# Community-based HIV prevalence in KwaZulu-Natal, South Africa: results of a cross-sectional household survey

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# Community-based HIV prevalence in KwaZulu-Natal, South Africa: results of a cross-sectional household survey

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## Summary

**Background** In high HIV burden settings, maximising the coverage of prevention strategies is crucial to achieving epidemic control. However, little is known about the reach and effect of these strategies in some communities.

**Methods** We did a cross-sectional community survey in the adjacent Greater Edendale and Vulindlela areas in the uMgungundlovu district, KwaZulu-Natal, South Africa. Using a multistage cluster sampling method, we randomly selected enumeration areas, households, and individuals. One household member (aged 15–49 years) selected at random was invited for survey participation. After obtaining consent, questionnaires were administered to obtain sociodemographic, psychosocial, and behavioural information, and exposure to HIV prevention and treatment programmes. Clinical samples were collected for laboratory measurements. Statistical analyses were done accounting for multilevel sampling and weighted to represent the population. A multivariable logistic regression model assessed factors associated with HIV infection.

**Findings** Between June 11, 2014, and June 22, 2015, we enrolled 9812 individuals. The population-weighted HIV prevalence was 36·3% (95% CI 34·8–37·8, 3969 of 9812); 44·1% (42·3–45·9, 2955 of 6265) in women and 28·0% (25·9–30·1, 1014 of 3547) in men (p<0·0001). HIV prevalence in women aged 15–24 years was 22·3% (20·2–24·4, 567 of 2224) compared with 7·6% (6·0–9·3, 124 of 1472; p<0·0001) in men of the same age. Prevalence peaked at 66·4% (61·7–71·2, 517 of 760) in women aged 35–39 years and 59·6% (53·0–66·3, 183 of 320) in men aged 40–44 years. Consistent condom use in the last 12 months was 26·5% (24·1–28·8, 593 of 2356) in men and 22·7% (20·9–24·4, 994 of 4350) in women (p=0·0033); 35·7% (33·4–37·9, 1695 of 5447) of women's male partners and 31·9% (29·5–34·3, 1102 of 3547) of men were medically circumcised (p<0·0001), and 45·6% (42·9–48·2, 1251 of 2955) of women and 36·7% (32·3–41·2, 341 of 1014) of men reported antiretroviral therapy (ART) use (p=0·0003). HIV viral suppression was achieved in 54·8% (52·0–57·5, 1574 of 2955) of women and 41·9% (37·1–46·7, 401 of 1014) of men (p<0·0001), and 87·2% (84·6–89·8, 1086 of 1251) of women and 83·9% (78·5–89·3, 284 of 341; p=0·3670) of men on ART. Age, incomplete secondary schooling, being single, having more than one lifetime sex partner (women), sexually transmitted infections, and not being medically circumcised were associated with HIV-positive status.

**Interpretation** The HIV burden in specific age groups, the suboptimal differential coverage, and uptake of HIV prevention strategies justifies a location-based approach to surveillance with finer disaggregation by age and sex. Intensified and customised approaches to seek, identify, and link individuals to HIV services are crucial to achieving epidemic control in this community.

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## Introduction

South Africa contributes about 18% of the global HIV burden.[1] In 2016, an estimated 7·1 million South Africans had HIV, 270 000 new HIV infections and 110 000 AIDS-related deaths occurred, and over 3·9 million people living with HIV were receiving antiretroviral therapy (ART).[1] National and regional HIV prevalence surveys feed into the country's information base and help to monitor epidemic trends over time.[2,3] In 2002, HIV prevalence among South Africans was 11·4% and by 2012 increased to 12·6%, whereas prevalence among 15–49-year olds increased from 15·6% to 18·8% over the same period. Provincially, KwaZulu-Natal had the highest prevalence, which increased from 15·7% in 2002 to 27·9% in 2012 compared with the Western Cape, which showed a decline from 13·2% in 2002 to 7·8% in 2012.[2]

In response to the ongoing high HIV prevalence, the South African Government, in 2010, launched a national campaign to increase[4] access to HIV testing services to enhance knowledge of HIV status and uptake of ART,[5] prevention of mother-to-child transmission of HIV,[6] medical male circumcision,[7] and provision of post-exposure prophylaxis, and recently expanded the provision of pre-exposure prophylaxis (PrEP).[8] To fast-track the response to HIV and AIDS, UNAIDS

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**Research in context**

**Evidence before this study**

South Africa, with a national HIV prevalence of 18·8% in the age group 15–49 years, has a special and unique typology of a generalised hyperendemic epidemic. To reduce the number of new HIV infections and associated morbidity and mortality, the South African Government has rolled out intensified HIV prevention strategies towards achieving epidemic control. We searched PubMed and MEDLINE up to June 20, 2017, for South African HIV surveillance studies in the English language that assessed HIV prevalence and the contemporaneous coverage of HIV prevention strategies such as knowledge of HIV status through HIV testing services, condom use, medical male circumcision, coverage of antiretroviral therapy (ART) among people with HIV, and HIV viral suppression. We used search terms individually and in combination. Search terms were "HIV", "AIDS", "surveillance", "prevalence", "HIV prevention strategies", "knowledge of HIV status", "condom use", "ART uptake or coverage", "antiretroviral therapy", and "viral suppression". We identified reports or studies on the annual National Antenatal Sentinel HIV Prevalence Surveys, annual Africa Centre Demographic Information System in the Hlabisa district from northern KwaZulu-Natal community surveys, the South African National household surveys of 2002, 2005, 2008, and 2012; the Mbongolwane and Eshowe HIV Impact Survey in KwaZulu Natal, South African Agincourt Health and Socio-Demographic Surveillance in Mpumalanga and the South African Orange Farm survey; however, the findings from these surveys are not generalisable to communities beyond the survey areas. To guide targeted rollout and scale-up of HIV prevention interventions more precisely and cost-efficiently, location-based HIV measures are vital.

**Added value of this study**

Our findings from the study area show a high overall population-level HIV prevalence of 36·3% among men and women aged 15–49 years; and a disproportionate burden among women (44·1%) compared with men (28·0%). The age–sex disaggregation of prevalence highlights the consistently higher prevalence in young women compared with young men and by age 24 years, one in three young women were HIV positive compared with one in nine young men. Although men and women self-reported engaging in HIV prevention strategies including testing services, condom use, medical male circumcision, and sustainable ART with associated viral suppression, the coverage of these strategies was suboptimal given the high HIV burden in this community.

**Implications of all the available evidence**

Our results emphasise an important missed opportunity and gap in the coverage of HIV prevention strategies that potentially fuel new infections. Intensified approaches to seek, to identify, and to link individuals to interventions will be crucial to achieving epidemic control in this region.

90-90-90 targets[9,10] and the universal test and treat[11] strategy have been adopted. These collectively aimed at reducing HIV transmission potential to reduce new infections, AIDS-related morbidity and mortality, and increase life expectancy.[12–14] As programmes are scaled up, HIV surveillance is similarly crucial to providing comprehensive structural, behavioural, and biological data to determine barriers and facilitators of programmatic effect on underlying dynamics of transmission within communities and geographical areas.[1,15] These are fundamental to achieving the optimistic and sustainable goals towards HIV epidemic control,[16] which aim to end the AIDS epidemic by the year 2030[1] with the realisation of an AIDS-free generation.[17]

The HIV Incidence Provincial Surveillance System has been established as a surveillance platform in a geographically defined region in KwaZulu-Natal, South Africa, to assess the effect of HIV prevention efforts in a real world, non-trial setting.[18] We report on the baseline findings of sex-specific and age-specific HIV prevalence, sociodemographic, biological, and behavioural factors associated with HIV, and the contemporaneous coverage of HIV prevention strategies.

## Methods

### Survey setting and source population

The household survey was done in rural Vulindlela and the adjacent periurban Greater Edendale area in the uMgungundlovu district of KwaZulu-Natal, South Africa.[18] Vulindlela has just over 150 000 people, is mainly rural, and has few employment opportunities through the commercial forestry projects and the neighbouring residential and manufacturing towns. The Greater Edendale area has a population of just over 210 000 people and consists of informal settlements, townships, and periurban areas. Primary health-care clinics and community-based organisations provide health care and psychosocial support, whereas district partners including the US President's Emergency Plan for AIDS Relief provide technical support to strengthen health services. Partnerships with stakeholders including health-service providers and traditional leaders from the community contribute to the development of research programmes in the area, recognising the high HIV burden in the district.[2,3]

### Survey design and procedures

The sampling frame for the number of households and the number of persons in each enumeration area was created from the Census undertaken in 2011, a community survey undertaken in 2007[18,19] and aerial imaging of dwellings supplied by Geo Terra Image. From a total of 600 enumeration areas, all 591 enumeration areas with more than 50 households were included in the sample. Of these, 221 enumeration areas were drawn randomly. Within an enumeration area the households were drawn systematically with a random start. We used multistage cluster sampling to randomly select enumeration areas, households, and individuals. Households were located on maps and study staff approached the head or designate, provided study information, obtained verbal consent, confirmed the selected household with global positioning system coordinates, administered the general household questionnaire, and enumerated household members. In view of the potential to overestimate HIV prevalence through clustering of infections within households, only one household member (aged 15–49 years) was selected at random and invited for survey participation. For participants agreeing to provide clinical samples and participate in the study, we obtained written informed consent for those 18 years and older, assent with parental consent for those younger than 18 years in English or isiZulu followed by obtaining fingerprints with a mobile biometric scanner.

Questionnaires were programmed on handheld personal digital assistants by MobenziR Researcher (Durban, South Africa) and administered by study staff to obtain general sociodemographic, psychosocial, and behavioural information. Information on HIV prevention and treatment exposures was obtained. Details included access to and use of condoms, access to HIV testing services, frequency of testing, knowledge of status, self-reported ART use, and male circumcision status ascertained with the aid of a chart with visual representation of traditional or medical circumcision and whether the procedure was done by professional health-care personnel within health-care facilities or as part of sociocultural practices of rituals of passage into manhood in non-clinical settings by non-professional members. Clinical samples collected were peripheral blood, urine (men), and self-collected vulvo-vaginal swabs (women). Participants were assigned a unique study number that linked them to the household, samples, and fingerprints. We tested samples for HIV antibodies with the fourth generation HIV enzyme Biomerieux Vironostika Uniform II Antigen/Antibody Microelisa system (BioMérieux, Marcy I'Etoile, France) and confirmed positive samples with the HIV 1/2 Combi Roche Elecys (Roche Diagnostics, Penzberg, Germany), and HIV-1 Western Blot Biorad assay (Bio-Rad Laboratories, Redmond, WA, USA). All indeterminate results were resolved with ADVIA Centaur HIV Antigen/Antibody Combo (CHIV) Assay (Siemens, Tarry Town, NY, USA). We measured CD4 cell counts using Becton Dickinson (BD) FACS Calibur flow cytometry (BD Biosciences, San Jose, CA, USA) and HIV viral load using the Roche COBAS AmpliPrep/COBAS TaqMan HIV-1 v2.0 assay (CAP/CTM HIV-1 V2.0, Roche Diagnostics, Penzberg, Germany) with a dynamic range of 20–10 million copies per mL. Participants were provided with barcoded referral cards and advised to return to their health clinic to access results and follow-up care.

| | Women (n=6265) | Men (n=3547) |
|---|---|---|
| Median age (years) | 27·4 (20·6–36·2) | 26·4 (20·1–35·0) |
| Age group (years) | | |
| 15–19 | 958 (18·2%) | 658 (19·6%) |
| 20–24 | 1266 (19·5%) | 814 (20·8%) |
| 25–29 | 1087 (17·9%) | 602 (18·2%) |
| 30–34 | 833 (13·7%) | 461 (13·9%) |
| 35–39 | 760 (12·3%) | 405 (12·3%) |
| 40–44 | 660 (9·6%) | 320 (8·6%) |
| 45–49 | 701 (8·9%) | 287 (6·5%) |
| Education | | |
| No schooling/preprimary | 265 (2·7%) | 153 (2·9%) |
| Primary (grade 1–7) | 375 (5·5%) | 232 (6·5%) |
| Incomplete secondary (grade 8–11) | 2674 (45·1%) | 1547 (47·0%) |
| Completed secondary (grade 12) | 2603 (41·3%) | 1406 (38·1%) |
| Tertiary (diploma/degree) | 345 (5·3%) | 207 (5·4%) |
| No response | 3 (0%) | 2 (0%) |
| Total household income per month* | | |
| No income | 766 (9·6%) | 524 (12·0%) |
| ZAR1–500 | 614 (6·7%) | 293 (5·7%) |
| ZAR501–2500 | 2720 (42·7%) | 1436 (40·4%) |
| ZAR2501–6000 | 1197 (24·2%) | 705 (24·4%) |
| >ZAR6000 | 432 (7·5%) | 242 (6·9%) |
| No response | 536 (7·7%) | 347 (8·7%) |
| Living in community | | |
| Always | 4890 (77·7%) | 2849 (80·5%) |
| Moved in <1 year ago | 183 (2·5%) | 71 (1·6%) |
| Moved in >1 year ago | 1180 (19·7%) | 621 (17·8%) |
| No response | 12 (0·1%) | 6 (0·1%) |
| Away from home >1 month in the last 12 months | | |
| Yes | 623 (9·7%) | 398 (11·2%) |
| No | 5620 (90·1%) | 3135 (88·5%) |
| No response | 22 (0·2%) | 14 (0·2%) |
| Relationship status | | |
| Single, not living with partner | 5055 (81·4%) | 3168 (88·7%) |
| Legally married | 682 (11·7%) | 180 (5·9%) |
| Single, but in stable relationship | 246 (3·2%) | 125 (2·9%) |
| Living together as husband and wife | 175 (2·5%) | 61 (2·0%) |
| Widowed | 76 (0·8%) | 6 (0·2%) |
| Divorced | 17 (0·2%) | 4 (0·1%) |
| Separated, but still legally married | 14 (0·2%) | 3 (0·2%) |
| Sexual behavioural characteristics | | |
| Median age at first sex (years) | 17·5 (16·1–19·1) | 16·5 (15·1–17·9) |
| Median age of partner at first sex (years) | 20·4 (18·5–23·0) | 16·1 (14·8–17·6) |
| Median number of lifetime sex partners (years) | 2 (1–3) | 3 (1–6) |

Data are median (IQR) or n (population-weighted percentage). ZAR=South African Rand. *15 ZAR=US$1; no response included in percentage calculation.

***Table 1:*** **Baseline characteristics of men and women (n=9812) in a rural and periurban community in KwaZulu-Natal, South Africa, 2014–15**

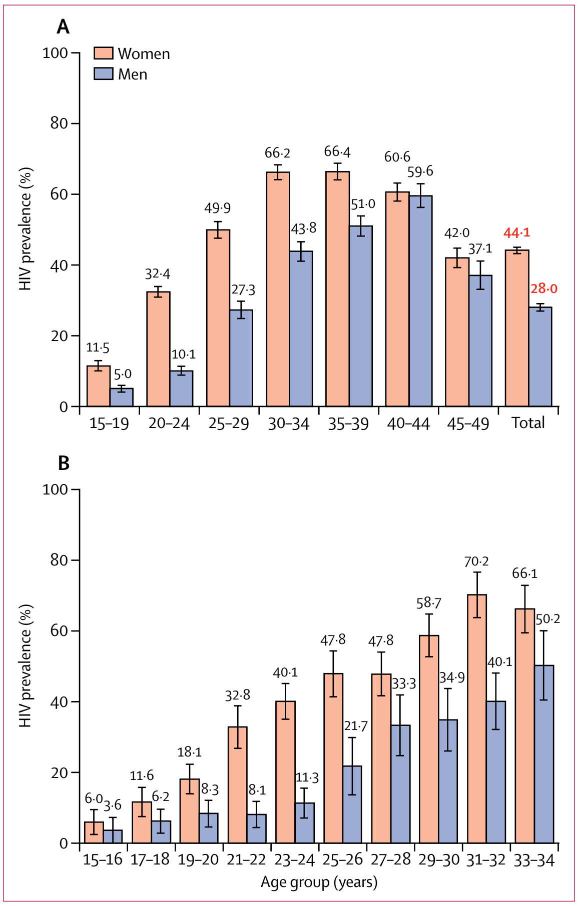


*Figure 1:* **Population-weighted HIV prevalence in a rural and periurban community in KwaZulu-Natal, South Africa, 2014–15**
(A) By sex and age. (B) By sex in 2-year age bands. Error bars show 95% CI.

See Online for appendix

The protocol, informed consent, and data collection forms were reviewed and approved by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (reference number BF269/13), KwaZulu-Natal Provincial Department of Health (HRKM 08/14), and the Center for Global Health, Centers for Disease Control and Prevention, USA.

## Statistical analysis

Analyses were done with SAS version 9.4. SAS survey procedures that accounted for the multilevel sampling and study weights were used. Sampling weights were calculated taking into account the probabilities of selecting the enumeration area, the household in the enumeration area, and the individual in the household, weighted for non-response and rescaled to the size of the population in the survey area with the StatsSA 2011 Census population.[19] Descriptive statistics with unweighted counts and population-weighted percentages with 95% CIs are presented. Taylor series linearisation methods were used to estimate standard errors of estimates, from which Wald confidence limits were derived. A design-adjusted $\chi^2$ test was used to test for the association between sociodemographic, behavioural, and biological factors and HIV prevalence. To identify factors associated with HIV infection we assessed individual-level predictors in a multivariable logistic regression model that corrected for sampling and non-response biases and used the Taylor series linearisation method for estimation of standard errors. Missing values of a predictor were included as a separate category of the predictor as all predictors were categorical variables. To calculate the median and geometric mean viral load, samples with undetectable or fewer than 20 copies per mL of viral load were assigned a value of 1 or 10 copies per mL respectively and reported as fewer than 20 copies per mL for the lower limit. We defined viral suppression as viral load less than 400 copies per mL.

## Role of the funding source

The funders of the survey contributed to the survey design and study monitoring; and reviewed the manuscript. ABMK, LL, and AG had full access to all the data. ABMK, CC, and DK had final responsibility for the decision to submit for publication.

## Results

Between June 11, 2014, and June 22, 2015, 15 100 households were approached. 14 618 were occupied, 11 289 heads or designates consented to household participation, and 9812 individuals were enrolled. Overall, 2144 (14·7%) households and 577 (5·1%) individuals refused participation, and the 9812 enrolled individuals accounted for 69·1% of individuals from the 14 618 occupied households participating and 86·7% of the 11 289 enrolled households (appendix p 1).

Of the household members enumerated, 22 369 (58·2%) were women or girls and 16 072 (41·8%) were men or boys (appendix p 2). The average household size was 4 members (range 1–20). The median age of household members overall was 26·1 years (IQR 13·4–45·4) for women and 20·7 years (10·1–35·4) for men. 24 701 (64·3%) of 38 441 household members were of working age (15–64 years). About a third (12 237, 36·0%) had incomplete secondary (high) schooling, a third (8341, 34·0%) were unemployed, and a third (14 014, 36·9%) of household members were financially reliant on social support grants. Overall, 11 097 (98·6%) households were connected to electricity, 10 623 (94·4%) had access to piped water, and 2873 (25·5%) had their toilet connected to a public sewer system.

On the basis of self-reported data, 41·3% women and 38·1% men had completed secondary schooling (table 1). Excluding non-responses, for more than 90% of participants, the total monthly household income was ZAR6000 or less. Only 9·7% of women and 11·2% of men had been away from home for more than a month in the last year, but 88·7% of men and 81·4% of women

| | Women (n=6265) | | Men (n=3547) | |
|---|---|---|---|---|
| | n/N | HIV prevalence (95% CI) | n/N | HIV prevalence (95% CI) |
| **Sociodemographic characteristics** | | | | |
| Overall | 2955/6265 | 44·1% (42·3–45·9) | 1014/3547 | 28·0% (25·9–30·1) |
| Age group (years), p<0·0001 for women and men | | | | |
| 15–19 | 131/958 | 11·5% (8·6–14·4) | 36/658 | 5·0% (3·1–70) |
| 20–24 | 436/1266 | 32·4% (29·4–35·5) | 87/814 | 10·1% (7·6–12·6) |
| 25–29 | 578/1087 | 49·9%(45·2–54·5) | 171/602 | 27·3% (22·4–32·2) |
| 30–34 | 561/833 | 66·2% (62·0–70·4) | 215/461 | 43·8% (38·2–49·4) |
| 35–39 | 517/760 | 66·4% (61·7–71·2) | 209/405 | 51·0% (45·3–56·7) |
| 40–44 | 426/660 | 60·6% (55·5–65·7) | 183/320 | 59·6% (53·0–66·3) |
| 45–49 | 306/701 | 42·0% (36·5–47·6) | 113/287 | 37·1% (29·1–45·2) |
| Education, p<0·0001 for women and men | | | | |
| No schooling/pre-primary | 136/265 | 46·1% (39·2–53·0) | 49/153 | 33·0% (24·5–41·4) |
| Primary (Grade 1–7) | 221/375 | 55·1% (48·7–61·6) | 94/232 | 40·2% (32·3–48·1) |
| Incomplete secondary (Grade 8–11) | 1304/2674 | 45·6% (43·1–48·0) | 493/1547 | 30·8% (27·1–34·5) |
| Completed secondary (Grade 12) | 1177/2603 | 42·3% (39·7–44·8) | 348/1406 | 24·2% (21·4–27·0) |
| Tertiary (diploma/degree) | 116/345 | 33·4% (26·6–40·2) | 30/207 | 13·8% (7·3–20·3) |
| No response | 1/3 | 33·8% (0–88·9) | 0/2 | .. |
| Income per household per month, p=0·013 for women and 0·0002 for men* | | | | |
| No income | 387/766 | 46·2% (40·7–51·7) | 140/524 | 27·6% (22·8–32·5) |
| ZAR1–500 | 334/614 | 51·0% (45·7–56·4) | 116/293 | 45·0% (38·0–52·1) |
| ZAR501–2 500 | 1294/2720 | 45·3% (42·6–48·0) | 435/1436 | 28·8% (25·7–31·9) |
| ZAR2501–6000 | 549/1197 | 43·1% (39·9–46·3) | 183/705 | 25·6% (20·9–30·3) |
| >ZAR6000 | 169/432 | 36·5% (28·7–43·2) | 51/242 | 23·3% (17·4–29·2) |
| No response | 222/536 | 40·0% (35·5–46·2) | 89/347 | 25·2% (20·1–30·2) |
| Away from home for >1 month in the last 12 months, p=0·45 for women and 0·29 for men | | | | |
| Yes | 311/623 | 46·1% (40·3–52·0) | 113/398 | 31·6% (24·5–38·7) |
| No | 2633/5620 | 43·9% (42·0–45·8) | 899/3135 | 27·6% (25·5–29·7) |
| Relationship status, p<0·0001 for women and men | | | | |
| Single, not living with partner | 2380/5055 | 44·2% (42·4–46·1) | 840/3168 | 26·1% (24·0–28·2) |
| Legally married | 258/682 | 34·8% (30·0–39·7) | 68/180 | 35·8% (26·1–45·4) |
| Single, but in stable relationship | 158/246 | 60·7% (53·2–68·3) | 63/125 | 41·7% (30·6–52·7) |
| Living as husband and wife | 97/175 | 53·2% (44·4–62·1) | 39/61 | 71·1% (57·1–85·1) |
| Widowed | 44/76 | 60·5% (45·1–75·8) | 3/6 | 45·1% (20·7–69·5) |
| Divorced | 10/17 | 68·8% (45·5–92·2) | 0/4 | .. |
| Separated, but still legally married | 8/14 | 57·2% (26·7–87·7) | 1/3 | 8·2% (0–26·8) |
| **Sexual behaviour characteristics** | | | | |
| Ever had sex, p<0·0001 for women and men | | | | |
| Yes | 2818/5447 | 49·6% (47·6–51·6) | 944/2855 | 32·5% (30·1–34·9) |
| No | 137/818 | 11·2% (8·7–13·8) | 70/692 | 9·0% (6·4–11·7) |
| Age at first sex, p=0·51 for women and 0·023 for men | | | | |
| <18 years | 741/1441 | 49·2% (45·5–52·9) | 292/1058 | 26·0% (22·8–29·3) |
| ≥18 years | 1044/2123 | 47·7% (44·8–50·6) | 210/670 | 32·0% (27·8–36·1) |
| Age of partner at first sex, p=0·97 for women and 0·19 for men | | | | |
| <18 years | 150/304 | 47·4% (39·8–54·9) | 313/1088 | 27·2% (23·8–30·7) |
| ≥18 years | 1503/3025 | 47·5% (45·1–49·9) | 164/541 | 31·4% (26·3–36·5) |
| Condom use at first sex, p<0·0001 for women and men | | | | |
| Yes | 381/860 | 38·5% (33·8–43·1) | 87/538 | 15·1% (10·8–19·4) |
| No | 2311/4337 | 52·0% (49·9–54·1) | 800/2156 | 37·2% (34·1–40·3) |

(Table 2 continues on next page)

| | Women (n=6265) | | Men (n=3547) | |
|---|---|---|---|---|
| | n/N | HIV prevalence (95% CI) | n/N | HIV prevalence (95% CI) |
| (Continued from previous page) | | | | |
| Number of sex partners in the last 12 months, p=0·051 for women and 0·83 for men | | | | |
| One | 1916/3837 | 47·5% (45·3–49·8) | 566/1633 | 33·1% (30·0–36·1) |
| More than one | 109/182 | 57·7% (47·5–67·8) | 150/481 | 32·4% (27·1–37·7) |
| Lifetime sex partners, p<0·0001 for women and men | | | | |
| None | 137/818 | 11·2% (8·7–13·8) | 70/692 | 9·0% (6·4–11·7) |
| One | 533/1546 | 31·8% (28·8–34·7) | 93/421 | 25·5% (20·1–30·9) |
| One-to-five | 1638/2853 | 56·1% (53·5–58·7) | 373/1197 | 28·1% (24·5–31·8) |
| More than five | 204/280 | 76·8% (70·3–83·3) | 314/760 | 42·2% (37·4–46·9) |
| Ever tested for HIV, p<0·0001 for women and men | | | | |
| Yes | 2513/4939 | 47·8% (45·8–50·0) | 754/2326 | 31·5% (28·8–34·2) |
| No | 442/1326 | 27·2% (23·7–30·6) | 260/1221 | 20·4% (17·5–23·4) |
| HIV status (self-report), p<0·0001 for women and men | | | | |
| Negative | 618/2989 | 19·1% (17·3–21·0) | 205/1719 | 11·7% (10·2–13·3) |
| Positive | 1833/1845 | 99·1% (98·4–99·7) | 504/522 | 97·1% (95·1–99·1) |
| Don't know | 475/1385 | 28·3% (24·9–31·8) | 297/1288 | 22·1% (19·0–25·1) |
| No response | 29/46 | 66·5% (47·0–86·0) | 8/18 | 36·8% (13·0–60·5) |
| Ever used alcohol, p<0·0001 for women and =0·0007 for men | | | | |
| Yes | 391/643 | 55·9% (50·6–61·1) | 481/1432 | 32·1% (29·3–35·0) |
| No | 2564/5622 | 42·9% (41·0–44·9) | 533/2115 | 25·2% (22·3–28·1) |
| Condom use in the last 12 months, p<0·0001 for women and 0·86 for men† | | | | |
| Always | 594/994 | 55·9% (50·6–61·1) | 196/593 | 31·9% (26·8–36·9) |
| Never | 418/1032 | 42·9% (41·0–44·9) | 165/469 | 32·9% (26·1–39·8) |
| Sometimes | 1207/2324 | 55·9% (50·6–61·1) | 439/1294 | 33·7% (30·4–37·0) |
| **Biological or clinical characteristics** | | | | |
| Ever diagnosed with tuberculosis, p<0·0001 for women and =0·0007 for men | | | | |
| Yes | 251/274 | 93·1% (89·8–96·5) | 150/203 | 72·1% (62·6–81·7) |
| No | 994/1364 | 71·7% (68·3–75·2) | 273/505 | 53·9% (48·4–59·4) |
| Ever diagnosed with any sexually transmitted infections (self-report), p<0·0001 for women and 0·0065 for men | | | | |
| Yes | 213/318 | 65·2% (59·3–71·1) | 99/231 | 41·9% (32–51·7) |
| No | 2742/5947 | 42·7% (40·9–44·5) | 915/3316 | 26·9% (24·6–29·1) |
| Currently has a laboratory diagnosed sexually transmitted infection, p<0·0001 for women and men‡ | | | | |
| Yes | 2817/4919 | 55·3% (53·3–57·3) | 913/1899 | 47·6% (44·7–50·4) |
| No | 138 /1346 | 8·8% (7·0–10·6) | 101/1648 | 6·0% (4·6–7·4) |
| Circumcised (men only), p=0·0035 | | | | |
| Medical | .. | .. | 158/1102 | 14·0% (11·4–16·6) |
| Traditional | .. | .. | 49/139 | 35·4% (24·6–46·1) |
| Don't know | .. | .. | 3/6 | 57·6% (13·1–100) |
| No | .. | .. | 800/2293 | 34·3% (31·6–37·0) |
| Ever pregnant (women only), p<0·0001 | | | | |
| Yes | 2353/4391 | 52·2% (50·0–54·4) | .. | .. |
| No | 602/1872 | 25·1% (22·1–28·2) | .. | .. |

Percentages are population-weighted and missing values were excluded from the percentage calculation. p values are for the association for variable with HIV status. NA=not applicable. *15 South African Rand (ZAR)=US$1. †From the number of men and women who reported having sex in the last 12 months. ‡Any laboratory diagnosis of *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, *Trichomonas vaginalis*, or *Mycoplasma genitalium* DNA from self-collected swabs (women) and first-pass urine (men) samples and antibodies to herpes simplex virus type 2 and *Treponema pallidum* (syphilis).

***Table 2:*** **HIV prevalence by baseline characteristics among men and women in a rural and periurban community in KwaZulu-Natal, South Africa, 2014–15**

were single and not living with their partner. The median age at first sex for women and men was 17·5 years (16·1–19·1) and 16·5 years (15·1–17·9) respectively (p<0·0001); the median age of the first sex partner for women was 20·4 years (18·5–23·0) and for men it was 16·1 years (14·8–17·6; p<0·0001). Women had fewer lifetime sex partners (median 2 [1–3]) compared with men (3 [1–6]; p<0·0001).

The overall population-weighted HIV prevalence was 36·3% (figure 1); 44·1% in women and 28·0% in men (p<0·0001). In the age group 15–19 years, prevalence was 11·5% in women and 5·0% in men (p<0·0001), whereas in the age group 20–24 years, HIV prevalence was three times higher in women than in men, at 32·4% versus 10·1% (p<0·0001). In men, HIV prevalence increased sharply from 10·1% in the age group 20–24 to 27·3% in the 25–29-year age group. Prevalence increased with age and was consistently higher in women across all age groups than in men. Prevalence peaked at 66·4% in women in the age group 35–39 years and 59·6% in men in the age group 40–44 years. In young women aged 15–16 years, HIV prevalence was 6·0% and increased over five times to 32·8% in the 21–22 year age group, and over six times to 40·1% in the 23–24 year age group (figure 1). HIV prevalence in men of similar age was consistently lower than their female counterparts; however, HIV prevalence in men aged 15–16 years old was 3·6% and increased almost three times to 8·3% in the age group 19–20 years and nearly six times to 21·7% in the 25–26 year age group (figure 1).

HIV prevalence was associated with age 25 years or older, incomplete education, lower household monthly income, relationship status, absence of condom use at first sex, higher number of lifetime sex partners, ever used alcohol, history of pregnancy, and past diagnosis of tuberculosis or sexually transmitted infections (table 2). However, being away from home and age of partner at first sex were not associated with HIV prevalence among men and women. Among men, HIV prevalence was lower in those reporting to be medically circumcised compared with those uncircumcised and traditionally circumcised, and higher among those with sexual debut at age 18 years or older.

Controlling for age, education, relationship status, number of lifetime partners, and male circumcision status and laboratory diagnosis of sexually transmitted infections (table 3), any sexually transmitted infection (adjusted odds ratio 10·4, p<0·0001, for men and 7·3, p<0·0001, for women), one to five lifetime sex partners (1·7, p<0·0001, for women), more than five lifetime sex partners (3·9, p<0·0001, for women), and not being medically circumcised (1·7, p=0·0011, for men) were associated with HIV. Completion of secondary schooling was protective (0·6, p=0·0001, for men and 0·8, p=0·044 for women).

Irrespective of ART a greater proportion of men than women had CD4 counts less than 200 cells per μL (p<0·0001; table 4). The median viral load in women was 67 and in men was 4940 copies per mL, and the geometric mean viral load in women was 163 and in men was 811 copies per mL (table 5). In both women and men on ART the median and geometric mean viral load were below 20 copies per mL, whereas in those not on ART the median viral load was 8177 and 27 042 and the geometric mean was 1966 and 8084 copies per mL in women and men respectively. Overall, 54·8% of women and 41·9% of men had viral suppression (p<0·0001); among those on ART 87·2% of women and 83·9% of men had viral suppression (p=0·37).

4204 (70·3%) of 6265 women and 2018 (60·1%) of 3547 men knew their HIV status (p<0·0001; appendix p 3; figure 2). 994 (22·7%) of 4350 women and 593 (26·5%) of 2356 men (p=0·0033) reported consistent condom use with sex acts in the past 12 months; 1695 (35·7%) of 5447 women reported that their male partner was circumcised whereas 1102 (31·9%) of 3547 men were medically circumcised (p<0·0001). Knowledge of HIV status, consistent condom use with sex acts in the last 12 months, and being medically circumcised was higher among younger participants and declined among men 25 years and older (figure 2). Among HIV-positive individuals, 1251 (45·6%) of 2955 women and 341 (36·7%) of 1014 men reported ART use (p=0·0003), and 1574 (54·8%) of 2955 women and

| | Women | | Men | |
|---|---|---|---|---|
| | Adjusted odds ratio | p value | Adjusted odds ratio | p value |
| **Age (years)** | | | | |
| 15–19 | 1 | .. | 1 | .. |
| 20–24 | 2·1 (1·3–3·4) | 0·0016 | 2·2 (1·1–4·7) | 0·0339 |
| 25–29 | 3·9 (2·6–6·0) | <0·0001 | 5·3 (2·5–11·3) | <0·0001 |
| 30–34 | 7·5 (4·9–11·6) | <0·0001 | 9·9 (4·6–21·7) | <0·0001 |
| 35–39 | 7·9 (5·1–12·2) | <0·0001 | 13·2 (6·3–27·7) | <0·0001 |
| 40–44 | 6·3 (3·8–10·2) | <0·0001 | 14·9 (6·5–34·4) | <0·0001 |
| 45–49 | 2·8 (1·7–4·5) | <0·0001 | 5·7 (2·7–12·1) | <0·0001 |
| **Education** | | | | |
| Incomplete secondary (grade 8–11) | 1 | .. | 1 | .. |
| Completed secondary (grade 12) | 0·8 (0·7–1·0) | 0·0438 | 0·6 (0·5–0·8) | 0·0001 |
| Tertiary (diploma/degree) | 0·6 (0·4–0·9) | 0·0113 | 0·4 (0·2–0·8) | 0·0100 |
| **Relationship status** | | | | |
| Legally married | 1 | .. | 1 | .. |
| Single | 2·8 (2·2–3·7) | <0·0001 | 1·9 (1·2–2·9) | 0·0049 |
| Living as husband and wife | 2·1 (1·4–3·3) | 0·0011 | 3·6 (1·4–9·0) | 0·0071 |
| Widowed or divorced | 2·8 (1·5–5·1) | 0·0011 | 0·4 (0·1–1·8) | 0·2295 |
| **Lifetime sex partners** | | | | |
| One | 1 | .. | .. | .. |
| One-to-five | 1·7 (1·5–2·1) | <0·0001 | .. | .. |
| More than five | 3·9 (2·5–5·9) | <0·0001 | .. | .. |
| Refused or missing | 1·6 (1·3–2·0) | <0·0001 | .. | .. |
| **Currently has a laboratory diagnosed sexually transmitted infection*** | | | | |
| No | 1 | .. | 1 | .. |
| Yes | 7·3 (5·3–10·2) | <0·0001 | 10·4 (7·4–14·7) | <0·0001 |
| **Circumcised (men only)** | | | | |
| Medical | .. | .. | 1 | .. |
| Traditional or don't know | .. | .. | 1·1 (0·6–2·1) | 0·6875 |
| No | .. | .. | 1·7 (1·2–2·3) | 0·0011 |

*Any laboratory diagnosis of *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, *Trichomonas vaginalis*, and *Mycoplasma genitalium* DNA from self-collected swabs (women) and first-pass urine (men) samples and antibodies to herpes simplex virus type 2 and *Treponema pallidum* (syphilis).

*Table 3*: **Characteristics associated with HIV prevalence among men and women in a rural and peri-urban community in KwaZulu-Natal, South Africa, 2014–15**

| | Women (N=2955) | | Men (N=1014) | |
|---|---|---|---|---|
| | n | Population-weighted %, (95% CI) | n | Population-weighted %, (95% CI) |
| **Overall CD4 cell count (cells per µL)** | | | | |
| <200 | 247 | 8·0% (6·7–9·3) | 178 | 17·2% (13·9–20·5) |
| 200–349 | 449 | 15·1% (13·6–16·7) | 261 | 23·9% (20·4–27·3) |
| 350–499 | 639 | 21·1% (19·0–23·1) | 243 | 23·9% (20·5–27·2) |
| >500 | 1594 | 55·8% (53·6–58·1) | 327 | 35·1% (31·3–38·9) |
| **On antiretroviral therapy (cells per µL)*** | | | | |
| <200 | 75 | 5·6% (4·1–7·1) | 54 | 17·0% (12·0–21·9) |
| 200–349 | 164 | 13·6% (11·2–16·0) | 90 | 24·7% (18·6–30·7) |
| 350–499 | 267 | 20·6% (17·5–23·7) | 82 | 23·6% (17·9–29·4) |
| >500 | 737 | 60·2% (56·4–64·0) | 114 | 34·8% (28·9–40·6) |
| **Not on antiretroviral therapy (cells per µL)*** | | | | |
| <200 | 172 | 10·1% (8·1–12·1) | 124 | 17·3% (12·8–21·8) |
| 200–349 | 285 | 16·4% (14·1–18·7) | 171 | 23·4% (19·3–27·4) |
| 350–499 | 372 | 21·5% (18·7–24·3) | 161 | 24·0% (19·3–28·8) |
| >500 | 856 | 52·0% (49·0–55·0) | 213 | 35·3% (30·3–40·3) |

CD4 cell count data are missing for 27 women and five men. *Self-report.

***Table 4:*** **CD4 cell count in HIV-positive men and women in a rural and periurban community in KwaZulu-Natal, South Africa, 2014–15**

| | Women (N=2955) | Men (N=1014) |
|---|---|---|
| **Overall HIV RNA viral load** | | |
| Median copies per mL (IQR)* | 67 (<20–13816) | 4940 (<20–45 448) |
| Geometric mean copies per mL (range)* | 163 (<20–5 400 000) | 811 (<20–2 300 000) |
| Viral suppression (n/N, percentage, 95% CI)† | 1574/2955, 54·8% (52·0–57·5) | 401/1014, 41·9% (37·1–46·7) |
| **On antiretroviral therapy‡** | | |
| Median copies per mL (IQR)* | <20 (<20–<20) | <20 (<20–36) |
| Geometric mean copies per mL (range)* | <20 (<20–1 000 000) | <20 (<20–516 440) |
| Viral suppression (n/N, percentage, 95% CI)† | 1086/1251, 87·2% (84·6–89·8) | 284/341, 83·9% (78·5–89·3) |
| **Not on antiretroviral therapy‡** | | |
| Median copies per mL (IQR)* | 8177 (179–30 808) | 27 042 (3434–76 519) |
| Geometric mean copies per mL (range)* | 1966 (<20–5 400 000) | 8084 (<20–2 300 000) |
| Viral suppression (n/N, percentage, 95% CI)† | 488/1704, 27·4% (24·3–30·5) | 117/673, 17·5% (13·5–21·6) |

Plasma viral load data are missing for nine women and four men. *To calculate the geometric mean and median HIV RNA viral load, HIV-positive participants with undetectable viral load or <20 copies per mL were assigned a value of 1 or 10 copies per mL respectively and reported as <20 copies per mL (ie, the lower limit of quantification for the assay). †Viral suppression at viral load <400 copies per mL; percentages are population-weighted. ‡Self-report.

***Table 5:*** **HIV RNA viral load in HIV-positive men and women in a rural and periurban community in KwaZulu-Natal, South Africa, 2014–15**

401 (41·9%) of 1014 men had achieved viral suppression (p<0·0001).

## Discussion

This first comprehensive community-based survey done in Vulindlela and the Greater Edendale areas of the uMgungundlovu district, KwaZulu-Natal, showed high HIV prevalence among men and women aged 15–49 years (36·3%) and a disproportionate burden among women compared with men (44·1% *vs* 28·0%). Furthermore, prevalence in this community was twice the national average of 18·8% and exceeded the 27·9% reported provincially for the same age groups just 3 years before.[2] Current national and provincial HIV prevalence estimates mask the heterogeneity within the country and hence are less useful in the current context of geographical location-based approaches to a better understanding of the

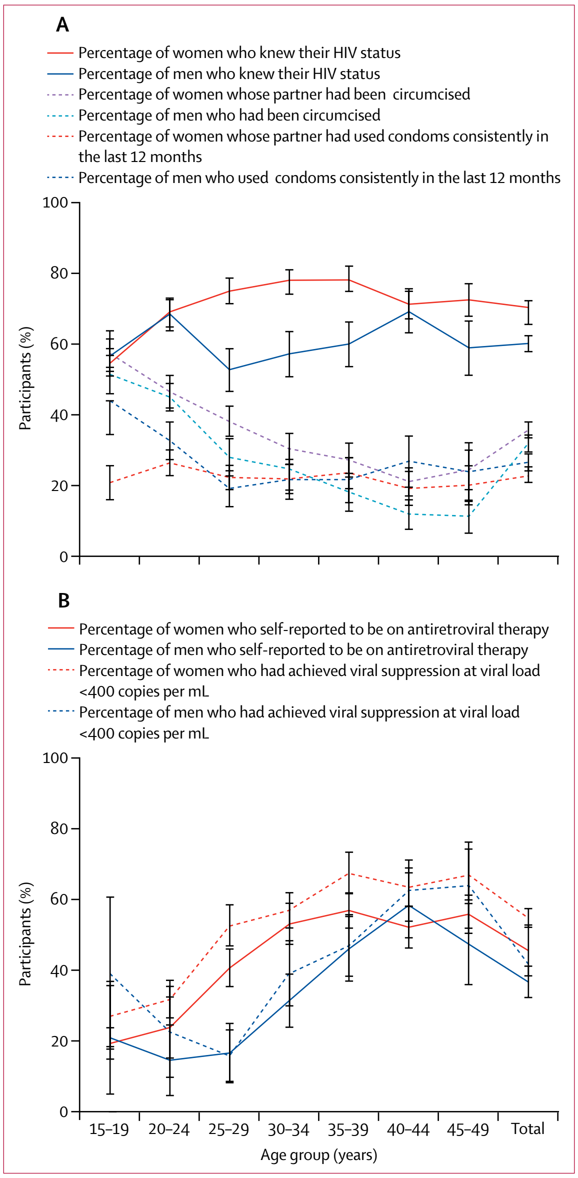


***Figure 2:*** **Exposure to HIV prevention and treatment strategies among men and women in a rural and periurban community in KwaZulu-Natal, South Africa, 2014–15**
(A) Exposure to HIV prevention strategies among all participants (n=9812). (B) Exposure to antiretroviral therapy and viral suppression among HIV-positive participants (n=3969). Error bars show 95% CI.

epidemic.[15] Disaggregation of prevalence by age and sex highlights the persistent features of the epidemic: young women across each 2 year age band had higher prevalence compared with young men in the same age group and by age 24 years, one in three young women were HIV positive compared with one in nine young men. More importantly, these key features of the epidemic in this community in 2014 are concerning as we have failed to protect young women and alter these exceptionally high prevalences and patterns of infections.

Comprehensive packages of evidence-based approaches of consistent condom use, medical male circumcision, knowledge of HIV status, and more recently the expanded use of HIV treatment to prevent transmission to sexual partners, are the main tools for reducing risk of HIV acquisition.[13] However, these tools have not been scaled up to maximise coverage and density to affect the epidemic. Further, condoms and circumcision are male-centric strategies with little or no decision-making options for women. Scientific advances using PrEP to reduce HIV risk provides one of the first opportunities for a high-impact woman-initiated HIV prevention option in this generalised, hyperendemic epidemic setting. Although South Africa became the first country in sub-Saharan Africa to have full regulatory approval and included PrEP in the national HIV programme, PrEP was initially reserved for high-risk individuals such as sex workers,[8] but is expected to become increasingly available for all young women to benefit from.[20]

Our findings show that a high proportion of households had tangible infrastructure amenities of clean drinking water and electricity yet lacked adequate sanitation facilities. These factors might not have direct causal association with HIV acquisition and transmission but highlight the health and social development challenges facing communities, which could lead to risk-taking behaviours. Major structural and socioeconomic barriers potentially lead to psychological stress, poor living conditions, and disrupted social cohesion within families and communities. Our study community is burdened with densely populated households, a high proportion of school attrition, low marriage frequencies, most individuals not living with their partners, and extensive financial dependency on social support grants; these social factors probably contribute to high unemployment and low income.[21] Although not directly measured in this study, these factors might motivate or discourage HIV-related risk and protective behaviours, including the uptake of HIV services.

Several factors contributed to vulnerability to HIV. Independent risk factors among women and men included older age, being unmarried, current sexually transmitted infections (defined as laboratory diagnosed), not having completed secondary (high) schooling, having more than one lifetime sex partner, and not being circumcised (men). Not completing high school is complex, as many structural level factors such as poverty, inadequate financial resources, single and or double parent orphans, child-headed households, and patriarchal societies could modify risk and influence retention in schools.[22] Premature attrition from schools could lead to behaviours placing young women at risk for unintended pregnancies, sexually transmitted infections, and HIV. Although these associations are important and biologically plausible, highlighting the complex multilevel interaction across the life-course, the cross-sectional design of our study limits the temporal relationship of these factors with HIV-positive status. For HIV prevention messaging, our findings are important as they guide the messaging to address, educate, and inform on risk behaviours crucial to reducing HIV incidence, specifically among adolescent girls and young women.

Studies at the individual level have shown medical male circumcision and ART to interrupt viral transmission and reduce HIV acquisition.[23,24] However, at the population-level, the effect of medical male circumcision is dependent on coverage and risk behaviours, and the effect of ART is moderated by the percentage of HIV-positive individuals who know their status, initiate treatment, and achieve viral suppression. The present study revealed largely suboptimal coverage of biomedical strategies of medical male circumcision and ART as well as knowledge of HIV status and consistent condom use, which was notably substantially low among men aged 25–29 years. Yet, men medically circumcised were less likely to be HIV positive and of those on ART, more than 80% had achieved viral suppression. We also found that at least 40% of men and 20% of women with HIV had low CD4 cell counts and were not on ART despite being eligible at the time of the study.[5] Even with marked immunosuppression, a substantial proportion of individuals might not be aware of their HIV-positive status or might have delayed seeking HIV care; thus, improving coverage through universal test (through expanded and innovative testing services) and treat strategy[11] would reduce transmission potential over time.[12]

The last several years have seen substantial improvements in ART provision with several countries in sub-Saharan Africa reaching almost 80% coverage of adults aged 15 years and older.[25,26] As ART is now a reasonably affordable and scalable intervention having the potential to almost instantaneously produce substantial improvements in population health, it is imperative that HIV programmes set targets with a focus on sustaining and scaling up ART provision to match the magnitude of the epidemic in the region. In this community social, economic, and environmental challenges could potentially undermine the success of programmes; hence, understanding of patient and provider perspectives is necessary to minimise barriers to uptake of ART and, together with strong monitoring and evaluation, to ensure sustainability of programmes. Furthermore, because ART is being rolled out at a rapid rate and because of the overwhelming number expected to be on ART, novel strategies to encourage behaviours to sustain adherence and long-term viral suppression will be crucial to potentially fast-tracking epidemic control.[27]

HIV surveillance has evolved substantially, and the inclusion of robust measurements provides a nuanced understanding of the evolving epidemic and guide programming and scale-up of prevention strategies. Although summary estimates are useful to understand the epidemic at an ecological level, disaggregation by sex and age provides a more precise understanding of the epidemic for targeted interventions.[2,28,29] Furthermore, as ART coverage expands, population viral load increasingly becomes a powerful proxy for the monitoring of ART implementation. The population-level median and geometric mean viral load in diagnosed and undiagnosed individuals provide insights into the dynamics of the epidemic and it is expected that the higher the coverage of ART, the larger the number of individuals with lower viral load in the population, and the lower the number of new infections. However, both the geometric mean and median mask individuals in sexual networks with excessively high viral loads who potentially sustain the epidemic.[30–32] This study demonstrates that across all age groups, men were less likely to know their HIV-positive status, less likely to be on ART, and less likely to have achieved viral suppression.[10] Although it might be easier to reach out to young women through a public health approach such as integrated school health and family planning services with an offer of PrEP over the period of high risk, it is far more challenging to reach out to men through similar approaches and therefore important to reach out to men through strong messaging and targeted community and workplace programmes.

Our study has several strengths and limitations. Although the large sample size was representative of the community and the robust sampling strategy minimised clustering of infections from households and over-estimation of HIV prevalence, the differential recruitment of men and women might bias our overall HIV prevalence. Despite similar sex distribution of the study sample across all age groups and its proportionality, like the Census population,[19] we analysed our data by sex to minimise potential bias from aggregated data. Our refusal frequency at the household and the individual level was lower than most community-based surveys, which require substantial adjustments for non-participation.[33] Stigma and discrimination in this community might have influenced individuals' decisions on disclosure of ART use, which could inadvertently disclose to family and community members and therefore self-reporting of ART use and sexual risk behaviours could be socially desirable rather than a true reflection of reality. It is also possible that the sensitivity and specificity of laboratory tests could misclassify our HIV test results; however, we used multiple assays to minimise misclassification. The cross-sectional design of our study limits the ability to conclude the temporal relation between the self-reported factors with HIV-positive status. Furthermore, our findings are limited to Vulindlela and the Greater Edendale areas of KwaZulu-Natal, South Africa, and not necessarily generalisable to other hyperendemic settings. Nevertheless, our data provide a reasonable representation of the community.

In conclusion, HIV prevalence in this community is among the highest in the world. Our findings of the large number of individuals already on ART emphasises the importance of the extent of the future care burden for HIV-positive individuals. The suboptimal coverage of HIV prevention strategies including ART means that the risk for future onward HIV transmission remains elevated as individuals with high viral load potentially sustain the epidemic. It is vitally important to scale up targeted risk-based HIV prevention strategies exponentially to attain HIV epidemic control in the region.

**Contributors**

ABMK is the principal investigator of the study and wrote the manuscript. ABMK, CC, and DK were responsible for the field work and quality assurance; LL and AG for statistical analysis; ABMK, AG, AP, LL, GG, KG, MG, and QAK contributed to analysis and interpretation of the data. AP, NS, ZC, and SM were responsible for laboratory measurements and quality assurance; DK, CC, and ABMK were responsible for community and stakeholder engagement activities; CT, SH, GG, KG, and SB contributed to the household and individual-level data collection tools; all authors critically reviewed and approved the final version of the manuscript.

**Declaration of interests**

We declare no competing interests.

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