001$[c]	0.70 [0.65; 0.74] $p = 0.9$[c]	0.58 [0.50; 0.66] $p = 0.018$[c]	0.62 [0.41; 0.77] $p > 0.9$[c]
	2017–2019	0.73 [0.70; 0.75] [ref]	0.77 [0.73; 0.81]	0.68 [0.58; 0.76]	0.72 [0.64; 0.79]	0.78 [0.72; 0.83]	0.66 [0.60; 0.71]	0.71 [0.62; 0.78]	0.56 [0.37; 0.72]
	2020–2022	0.77 [0.74; 0.79] $p < 0.001$[b]	0.79 [0.74; 0.83] $p = 0.012$[c]	0.83 [0.71; 0.90] $p = 0.058$[c]	0.72 [0.64; 0.79] $p = 0.11$[c]	0.80 [0.73; 0.86] $p = 0.7$[c]	0.74 [0.66; 0.80] $p = 0.11$[c]	0.76 [0.67; 0.83] $p > 0.9$[c]	0.69 [0.38; 0.87] $p = 0.066$[c]
	p-value[d]		[ref]	0.050	0.001	0.054	<0.001	<0.001	0.003

(Continues)

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TABLE 2 (Continued)

		Total	BMSM	EMSM	OMSM	BH	SSAH	OH	PWID
LTFU after linkage to care[f] 1-year CI	2014–2016	0.03 [0.02; 0.03] $p = 0.6$[b]	0.01 [0.00; 0.02] $p > 0.9$[c]	0.04 [0.02; 0.07] $p = 0.2$[c]	0.04 [0.02; 0.08] $p = 0.3$[c]	0.02 [0.01; 0.04] $p = 0.8$[c]	0.05 [0.03; 0.07] $p > 0.9$[c]	0.03 [0.01; 0.07] $p = 0.13$[c]	0.04 [0.00; 0.16] NA[h]
	2017–2019	0.03 [0.02; 0.04] [ref]	0.00 [0.00; 0.02]	0.04 [0.02; 0.09]	0.04 [0.02; 0.08]	0.01 [0.00; 0.03]	0.04 [0.03; 0.07]	0.07 [0.04; 0.12]	0.04 [0.00; 0.16]
	2020–2022	0.01 [0.01; 0.02] $p < 0.001$[b]	0.01 [0.00; 0.03] $p = 0.5$[c]	NA[h]	0.01 [0.00; 0.04] $p = 0.14$[c]	0.01 [0.00; 0.03] NA[h]	0.01 [0.00; 0.03] $p = 0.3$[c]	0.02 [0.01; 0.05] $p = 0.3$[c]	0.03 [0.00; 0.16] NA[h]
	p-value[d]		[ref]	<0.001	<0.001	0.069	<0.001	<0.001	<0.001
LTFU after ART initiation[g] 1-year CI	2014–2016	0.01 [0.01; 0.01] $p = 0.067$[b]	0.00 [0.00; 0.01] NA[h]	0.03 [0.01; 0.06] NA[h]	0.01 [0.00; 0.04] NA[h]	0.00 [0.00; 0.02] NA[h]	0.01 [0.00; 0.03] NA[h]	0.03 [0.01; 0.07] NA[h]	0.03 [0.00; 0.18] NA[h]
	2017–2019	0.02 [0.01; 0.03] [ref]	0.00 [0.00; 0.01]	0.01 [0.00; 0.06]	0.04 [0.01; 0.08]	0.02 [0.01; 0.05]	0.03 [0.01; 0.05]	0.04 [0.02; 0.08]	0.03 [0.00; 0.14]
	2020–2022	0.01 [0.00; 0.02] $p = 0.4$[b]	0.01 [0.00; 0.03] NA[h]	0.02 [0.00; 0.08] NA[h]	0.01 [0.00; 0.04] NA[h]	NA[h]	0.02 [0.00; 0.04] NA[h]	0.01 [0.00; 0.05] NA[h]	NA[h]
	p-value[d]		[ref]	0.006	0.016	0.4	0.010	0.008	<0.001

Abbreviations: ART, antiretroviral therapy; BH, Belgian heterosexuals; BMSM, Belgian MSM; CI, cumulative incidences; EMSM, European MSM; LTFU, loss to follow-up; OH, other heterosexuals; OMSM, other MSM; PWID, people who inject drugs; SSAH, sub-Saharan African heterosexuals.

[a]Variables included in the multivariable model for time between infection and diagnosis: population, period of diagnosis, sex and age (categorical).

[b]p-value of the adjusted hazard ratio for the comparison to the reference period (2017–2019; main effect).

[c]p-value of the adjusted hazard ratio for the comparison to the reference period (2017–2019; stratified model by population).

[d]p-value of the adjusted hazard ratio for the comparison of key populations to the reference population (BMSM; main effect).

[e]Variables included in the multivariable model for time between diagnosis and linkage to care: population, period of diagnosis, sex, age (categorical), CD4 at diagnosis (categorical) and VL at diagnosis (categorical).

[f]Variables included in the multivariable models for time between linkage to care and (a) ART initiation and (b) LTFU: population, period of linkage to care, sex, age (categorical), CD4 at linkage to care (categorical), VL at linkage to care (categorical).

[g]Variables included in the multivariable models for time between ART initiation and (a) VL suppression and (b) LTFU: population, period of linkage to care, sex, age (categorical), CD4 at ART initiation (categorical) and VL at ART initiation (categorical).

[h]Estimate not available because no events were observed or not possible to fit a stratified model.

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TABLE 3 Cumulative incidences at 1 year from either infection or immigration in case of a pre-migration infection to diagnosis by period of diagnosis and key populations and results of the time-to-diagnosis model.[a]

		Total	BMSM	EMSM	OMSM	BH	SSAH	OH	PWID
Infection to diagnosis 1-year CI	2014–2016	0.52 [0.48; 0.57] $p = 0.12$[b]	0.52 [0.46; 0.59] $p = 0.2$[c]	0.63 [0.54; 0.71] $p = 0.6$[c]	0.62 [0.53; 0.71] $p > 0.9$[c]	0.33 [0.26; 0.42] $p = 0.13$[c]	0.57 [0.51; 0.63] $p > 0.9$[c]	0.51 [0.43; 0.59] $p = 0.4$[c]	0.46 [0.29; 0.67] $p = 0.4$[c]
	2017–2019	0.50 [0.45; 0.54] [ref]	0.49 [0.43; 0.55]	0.59 [0.48; 0.69]	0.63 [0.55; 0.72]	0.2 [0.22; 0.36]	0.56 [0.50; 0.62]	0.47 [0.39; 0.56]	0.45 [0.27; 0.68]
	2020–2022	0.50 [0.45; 0.54] $p = 0.4$[b]	0.49 [0.42; 0.56] $p = 0.7$[c]	0.59 [0.48; 0.70] $p = 0.7$[c]	0.63 [0.55; 0.71] $p = 0.8$[c]	0.26 [0.18; 0.35] $p > 0.9$[c]	0.55 [0.48; 0.61] $p > 0.9$[c]	0.50 [0.42; 0.59] $p = 0.6$[c]	0.47 [0.30; 0.66] $p = 0.9$[c]
	p-value		[ref]	<0.001[d]	<0.001[d]	<0.001[d]	0.11[d]	0.3[d]	0.5[d]

Abbreviations: BH, Belgian heterosexuals; BMSM, Belgian MSM; CI, cumulative incidences; EMSM, European MSM; OH, other heterosexuals; OMSM, other MSM; PWID, people who inject drugs; SSAH, sub-Saharan African heterosexuals.

[a]Variables included in the multivariable model: population, period of diagnosis, sex and age (categorical).

[b]*p*-value of the adjusted hazard ratio for the comparison with the reference period (2017–2019; main effect).

[c]*p*-value of the adjusted hazard ratio for the comparison with the reference period (2017–2019; stratified model by population).

[d]*p*-value of the adjusted hazard ratio for the comparison of key populations with the reference population (BMSM; main effect).

sexual partners to take an HIV test [21, 22]. The relevance of these types of intervention to improve early testing should be explored in our context.

Remarkable progress was noted in the time required to initiate ART and to achieve a suppressed viral load. The reimbursement of ART for all people living with HIV in Belgium, regardless of their CD4 count, since December 2016, and the increasing use of highly effective ART such as integrase inhibitors [23] as the first-line treatment certainly contributed to these trends. Also, fewer individuals have interrupted HIV care in recent years, potentially thanks to a more systematic approach adopted by HRCs for monitoring those who miss appointments.

Both continuum analysis approaches revealed a progress across all key populations, yet disparities between them persisted at every stage. MSM showed the best outcomes in each stage; nearly half of Belgian MSM were diagnosed within the year following infection, while heterosexuals presented the longest delays. Raising awareness about early testing among heterosexual individuals is challenging due to their diverse profiles and often low self-perception of risk. Information campaigns and the education of healthcare professionals should acknowledge this diversity. Foreign heterosexuals presented overall the longest delays of diagnosis as many were infected abroad and migrated to Belgium afterwards, calling for intensifying provider-initiated HIV testing for migrants. A study among general practitioners in Belgium showed high acceptability of a culturally sensitive tool designed to support provider-initiated testing among sub-Saharan African migrants. However, scaling up such a testing approach would require sustained investment in the training of physicians [24]. More systematically addressing the sexual health of migrants from high-prevalence countries during medical consultations—including prevention and screening where appropriate—could help both prevent post-migration infections and facilitate earlier diagnosis for those already infected upon arrival. Increasing HIV awareness among sub-Saharan African migrant communities, with messages on both prevention and stigma reduction, will further promote open and effective communication about HIV with healthcare providers.

In the other stages of care, despite huge progress in their time to ART initiation, people who inject drugs more frequently experience delays in entering care and achieving viral suppression. They also remain the most vulnerable for HIV care interruption. Although people who inject drugs represent a small proportion of people living with HIV in care in Belgium (2.5% during the study period), they constitute a particularly challenging group to engage in chronic HIV care, as observed in other studies [25]. Barriers to retention and adherence related to substance use encompass forgetting medications and appointments due to drug use and prioritizing drug use over HIV treatment. Some factors supporting engagement and reengagement in care were identified, such as establishing a daily routine around ART intake and fostering a strong patient–provider relationship [26]. Strengthening the collaboration between HRCs and harm reduction services could enhance comprehensive care for people who inject drugs living with HIV. African and other non-Belgian heterosexuals initiate ART slightly later than others, although the

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delay strongly improved over the study period. This might be explained by additional barriers to ART initiation faced by migrants such as language, fear of stigma, cultural beliefs, lower familiarity with the healthcare system or administrative issues to access therapy [27].

The CoC for people living with HIV should be complemented by efforts to ensure the best possible quality of life. This essential aspect of their lives is equally important and should be carefully monitored in Belgium [28].

Previous studies indicate that achieving the 95-95-95 UNAIDS care targets alone will not be sufficient to control the HIV epidemic [29, 30], particularly in populations with high transmission rates, such as MSM [31–33]. Progress in the continuum of HIV care must be combined with advances in the other UNAIDS targets [12], including the crucial goal of achieving 95% usage of combination prevention—such as consistent use of condoms or pre-exposure prophylaxis—among those exposed to HIV [32]. The full potential of combination prevention will be realized only if a substantial number of individuals recognize their risk of contracting HIV and adopt appropriate prevention measures, thereby interrupting HIV transmission.

This study focused on the key populations most prevalent within the Belgian HIV epidemic, provided they were large enough for meaningful analysis and sufficient data were available. Consequently, it did not specifically focus on some of the groups considered by UNAIDS as particularly vulnerable, such as sex workers, transgender people or prisoners. However, it is likely that the administrative, legal, cultural and language barriers faced by these groups are similar to those encountered by the studied key populations to which they belong.

In conclusion, the observed advancements in the continuum of HIV care are attributable to both the spontaneous course of the epidemic and specific improvements in care. The increasing number and proportion of long-term patients having reached suppressed viral loads reflect the natural evolution of the epidemic, while significant enhancements, particularly in the early initiation and effectiveness of treatment, reflect active efforts made to optimize care. However, certain key populations, such as injecting drug users and migrants, continue to encounter specific barriers to HIV care. Respectful, culturally sensitive approaches tailored to the unique needs of these groups are essential to overcoming these challenges. On the other hand, no progress is seen in the earliness of diagnosis, while it is key for entry into HIV care and reducing onward transmission risk. Therefore, it is imperative to enhance existing testing strategies and adopt innovative approaches to improve early diagnosis. For a realistic chance at controlling the HIV epidemic, these measures must be integrated in an efficient combination prevention strategy.

AUTHOR CONTRIBUTIONS

D. Van Beckhoven and B. Serrien developed the study design. R. Demeester, J. Van Praet, P. Messiaen, G. Darcis, S. Henrard, P. De Munter and A. Libois contributed to data collection. B. Serrien performed the statistical analyses. D. Van Beckhoven and B. Serrien interpreted the results with inputs from all authors. D. Van Beckhoven drafted the manuscript. J. Deblonde supervised the study. All authors read and critically revised the subsequent drafts of the manuscript. All authors approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author upon approval of a project proposal to the HIV surveillance Steering Committee and clearance by the Belgian Information Security Committee.

ETHICS STATEMENT

The data were collected and analysed as part of the infectious disease surveillance and control by Sciensano, the Belgian institute of Health, which is legally entitled to conduct the surveillance of infectious diseases as part of its public health surveillance mandate. The HIV surveillance has been approved by an independent administrative authority protecting privacy and personal data (https://www.ehealth.fgov.be/ehealthplatform/file/cc73d96153bbd5448a56f19d925d05b1379c7f21/1cb59e77715c6cbc5910c153fe009af6be0bdd78/14-017-f102-surveillance-epidemiologique-du-vih-et-du-sida-en-belgique-modifiee-le-5-mars-2024.pdf). A strict attention to confidentiality is present at every stage of data collection, analysis and storage.

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