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Behavioral HIV-serosurvey reveals clustering of risk factors likely plays a key role in sustaining HIV epidemic in rural KwaZulu-Natal, South Africa

Nolwenn Conan¹, Jihane Ben-Farhat^{1*}, Liesbet Ohler², Chris Kenyon^{3,5}, Gilles Van Cutsem^{4,5}, Helena Huerga¹ and Jihane Ben Farhat¹

Abstract

New Human immunodeficiency virus (HIV) infections among adults have decreased in the last ten years in high HIV prevalent countries. However, unsuppressed individuals with high-risk sexual practices can play a key role in transmitting HIV and maintaining the HIV epidemic. We assessed the association between sexual behavior, HIV awareness, antiretroviral therapy (ART) intake and viral suppression, and the age-gender groups most at risk of maintaining HIV transmission in KwaZulu-Natal, South Africa.

We conducted a population-based cross-sectional survey including adolescents and adults aged 15 years and above from August to December 2018 in KwaZulu-Natal, South Africa. In this analysis we included only data from HIV-positive participants aged 15–59 years.

In total, 862 HIV-positive individuals aged 15–59 years were included, 76.2% (657) were women, and the median age was 36 [IQR 29–46] years, 10.1% (95%CI 8.2–12.3) were unaware of their HIV status, 15.8% (95%CI 13.4–18.2) not on ART, and 16.3% (95%CI 13.9–18.9) virally unsuppressed. Among the 671 participants who had sexual intercourse in the preceding year, 46.9% (315) consistently used condoms. Among those who provided information on the number of sexual partners, 7.5% (64/856) reported more than one. Overall, 10.6% (88/831) (95%CI 8.7–12.9) of HIV-positive participants were either at high or very high risk of sexually transmitting HIV. Of these, 42.0% (37/88) (95%CI 32.1–52.7) were women aged 20–34 years, 39.8% (35/88) (95%CI 30.0–50.4) were men aged 20–59 years, 50.0% (44/88) (95%CI 39.6–60.4) were unaware of their HIV-positive status and 76.1% (67/88) (95%CI 66.0–84.0) were not on ART. Within the 2.3% (95%CI 1.5–3.6) individuals at very high risk of HIV transmission (19 individuals virally unsuppressed with more than one partner and inconsistent condom use), 68.4% (13/19) (95%CI 43.4–85.9) were men aged 20 to 59 years, 52.6% (10/19) (95%CI 29.7–74.5) were unaware of their HIV- positive status, and 78.9% (15/19) (95%CI 53.5–92.4) were untreated.

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Efforts and age-gender targeted interventions to increase HIV diagnosis and HIV-positivity awareness, detect early ART treatment failure, provide enhanced adherence support and second- or third-line ART, as well as promote behavioral-risk reduction interventions, are needed to reduce the pool of individuals at high-risk of transmitting HIV.

Keywords HIV transmission, Viral suppression, Antiretroviral therapy, Sexual behavior, Kwazulu-Natal

Background

Across South Africa, various studies reported a substantial reduction of new Human immunodeficiency virus (HIV) infections among adults over the last ten years [1–4]. This reduction was most likely attributed to significant resources invested in large-scale combination HIV prevention interventions, such as the wide distribution of free condoms and the scale-up of treatment as prevention (TasP) [5, 6]. Given the evidence that people living with HIV (PLHIV) on antiretroviral treatment (ART) with sustained viral suppression do not sexually transmit HIV [7–9], and considering that the majority of HIV transmission in South Africa is attributed to sexual transmission [10], the launch of the new guideline on universal test and treat in 2016 [11, 12] was most likely an important factor in reducing the risk of transmitting HIV to sexual partners through increased ART coverage and viral suppression.

However, while the implementation of TasP and the rise of ART coverage in the general population have been promising, they do not exclude other factors that could affect the elimination of HIV transmission. Additionally, the HIV epidemic in South Africa remains one of the largest in the world, with a National prevalence of 14.0% (95% CI: 13.1–15.0) and incidence of 0.48% per year (95% CI: 0.42–0.54%), which is sufficient to sustain the epidemic [10]. Certain sub-groups of the population, such as young women or female sex workers, remain at high risk of HIV infection [13–15].

Recently, several arguments have been raised highlighting the necessity to understand the heterogeneity of HIV acquisition and transmission risk. From an HIV prevention perspective, it is crucial to consider not only the number of people receiving treatment, but also who is receiving it [16, 17], since a few virally unsuppressed individuals with high-risk sexual practices can sustain an epidemic [18]. Moreover, as commented by Baral et al., “the expectation of one-to-one reduction in onward HIV transmission is only applicable (or restricted) to fixed sero-discordant couples that are mutually monogamous over time” [16].

In 2013, a community-based HIV survey conducted in the subdistricts of Eshowe/Mbongolwane in KwaZulu-Natal (South Africa) showed that higher risk sexual behavior was associated with HIV-positive status unawareness and the absence of viral load suppression among those aware of their HIV-positive status [19]. A second community-based survey conducted in 2018 in

the same geographical area showed improvements and achievements in all 90-90-90 indicators [20] with a decline in x HIV- incidence among women aged 20–30 years old although the incidence remained high. However, there was no Significant decline among men or women under 20 years old [15]. These findings suggest that considerable HIV transmission is ongoing in the population and is maintaining the HIV epidemic in the area.

Using data from this second survey, we described sexual behavior and assessed the association between HIV awareness, ART intake, viral suppression, and sexual behavior, to identify the age-gender groups most at risk of HIV transmission. These findings will help understand the pockets of residual transmission in this setting.

Method

We conducted a two-staged, population-based cross-sectional survey from August to December 2018 in Eshowe/Mbongolwane, KwaZulu-Natal, South Africa, including adolescents and adults aged 15 years and above [20]. All members part of the randomly selected households aged 15 years and over were included in the survey [20]. For this analysis only HIV-positive participants aged 15 to 59 years were included. The age restriction was applied to allow comparisons with a previous HIV survey conducted in 2013, which included participants of this age group [19]. MSF supported HIV prevention, diagnosis, and treatment in the surveyed area.

After written consent, eligible participants were enrolled and invited to participate in a face-to-face interview in a private area where they felt comfortable answering questions. Structured questionnaires collected information on demographic characteristics, HIV testing frequency, HIV status awareness, ART intake, sexual behavior and condom use (Supplementary file – Men/Women questionnaires). Participants were free to refuse to answer questions or to withdraw from the study at any time. HIV testing was performed on-site for all participants regardless of their knowledge of HIV status or ART status, using Determine Rapid HIV-1/2 Antibody test (Abbott Laboratories, Abbott Park, IL, USA), followed, if positive, by the Unigold Rapid HIV Test (Trinity Biotech PLC, Bray, Ireland) for confirmation of results. Both tests have shown a good sensitivity and specificity in different settings, including South Africa [21, 22]. Participants with discordant results (Determine positive, Unigold negative) had a third “tiebreaker” test using a Western Blot platform (Bio-Rad, USA) to confirm their HIV

status. Counselling sessions were provided to all HIV positive participants, including participants aged 15–17 years old, and to participants who did not want to receive their HIV test results on site, according to the national HIV counselling and testing guideline [12]. All HIV-positive participants had a blood sample collected for HIV-RNA viral load testing, quantified on plasma HIV-RNA Polymerase chain reaction using the Abbott RealTime HIV-1 platform (m2000sp) with a detection limit of 40 copies/mL, at the laboratory level [23]. Participants who were willing to contribute to the survey but did not want to receive the HIV test results on-site (and therefore not know their HIV test results), had blood collected for HIV and HIV-RNA VL tests to be conducted at the laboratory. Sample size calculation, study and laboratory procedures are detailed in the main study article [20].

Definitions

'Aware of being HIV-positive' were participants who reported knowing their HIV-positive status before being tested. HIV-positive participants on ART were considered aware of their HIV status even they did not report as such. ART intake was determined by documentation from individual health records or self-reported if their health record was not available. Viral load suppression was defined as VL < 1000 copies/mL [20].

Similar to the first survey, condom use was considered consistent when individuals reported using condoms during the last sexual intercourse in the preceding year with their most recent partner if they had one partner in the preceding year, or with both of their two most recent partners if they had two partners or more in the preceding year. Condom use was defined as inconsistent otherwise [19]. The risk of individuals to transmit HIV was defined based on the VL and the sexual behavior as follows:

Group 1: Low risk

- VL < 1000 copies/mL & 0 partner in the preceding year.
- VL < 1000 copies/mL and 1 partner in the preceding year & condom consistency or inconsistency.
- VL < 1000 copies/mL and > 1 partner in the preceding year & condom consistency.

Group 2: Moderate risk

- VL < 1000 copies/mL and > 1 partner in the preceding year & condom inconsistency.
- VL ≥ 1000 copies/mL and 0 partner in the preceding year.
- VL ≥ 1000 copies/mL and 1 partner in the preceding year & condom consistency.

Group 3: High risk

- VL ≥ 1000 copies/mL and 1 partner in the preceding year & condom inconsistency.
- VL ≥ 1000 copies/mL and > 1 partner in the preceding year & condom consistency.

Group 4: Very high risk

- VL ≥ 1000 copies/mL and > 1 partner in the preceding year & condom inconsistency.

Youth were defined as individuals aged 15 and 19.

Statistical analysis

Data were analyzed using Stata 16 (Stata Corp., College Station, Texas, USA). Descriptive analyses were conducted, and the results are presented with 95% confidence intervals (CIs) to reflect precision. Continuous and categorical variables were compared using two-sample t-tests and Pearson chi-square tests, respectively, depending on the nature of the data. Proportions were calculated after excluding any missing values from the denominator. The population was divided into three distinct age categories: 15–19 years, 20–34 years, and 35–59 years. These age groups were selected based on differences in sexual behavior, which is known to vary in a non-linear manner across age ranges. This stratification was informed by existing evidence of age-related differences in sexual behaviors in South Africa and other contexts [19].

Ethical approval

Prior to participation, participants provided written informed consent (in English or isiZulu). Although minors aged 15–17 years did not need guardian consent to participate in the survey, since they are considered mature and able to consent to HIV testing on their own from the age of 12 according to the South African national HIV testing guidelines, they were advised to disclose their status, regardless of the result, to their parent/guardian, as agreed upon with the local committee. All methods were performed in accordance with the relevant guidelines and regulations.

Results

In total, 3,286 individuals 15–59 years were included in the survey. The inclusion rate among this age group was 80.0% (3,286/4,109), with a higher rate among women (84.7%, 2,165/2,557) compared to men (72.2%, 1,121/1,552), $p < 0.001$. The median age of participants was 30 years [IQR 20–44], with 2,165 individuals (65.9%) being women. In total, 38.4% of the participants were aged 15 to 24, 71.9% had never been married, and 92.2% had completed at least primary school.

Table 1 Socio-demographic characteristics of the 862 HIV-positive participants

	n (%)
Gender	
Men	205 (23.8)
Women	657 (76.2)
Median age [IQR] (years)	36 [29–46]
Age (years)	
15–19	41 (4.8)
20–34	326 (37.8)
35–59	495 (57.4)
Marital Status †	
Married or living together	203 (23.5)
Never married	592 (68.7)
Separated/divorced/widow	66 (7.7)
Education	
Completed at least primary school	786 (91.2)
No schooling	76 (8.8)
Occupation	
Unemployed	546 (63.3)
Employed	166 (19.3)
Housewife/husband	55 (6.4)
Student	42 (4.9)
Other	53 (6.1)

†One missing value in 2018

IQR Interquartile range

In total, 862 individuals HIV-positive aged 15–59 years were included in this analysis. Of them, 657 (76.2%) were women and the median age was 36 years [interquartile range, IQR: 29–46]. Overall, 68.7% (592/861) of these individuals had never been married and 91.2% (786/862) had completed at least primary school. Demographic data are presented in Table 1.

Sexual partners and condom use

Among the 856 HIV-positive participants who reported the number of partners they had in the past, 671 (78.4%, (95%CI 75.5–81.0)) reported at least one sexual partner in the preceding year (Table 2). More men than women reported having more than one partner in the previous year: 20.2% of men versus 3.5% of the women ($p < 0.001$).

The proportion of HIV-positive participants who reported having more than one partner in the previous year was higher among those aged 20–34 years (10.1%) compared to those aged 15–19 years (4.9%), and those aged 35–59 years (5.9%), $p < 0.001$. Half (53.7% (95%CI 38.1–68.6), 22/41) of the 15–19-years-old reported they had never had sexual intercourse. Of these, 17/22 (77.3%, (95%CI 54.1–90.7)) were on ART.

Among the 677 HIV-positive individuals who reported having sexual intercourse in the preceding year (including 6 who did not report the number of partners), 33 (4.9%) engaged in a casual or transactional relationship. This proportion was higher among men than women, 12.6% (22/175) versus 2.2% (11/502) respectively ($p < 0.001$).

Among participants who had sexual intercourse in the preceding year, 46.9% (95%CI 43.2–50.7) (315/671) consistently used condoms: 47.1% among women versus 46.3% among men; $p = 0.83$. Consistent condom use was lower in individuals aged 20–34 years compared to those aged 15–19 and 35–59 (42.9% (139/324), 57.9% (11/19) and 43.1% (212/492) respectively, p -value=0.43), and in those reporting more than one partner compared to those with one partner (23.4%, (95%CI 14.5–35.6) (15/64) versus 49.4%, 45.4–53.4 (300/607), $p < 0.001$).

HIV-positive awareness, ART intake and viral suppression

In total, 10.1% (95%CI 8.2–12.3) (87/862) of the HIV-positive participants were unaware of their HIV status, 15.8% (95%CI 13.4–18.2) (135/862) were not on ART and 16.3% (95%CI 13.9–18.9) (136/837) had a VL $\geq$ 1000 copies/mL. Both men and youths aged 15 to 19, regardless of gender, were more likely to be unaware and virally unsuppressed (Table 3). Among those aware, 6.2% (95%CI 4.7–8.1) (48/775) were not on ART. Among those aware and treated, there were no differences between women and men with regards to viral suppression (5.0% (28/564) versus 7.7% (11/143) were unsuppressed respectively, $p = 0.20$); however, youths aged 15–19 on ART were more likely to be virally unsuppressed than older counterparts (23.3% (95%CI 11.1–42.4) (7/30) versus 8.2% (95%CI

Table 2 Number of sexual partners in the previous 12 months by sex and age group

	Total	Women	Men	15–19 years	20–34 years	35–59 years
	% (n) N=856	% (n) N=653	% (n) N=203	% (n) N=41	% (n) N=326	% (n) N=489
No partner ever	2.8 (24)	2.1 (14)	4.9 (10)	53.7 (22)	0.6 (2)	0
No partner in previous 12 months	18.8 (161)	21.6 (141)	9.9 (20)	2.4 (1)	7.4 (24)	27.8 (136)
1 partner in previous 12 months	70.9 (607)	72.7 (475)	65.0 (132)	39.0 (16)	81.9 (267)	66.3 (324)
> 1 partner in previous 12 months	7.5 (64)	3.5 (23)	20.2 (41)	4.9 (2)	10.1 (33)	5.9 (29)

Table 3 Viral suppression and awareness of HIV status among participants reporting sexual activity, by gender and age group

	Total % n/N	Women % n/N	Men % n/N	15–19 % n/N	20–34 % n/N	35–59 % n/N
Unaware of HIV positivity	10.1 87/862	7.9 52/657	17.1 35/205	22.0 9/41	15.0 49/326	5.9 29/574
Not on ART among aware	6.2 48/775	4.3 26/605	12.9 22/170	-	8.3 23/277	5.4 25/466
VL ≥ 1000 copies/mL among all HIV+	16.3 136/837	12.9 82/638	27.1 54/199	33.3 13/39	23.2 72/310	10.5 51/488
VL ≥ 1000 copies/mL among aware	9.4 71/757	7.3 43/590	16.7 28/167	23.3 7/30	13.2 35/266	6.3 29/461
VL ≥ 1000 copies/mL among aware and on ART	5.5 39/707	5.0 28/564	7.7 11/143	23.3 7/30	8.2 20/244	2.8 12/433
VL ≥ 1000 copies/mL among unaware	81.3 65/80	81.3 39/48	81.3 26/32	66.7 6/9	84.1 37/44	81.5 22/27

5.3–12.4) (20/244) among the 20–34 and 2.8% (95%CI 1.6–4.8) (12/433) among the 35–59, $P < 0.001$).

Groups at risk of maintaining HIV transmission

Participants with more than one partner and inconsistent condom use had the highest proportion of unawareness compared to other groups (Table 4). Among HIV-positive men, 43.3% (13/30) with more than one partner and inconsistent condom use, 54.6% (6/11) with more than one partner and consistent condom use and 28.3% (17/60) with one partner with inconsistent condom use, were virally unsuppressed. In women, these proportions were 31.6% (6/19), 25.0% (1/4), and 19.1% (45/236) respectively.

The proportion of virally unsuppressed participants on ART was higher among those with more than one partner and consistent or inconsistent condom use compared to the other groups. It was similar among men and women with consistent condom use (28.6% (2/7) versus 25.0% (1/4) respectively; $p = 0.898$), and with inconsistent condom use (11.8% (2/17) versus 13.3% (2/15), $p = 0.893$). In all sexual behavior groups, individuals aged 15–19 years were more virally unsuppressed than other age groups. The distribution of sexual behavior, unawareness and being unsuppressed among HIV-positive by age group is presented in the Supplement file (Table S1).

Among HIV-positive participants with a viral load result and information of sexual behavior, 88/831 (10.6%, (95%CI 8.7–12.9)) had a high or very high risk of sexually transmitting HIV (Figure 1). Of these, 40.9% (95%CI 31.0–51.6) were men, 58.0% (95%CI 47.3–67.9) were aged 20–34 years, 42.0% (95%CI 32.1–52.7) were women aged 20 to 34 years, and 39.8% (95%CI 30.0–50.4) were men aged 20 to 59 years (Table 5). In the low or moderate risk groups, 21.7% (95%CI 18.8–24.8) were men, 34.9% (95%CI 31.5–38.4) were aged 20–34 years, 29.2% (95%CI 26.0–32.6) were women aged 20 to 34 years, and 20.2% (95%CI 17.5–23.2) men aged 20–59 years.

Among HIV-positive participants with a viral load result and information of sexual behavior, 88/831 (10.6%, (95%CI 8.7–12.9)) had a high or very high risk of sexually transmitting HIV (Figure 1). Of these, 40.9% (95%CI 31.0–51.6) were men, 58.0% (95%CI 47.3–67.9) were aged 20–34 years, 42.0% (95%CI 32.1–52.7) were women aged 20 to 34 years, and 39.8% (95%CI 30.0–50.4) were men aged 20 to 59 years (Table 5). In the low or moderate risk groups, 21.7% (95%CI 18.8–24.8) were men, 34.9% (95%CI 31.5–38.4) were aged 20–34 years, 29.2% (95%CI 26.0–32.6) were women aged 20 to 34 years, and 20.2% (95%CI 17.5–23.2) men aged 20–59 years.

Participants at high or very high-risk of transmitting HIV were more frequently unaware of their HIV status and untreated compared to those with lower risk: 50.0% versus 4.8% unaware ($p < 0.001$), and 76.1% versus 8.5% untreated ($p < 0.001$) respectively.

Of the 19 participants at very high risk of HIV transmission (2.3% of the HIV-positive with viral load result), 68.4% (95%CI 43.4–85.9) were men aged 20–59 years, 52.6% (95%CI 29.7–74.5) were unaware of their status, 78.9% (95%CI 53.5–92.4) were not on ART, 26.3% were aware but not on ART, and 21.1% were aware and on ART. The majority (89.5%, (95%CI 63.9–97.6)) had at least one previous HIV test and 26.3% (95%CI 10.7–51.6) had a casual or transactional partner in the preceding year.

Discussion

Our analysis shows that the proportion of participants unaware of their HIV positive status or being virally unsuppressed, in the Eshowe/Mbongolwane area was higher among those with more than one sexual partner in the preceding year (regardless of condom use) compared to participants with no sexual partner or with one partner. We also observed that 10.6% of the HIV-positive individuals were at high or very high risk to transmit HIV, half of whom were unaware of their status and three quarters were not on ART. Having a high or very high

Table 4 Sexual behavior, HIV-positive awareness and viral suppression among HIV-positive participants by gender (N = 856)

	Among participants with no partners in the preceding year or ever				Among participants with 1 partner in the preceding year and consistent condom use				Among participants with 1 partner in the preceding year and inconsistent condom use				Among participants with > 1 partner in the preceding year and consistent or inconsistent condom use			
	Women % n/N	Men % n/N	Total % n/N		Women % n/N	Men % n/N	Total % n/N		Women % n/N	Men % n/N	Total % n/N		Women % n/N	Men % n/N	Total % n/N	
Unaware of HIV positivity	5.2 8/155	20.0 6/30	7.6 14/185		5.2 12/231	10.1 7/69	6.3 19/300		12.3 30/244	14.3 9/63	12.7 39/307		9.1 2/23	31.7 13/41	23.4 15/64	
Not on ART among aware	1.4 2/147	16.7 4/24	3.5 6/171		4.6 10/219	6.5 4/62	5.0 14/281		5.6 12/214	18.5 10/54	8.2 22/268		11.8 2/21	14.3 4/28	12.2 6/49	
VL ≥ 1000 copies/mL	7.2 11/153	27.6 8/29	10.4 19/182		8.6 19/222	14.9 10/67	10.0 29/289		19.1 45/236	28.3 17/60	21.0 62/296		30.4 7/23	46.3 19/41	40.6 26/64	
VL ≥ 1000 copies/mL among aware	4.8 7/146	17.4 4/23	6.5 11/169		5.2 11/212	8.2 5/61	5.9 16/273		9.7 20/207	20.8 11/53	11.9 31/260		23.8 5/21	28.6 8/28	26.5 13/49	
VL ≥ 1000 copies/mL among aware and on ART	3.5 5/143	11.1 2/18	4.3 7/161		3.9 8/203	5.3 3/57	4.2 11/260		6.2 12/195	4.8 2/42	5.9 14/237		15.8 3/19	16.7 4/24	16.3 7/43	
VL ≥ 1000 copies/mL among unaware	57.1 4/7	66.7 4/6	61.5 8/13		80.0 8/10	83.3 5/6	81.3 13/16		86.2 25/29	85.7 6/7	86.1 31/36		100 2/2	84.6 11/13	86.7 13/15	

risk to transmit HIV was higher among men compared to women and among young people 20–34 years compared to other age groups. Among the 2.3% at very high risk of transmitting HIV (those who were virally unsuppressed with more than one partner and with inconsistent condom use), one third were men aged 20 to 34 years, another third were men aged 35 to 59 years, one fifth were women aged 20 to 34 years. Most individuals in this very high-risk group unaware of their HIV-positive status and untreated.

Only a small proportion of HIV-positive individuals reported more than one partner in the previous 12 months with men more frequently having more than one partner than women. Similar findings were observed in the same area in 2013 [19]. Findings indicate that half of youths aged 15 to 19 years reported never having engaged in sexual intercourse, suggesting that they acquired HIV through vertical transmission. Additionally, only three quarters of these youths were on ART. These results underscore the critical need for early diagnosis and treatment of HIV in pregnant women to prevent mother-to-child transmission. They also highlight the need for continuous support and care for adolescents living with HIV, ensuring they adhere to ART to achieve viral suppression and prevent further transmission. Moreover, condom use was low, as reported in other settings [24–26], particularly among participants reporting more than one partner. Reduced condom use with greater sexual frequency has also been reported in other studies [25, 27]. Reiterating efforts already done in this context (large condom distribution and promotion programs during the years preceding the survey) to increase condom use, specifically among individuals with more than one partner, by reinvigorating condom promotion and distribution programs, is needed. Likewise, enhancing HIV testing services for the population is essential to increase the likelihood of changes in sexual behavior and condom use [28].

Despite an important decrease in the proportion of individuals unaware of their HIV status (between 2013 and 2018) and in the proportion of virally unsuppressed individuals (24.7% versus 10.1%, and 42.9% versus 16.3% respectively), the proportion of unsuppressed participants on ART with more than one partner in the preceding year remained high in 2018 in both men and women: 16.7 % and 15.8% respectively.

Our analysis reveals a relatively high proportion of men aware of their HIV-positive status but virally unsuppressed, with one partner and inconsistent condom use, which poses a significant challenge to controlling HIV transmission. Several studies conducted in Sub-Saharan Countries, including South Africa, have shown that a significant proportion of new infections occur in HIV sero-discordant stable partnerships [29–31]. Additionally, HIV

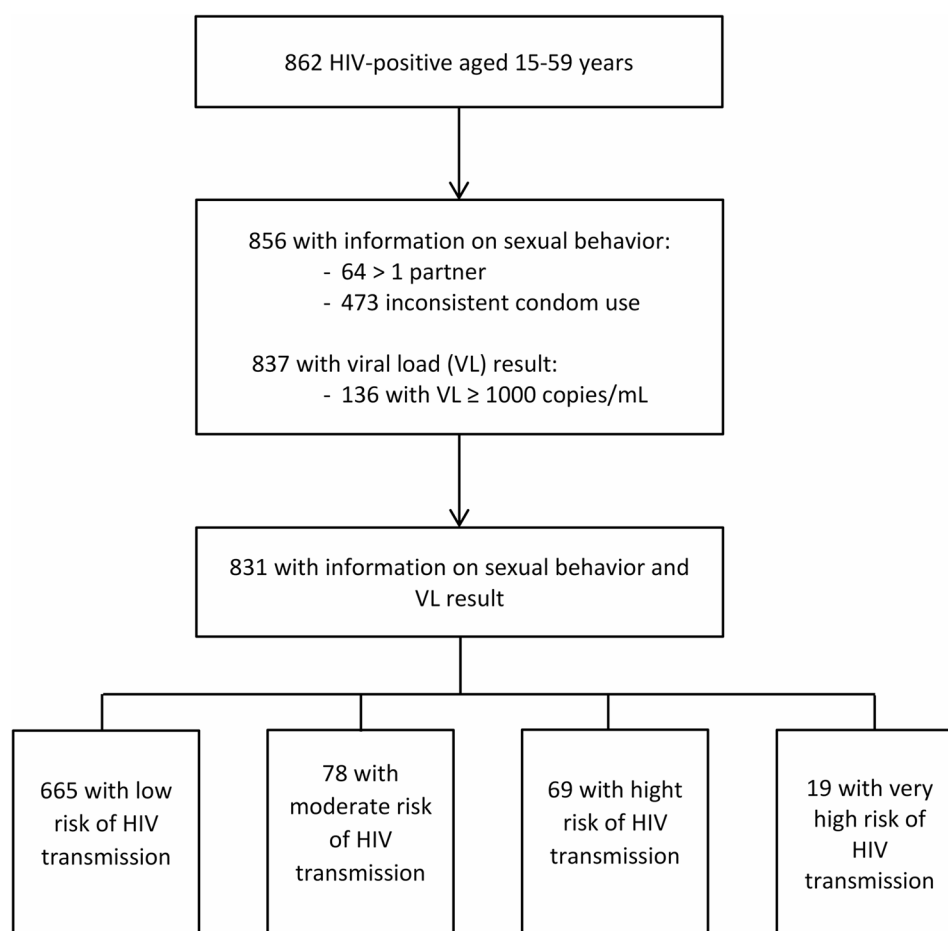


Fig. 1 Levels of HIV transmission risk among participants

can be transmitted to new partners after the dissolution of the current relationship. Therefore, it remains essential to strengthen messages for unsuppressed men who have one partner with inconsistent condom use about initiating and adhering to ART in this setting.

Furthermore, we observed that about half of the HIV-positive individuals in high and very high-risk groups were unaware of their status, and three quarters were untreated. These findings align with those observed in the first survey [19]. This leads to several hypotheses: 1) the individuals did not get access to treatment after being tested positive, suggesting a failure of the TasP strategy to contain HIV transmission; 2) the individuals did not want or could not take ART because of stigma or other reasons; 3) the persons reported to be aware of their status during the survey while they were not, which is very unlikely.

Our data reveals that the majority of the individuals at very high-risk of transmitting HIV were men aged 20-59 years old. Other studies have reported that young women are more likely to be infected with HIV when involved in age-disparate relationships, and are key drivers of the

HIV transmission [32–34]. This may explain why the number of new infections among women aged less than 20 years old did not decline in our setting [15]. Furthermore, only one fifth of this high-risk group were on ART, with most of them unaware of their HIV-positive status, highlighting the limitations of TasP in this setting, as described elsewhere [32].

Even though it is small, the group of men aged 20 to 59 may constitute a priority for targeted combination prevention interventions, as they are likely to be significant drivers of the epidemic.

Limitations

These results should be interpreted with caution, as the data were collected in 2018. However, the HIV epidemic continues to be a significant burden in this area [35]. Therefore, our findings remain valuable for understanding ongoing challenges and informing future interventions. Self-reporting bias may have been present in the study. Firstly, the awareness of HIV-positive status that have been underestimated among participants who incorrectly reported their HIV-positive status. Secondly,

Table 5 Characteristic of HIV-positive according to their risk of HIV transmission (N=831)

	Group 1 (Low risk)	Group 2 (Moderate risk)	Total Groups 1 and 2	Group 3 (High risk)	Group 4 (Very high risk)	Total Groups 3 and 4
	N=665 n (%)	N=78 n (%)	N=743 n (%)	N=69 n (%)	N=19 n (%)	N=88 n (%)
Gender						
Women	539 (81.1)	43 (55.1)	582 (78.3)	46 (66.7)	6 (31.6)	52 (59.1)
Men	126 (19.0)	35 (44.9)	161 (21.7)	23 (33.3)	13 (68.4)	36 (40.9)
Age group						
15–19	25 (3.8)	10 (12.8)	35 (4.7)	4 (5.8)	0 (0.0)	4 (4.5)
20–34	223 (33.5)	36 (46.2)	259 (34.9)	41 (59.4)	10 (52.6)	51 (58.0)
35–59	417 (62.7)	32 (41.0)	449 (60.4)	24 (34.8)	9 (47.4)	33 (37.5)
Age/gender group						
Women 15–19	18 (2.7)	6 (7.7)	24 (3.2)	3 (4.3)	0 (0.0)	3 (3.4)
Men 15–19	7 (1.1)	4 (5.1)	11 (1.5)	1 (1.4)	0 (0.0)	1 (1.1)
Women 20–34	195 (29.3)	22 (28.2)	217 (29.2)	33 (47.8)	4 (21.1)	37 (42.0)
Men 20–34	28 (4.2)	14 (18.0)	42 (5.7)	8 (11.6)	6 (31.6)	14 (15.9)
Women 35–59	326 (49.0)	15 (19.2)	341 (45.9)	10 (14.5)	2 (10.5)	12 (13.6)
Men 35–59	91 (13.7)	17 (21.8)	108 (14.5)	14 (20.3)	7 (36.8)	21 (23.9)
Marital Status ^Y						
Married or living together	165 (24.8)	12 (15.8)	177 (23.9)	16 (23.2)	3 (15.8)	19 (21.6)
Never married	439 (66.1)	63 (82.9)	502 (67.8)	52 (75.4)	16 (84.2)	68 (77.3)
Separated/divorced/widow	60 (9.0)	1 (1.3)	61 (8.2)	1 (1.4)	0 (0.0)	1 (1.1)
Had a casual/transactional partner (s) in the last 12 months	12 (1.8)	15 (19.2)	27 (3.6)	3 (4.3)	5 (26.3)	8 (9.1)
HIV testing ^f						
None	2 (0.3)	2 (2.6)	4 (0.5)	2 (2.9)	2 (10.5)	4 (4.5)
1 time	201 (30.8)	31 (40.3)	232 (31.2)	17 (24.6)	5 (26.3)	22 (25.0)
> 1 time	449 (68.9)	44 (57.1)	493 (66.4)	50 (72.5)	12 (63.2)	62 (70.5)
Unaware of HIV-positive status	13 (2.0)	23 (29.5)	36 (4.8)	34 (49.3)	10 (52.6)	44 (50.0)
Not on ART	31 (4.7)	32 (41)	63 (8.5)	52 (75.4)	15 (78.9)	67 (76.1)

^YMissing values: 1 in group 1 and 2 in group 2^fMissing values: 13 in group 1 and 1 in group 2

ART coverage might have been either overestimated or underestimated. Participants might have overreported to be on ART to align with perceived social expectations, or underreported it due to stigma or fear of disclosure. However, previous studies in this setting have shown no significant difference between self-reported ART coverage and ART coverage estimated using ARV blood detection tests [36]. Thirdly reporting bias may have occurred when reporting the number of sexual partners, as men are more likely to overreport and women to underreport numbers of partners [37, 38].

Conclusion

In the Eshowe/Mbongolwane setting, with a well-supported HIV program and high ART coverage, a small number of individuals, the majority men aged 20–59 years, remained at very high risk of transmitting HIV. This group combine multiple partners and low condom use with the absence of viral suppression, with only half of them aware of their status, and one in five on ART.

Efforts and age-gender targeted interventions to increase HIV diagnosis and HIV-positivity awareness, detect early ART treatment failure, provide enhanced adherence support and second- or third-line ART, as well as promote behavioral-risk reduction interventions, are needed to reduce the pool of individuals at high risk of transmitting HIV.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

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Authors' contributions

H.H conceived and designed the study; N.C, J.B.F and H.H analyzed the data; N.C wrote the paper; J.B.F; H.H, L.O, G.V.C and C.K critically reviewed the manuscript.

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Data availability

Deidentified data from 2018 are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate

Ethical approval was received from the University of Cape Town Human Research Ethics Committee (HREC reference: 320/2018), the Provincial Health Research Unit of the KwaZulu Natal Department of Health (NHRD 2018 Ref: KZ_201807_26) and the Médecins Sans Frontières Ethics Review Board (Reference: ID1842). Written informed consent (in English or isi-Zulu) was collected prior to participation. Approvals included the cut off of 15 years of age in seeking guardian consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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