Heterogeneity of the HIV epidemic in agrarian, trading, and fishing communities in Rakai, Uganda: an observational epidemiological study

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Summary

Background Understanding the extent to which HIV burden differs across communities and the drivers of local disparities is crucial for an effective and targeted HIV response. We assessed community-level variations in HIV prevalence, risk factors, and treatment and prevention service uptake in Rakai, Uganda.

Methods The Rakai Community Cohort Study (RCCS) is an open, population-based cohort of people aged 15–49 years in 40 communities. Participants are HIV tested and interviewed to obtain sociodemographic, behavioural, and health information. RCCS data from Aug 10, 2011, to May 30, 2013, were used to classify communities as agrarian (n=27), trading (n=9), or lakeside fishing sites (n=4). We mapped HIV prevalence with Bayesian methods, and characterised variability across and within community classifications. We also assessed differences in HIV risk factors and uptake of antiretroviral therapy and male circumcision between community types.

Findings 17 119 individuals were included, 9215 (54%) of whom were female. 9931 participants resided in agrarian, 3318 in trading, and 3870 in fishing communities. Median HIV prevalence was higher in fishing communities (42%, range 38–43) than in trading (17%, 11–21) and agrarian communities (14%, 9–26). Antiretroviral therapy use was significantly lower in both men and women in fishing communities than in trading (age-adjusted prevalence risk ratio in men 0·64, 95% CI 0·44–0·97; women 0·53, 0·42–0·66) and agrarian communities (men 0·55, 0·42–0·72; women 0·65, 0·54–0·79), as was circumcision coverage among men (*vs* trading 0·48, 0·42–0·55; *vs* agrarian 0·64, 0·56–0·72). Self-reported risk behaviours were significantly higher in men than in women and in fishing communities than in other community types.

Interpretation Substantial heterogeneity in HIV prevalence, risk factors, and service uptake in Rakai, Uganda, emphasises the need for local surveillance and the design of targeted HIV responses. High HIV burden, risk behaviours, and low use of combination HIV prevention in fishing communities make these populations a priority for intervention.

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Introduction

Increasingly, funders of HIV treatment and prevention programmes are calling for targeted approaches that focus on geographical areas and populations at highest risk so that scarce resources can have the greatest effect.[1] Correspondingly, attention has focused on the usefulness of HIV epidemiological data at finer levels of scale to inform targeted responses, with granularity becoming a watchword.[2,3] However, most population-based studies in sub-Saharan Africa use sparsely collected data collected at national administrative levels, limiting the reliability and depth of inferences that can be made regarding local HIV epidemics.[3–5]

Finer resolution, population-based epidemiological data can provide more detailed understanding of sub-national HIV epidemics. For example, community-level surveillance might reveal hotspots (ie, geographical areas with significantly higher HIV prevalence), important population-level differences in sexual behaviours, or crucial gaps in HIV service coverage. Such data might also reveal why HIV epidemics in some regions have not decreased despite scale-up of HIV services nationally, as might have been the case in Uganda.[6]

The Rakai Community Cohort Study (RCCS), a population-based cohort of agrarian, trading, and fishing communities in and around Rakai District, Uganda, offers an opportunity to study heterogeneities in HIV disease burden, sexual behaviours, and treatment and prevention service coverage in sub-Saharan Africa. The first AIDS cases in east Africa were identified in Rakai District,[7] and Rakai continues to have among the highest HIV prevalences in Uganda.[8] We report community-level variations in HIV prevalence, risk factors, and treatment and prevention service uptake in the RCCS,

Research in context

Evidence before this study

We searched PubMed for longitudinal HIV cohort studies that included fishing communities in sub-Saharan Africa published up to April 21, 2016. Key search terms were "HIV or AIDS", "cohort or observational", "fishing", and "Africa". No language limitations were set. A small number of studies reported high HIV seroprevalence and risk factors in fishing communities, but none used population-level data to compare findings directly with inland communities. In view of study heterogeneity, no meta-analysis was done. No comparable analysis from this particular cohort has been reported since the early 1990s.

Added value of this study

This study provides an update on HIV epidemiology in the Rakai Community Cohort Study (RCCS), one of a few large population-based studies of HIV in sub-Saharan Africa. The RCCS has been ongoing since 1994, and nowadays surveys about 17 000 individuals in 40 communities. Community-level HIV burden and risk factor distribution in the RCCS were first reported at its inception. Since then, the RCCS has expanded its surveillance to include Lake Victoria fishing communities, a key population. In this study, we re-examined HIV epidemiology in the RCCS more than 20 years after its founding, using granular data obtained at the community and household levels. We show that within a single region in Uganda, extensive heterogeneity exists in HIV disease burden, behavioural risk factors, and service coverage. Additionally, our analyses of HIV epidemiology in Lake Victoria fishing communities used population-level data to directly compare these key populations with inland communities in sub-Saharan Africa.

Implications of all the available evidence

The available evidence suggests the need for strong local HIV surveillance programmes, a better understanding of the HIV transmission links between high-risk and lower risk populations, and assessment of targeted HIV interventions.

and discuss the implications of our findings for targeting the HIV response.

Methods

Study design

The study was predominantly done in Rakai District (area ~2200 km², population ~518 000), a mostly rural district in south-central Uganda.[9] Rakai District is bordered to the south by Tanzania and to the east by Lake Victoria (figure 1). Kampala, the capital city of Uganda, is about 150 km northeast of Rakai District. The RCCS is done in the Rakai region, which consists of Rakai District, Lyantonde District (formerly part of the Rakai District), and Kyanamukaaka, a subdistrict of Masaka bordering both Rakai District and Lake Victoria. The Rakai region has two primary highways, one connecting Kampala to Tanzania, and the Trans-African Highway, which connects Kampala to the Democratic Republic of the Congo.

The RCCS is an open, population-based cohort that was established by the Rakai Health Sciences Program (RHSP) in 1994.[10] The RCCS surveys individuals aged 15–49 years in 40 communities. Agrarian and trading community boundaries were established in 1994 as part of a community-randomised trial on treatment of sexually transmitted infections for HIV prevention.[10] In 2011, the four largest Lake Victoria fishing communities in the Rakai region were added to the RCCS on the basis of their proximity and access to Rakai District's non-fishing community populations.

To identify eligible cohort participants in these study communities, the RCCS first holds an informational community mobilisation event. A census is then done as follows: all households within the communities are systematically approached, household global positioning system (GPS) coordinates are recorded, and all resident household members are enumerated by sex, age, and duration of residence, regardless of whether they are present or absent at the time of the census. People must be resident for at least 6 months in agrarian and trading communities and 1 month with an intention to stay longer in fishing communities for inclusion in the RCCS. After the census, the RCCS enrols eligible participants at central community locations (termed hubs). Eligible participants who are not identified at the

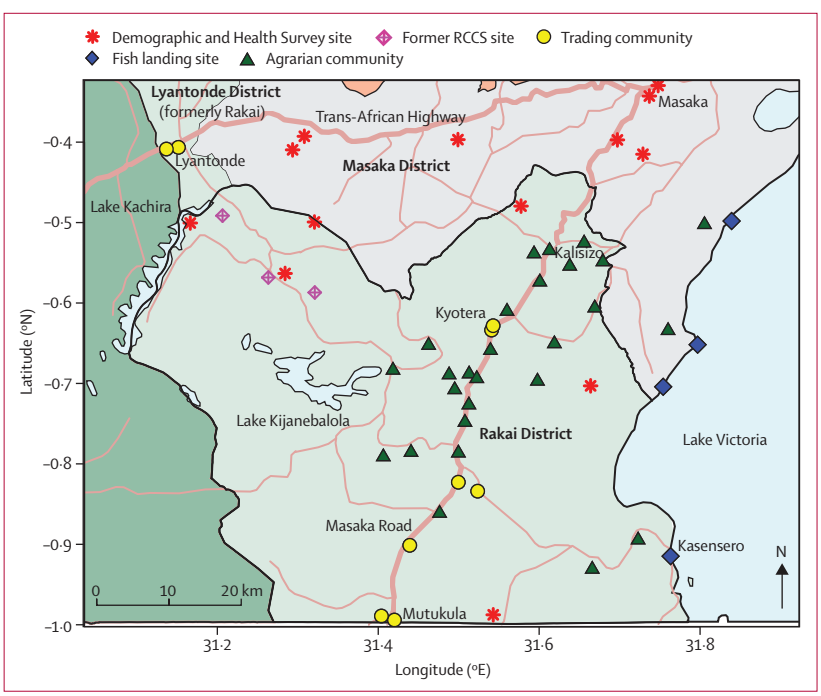

Figure 1: **Map of the Rakai region**

RCCS=Rakai Community Cohort Study.

	Women (n=9215)			Men (n=7904)		
	Agrarian (n=5416)	Trading (n=1940)	Fishing (n=1859)	Agrarian (n=4515)	Trading (n=1378)	Fishing (n=2011)
Age (years)						
15–19	1001 (18%)	288 (15%)	201 (11%)	1047 (23%)	247 (18%)	145 (7%)
20–29	1992 (37%)	820 (42%)	823 (44%)	1459 (32%)	546 (40%)	803 (40%)
30–39	1695 (31%)	613 (31%)	653 (35%)	1315 (29%)	387 (28%)	777 (39%)
40–49	728 (13%)	219 (11%)	182 (10%)	694 (15%)	198 (14%)	286 (14%)
Marital status						
Never married	1277 (24%)	396 (20%)	145 (8%)	1784 (40%)	517 (38%)	403 (20%)
Married, monogamous union	2556 (47%)	807 (42%)	914 (49%)	2069 (46%)	639 (46%)	1060 (53%)
Married, polygamous union	667 (12%)	291 (15%)	262 (14%)	294 (7%)	121 (9%)	181 (9%)
Previously married	912 (17%)	445 (23%)	538 (29%)	365 (8%)	101 (7%)	367 (18%)
Data missing	4 (<1%)	1 (<1%)	0	3 (<1%)	0	0
Educational status						
None	242 (4%)	100 (5%)	213 (11%)	116 (3%)	53 (4%)	164 (8%)
Primary	3180 (59%)	1027 (53%)	1287 (69%)	2830 (63%)	755 (55%)	1475 (73%)
Secondary	1568 (29%)	639 (33%)	318 (17%)	1143 (25%)	414 (30%)	294 (15%)
Tertiary	364 (7%)	168 (9%)	33 (2%)	306 (7%)	141 (10%)	40 (2%)
Data missing	62 (1%)	6 (<1%)	8 (<1%)	120 (3%)	15 (1%)	38 (2%)
Religion						
Catholic	3644 (67%)	1062 (55%)	1038 (56%)	3046 (67%)	761 (55%)	1179 (59%)
Muslim	601 (11%)	390 (20%)	340 (18%)	452 (10%)	270 (20%)	346 (17%)
Protestant	885 (16%)	318 (16%)	283 (15%)	709 (16%)	221 (16%)	299 (15%)
Born again or Pentecostal	190 (4%)	146 (8%)	171 (9%)	152 (3%)	94 (7%)	123 (6%)
Other	34 (1%)	18 (1%)	19 (1%)	36 (1%)	17 (1%)	26 (1%)
Data missing	62 (1%)	6 (<1%)	8 (<1%)	120 (3%)	15 (1%)	38 (2%)
Primary occupation						
Agricultural or housework	2855 (53%)	633 (33%)	569 (31%)	1270 (28%)	144 (10%)	104 (5%)
Bar or restaurant work	172 (3%)	157 (8%)	344 (19%)	13 (<1%)	17 (1%)	7 (<1%)
Boda boda driving* or trucking	0	0	0	80 (2%)	41 (3%)	33 (2%)
Fishing	1 (<1%)	0 (0%)	8 (<1%)	62 (1%)	1 (<1%)	1100 (55%)
Student	872 (16%)	174 (9%)	40 (2%)	1266 (28%)	229 (17%)	56 (3%)
Trader or shopkeeper	541 (10%)	529 (27%)	526 (28%)	578 (13%)	336 (24%)	339 (17%)
Other	975 (18%)	447 (23%)	372 (20%)	1246 (28%)	610 (44%)	372 (18%)

Data are number (%). Some percentages do not add up to 100 because of rounding. *Motorcycle taxi.

Table 1: **Demographics and baseline characteristics**

For the **WorldPop database** see http://www.worldpop.org.uk/

hubs are approached at their household to request their participation. If needed, up to two return visits are made to the household to enrol eligible participants.

In the RCCS, all participants who provide written informed consent are interviewed to assess demographics, sexual and health-seeking behaviours, and HIV service uptake. After the interview, free HIV testing is provided by an algorithm that incorporates three rapid HIV tests, with participants offered results and counselling after the test by on-site counsellors. For most of these analyses, unless otherwise specified, RCCS data from a single survey done between Aug 10, 2011, and May 30, 2013, were used. This RCCS survey was the first to include the four fishing communities, and is therefore their baseline assessment. This RCCS survey also included 27 agrarian communities and nine trading centre communities located on or near the main highways. Communities were classified as trading centres if the proportion of their population who reported trading as their primary occupation was in the top quartile among all RCCS communities; within this community stratum, 16–36% of the surveyed population listed trading as their main occupation and all known major trading centres within Rakai District were included.

Antiretroviral therapy (ART) services have been provided since 2004 and male circumcision services since 2007 to RCCS trading and agrarian communities by the RHSP through support from the US President's Emergency Plan for AIDS Relief (PEPFAR). Beginning in 2011, the RHSP provided combination HIV prevention and treatment services in the four fishing communities in conjunction with their initial RCCS survey. Previously, some service coverage in these fishing communities had been provided by other non-governmental organisations.

Statistical analysis

We used a hierarchical Bayesian modelling framework to estimate and map HIV prevalence and the number of people living with HIV throughout the Rakai District and neighbouring areas (figure 1). Maps were generated with three data sources: the RCCS, the Ugandan Demographic and Health Survey (DHS), and the WorldPop database. Specifically, we used RCCS household GPS and HIV serostatus information from RCCS participants residing in the 40 communities included in the 2011–13 RCCS survey period. Data from three additional RCCS communities (all agrarian) included in a previous RCCS survey period (Sept 21, 2010, to Nov 26, 2010), but subsequently dropped from the RCCS because of financial constraints, were included in the mapping analysis to improve estimates of HIV prevalence and case counts in the western region of the Rakai District, where data were more sparse (figure 1). We also included cluster-level GPS and weighted HIV serostatus data from the DHS done in Uganda in 2011.[11] DHS clusters in the Rakai region did not overlap geographically with RCCS communities. RCCS and DHS data were used in combination to estimate HIV prevalence and then were combined with WorldPop data, which provide high-spatial-resolution population density estimates, to estimate the number of people aged 15–49 years living with HIV.

To examine fine-scale spatial variation in prevalence and the number of people living with HIV within the region, the region was divided into 1 km² grid cells, excluding grid cells entirely covered by water or with a population density of zero in the WorldPop dataset. HIV

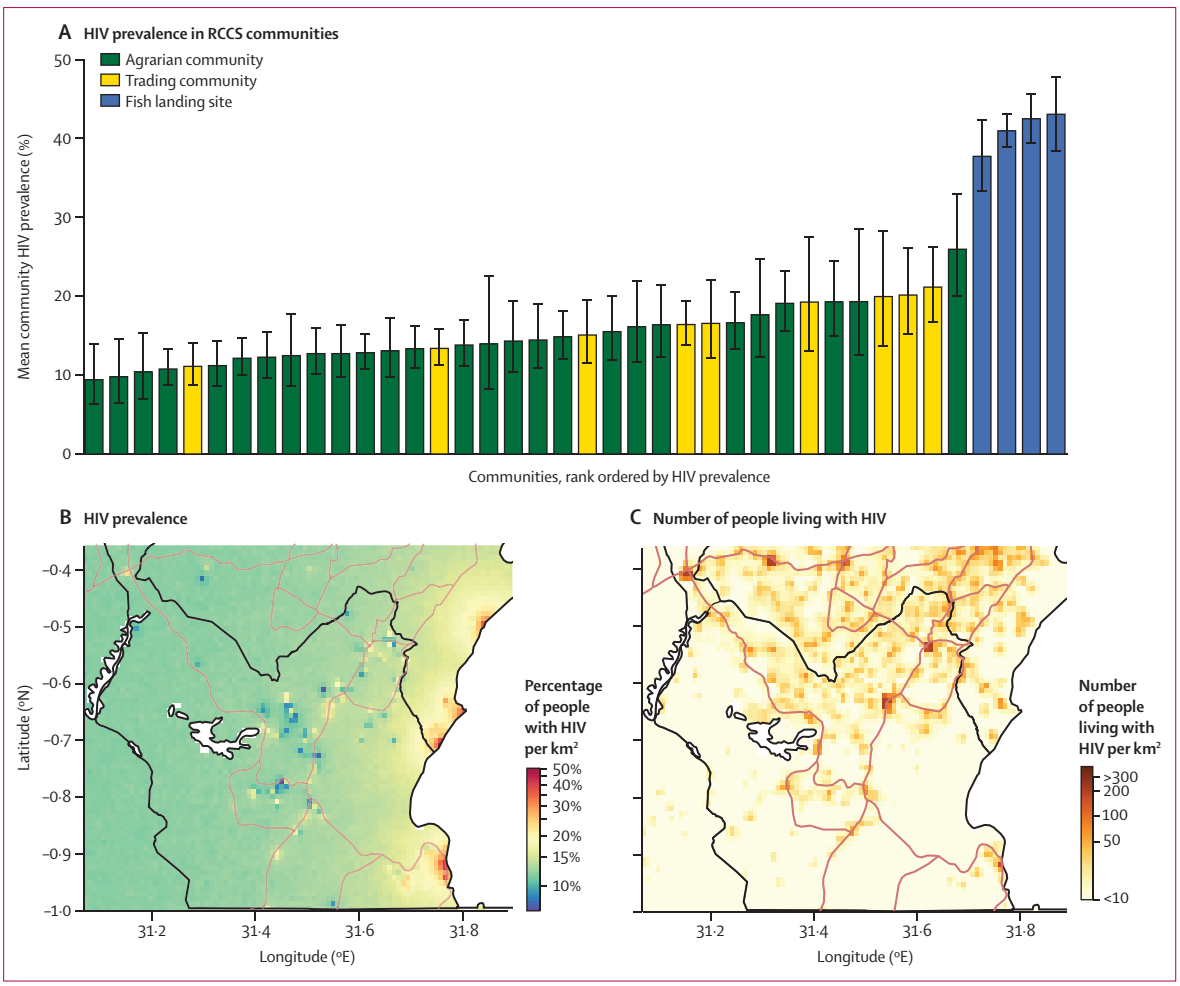

Figure 2: **HIV disease burden among people aged 15–49 years in the Rakai region**
(A) Mean community HIV prevalence in 40 RCCS communities. Error bars are 95% CIs. (B) Interpolated map of HIV prevalence (1 km² resolution). (C) Interpolated map of the number of people living with HIV (1 km² resolution). RCCS=Rakai Community Cohort Study.

prevalence in each grid cell was modelled by use of logistic regression with $\log_{10}$ distance to the Lake Victoria shoreline as a covariate. The logistic regression included a spatially autocorrelated random-effects term modelled by a conditional autoregressive distribution with a flexible spatial dependence parameter to account for over-dispersion and spatial autocorrelation in HIV infection status.[12–14] We implemented this binomial–logistic hierarchical model in Stan 2.8.0.

We also compared HIV burden (ie, the estimated number of people living with HIV), HIV risk factors, and use of HIV services using data at the individual and community levels from the 2011–13 RCCS survey from the three community strata (ie, agrarian, trading, and fishing). We first obtained estimates of sex-specific and age-specific HIV prevalence in 5 year age groups with Poisson regression models separately for each of the three community types. Next, we compared the prevalence of high-risk sexual behaviours, genital ulcer disease, HIV, self-reported ART use in people living with HIV, and male circumcision status in non-Muslim men (to assess uptake of circumcision for HIV prevention services) between the three community strata. We used age-adjusted modified Poisson regression models with relative prevalence and 95% CIs reported as adjusted prevalence risk ratios (PRRs). In a sensitivity analysis, we used inverse probability weighting to account for potential differences associated with study participation. Inverse probability weights were constructed with a logistic regression model and RCCS census data on the age, sex, and community stratum of participants and non-participants. Lastly, we measured community-level coverage of ART use among people living with HIV and male circumcision in non-Muslim men by use of aggregated self-reported data for each of the 40 communities, and compared the median community coverage estimates between the three community strata with a non-parametric Wilcoxon rank sum test.

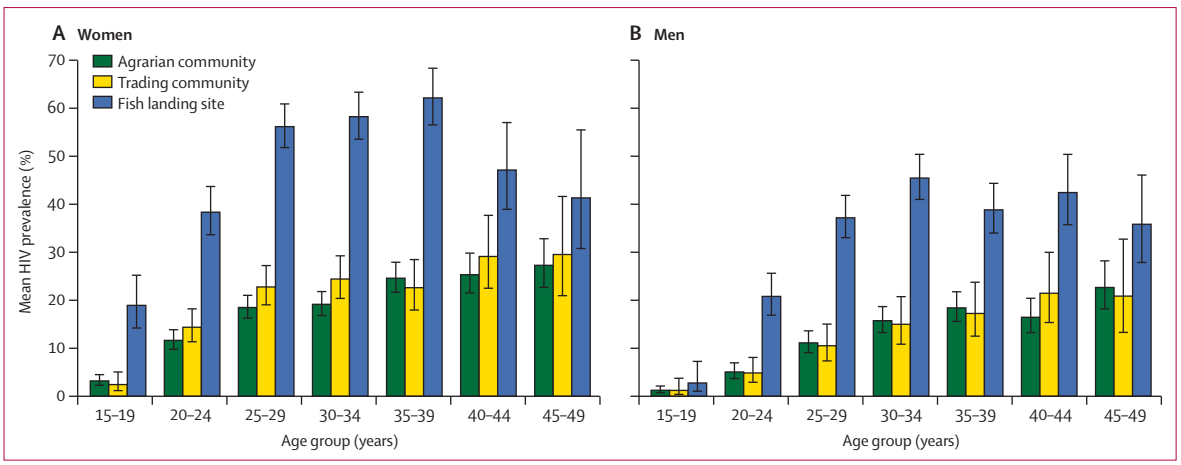

Figure 3: **Age-specific mean HIV prevalence in men and women**
Error bars are 95% CIs.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. LWC and MKG had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

See Online for appendix

The RCCS surveyed 17 119 individuals (9215 [54%] women) in 27 agrarian communities (n=9931), nine trading communities (n=3318), and four Lake Victoria fishing communities (n=3870) between Aug 10, 2011, and May 30, 2013. The median community sizes were 309 participants (IQR 213–495) in agrarian, 283 participants (208–548) in trading, and 695 participants (435–1227) in fishing communities. Mean community-level participation was 70% (SD 9·0) of the eligible population included in the census. At the time of the survey, 17 119 (99%) of 17 326 eligible individuals present agreed to participate. Of those individuals who were eligible by census but who did not participate in the survey (n=8090), 7830 (97%) were away for work or school and 4752 (59%) were men. These missing individuals were significantly more likely to be younger (PRR 0·98 per year of age, 95% CI 0·97–0·98) and male (1·41, 1·35–1·48), and more likely to be residents of trading communities than agrarian communities (1·49, 1·42–1·57). The likelihood of study participation was higher in fishing communities than in agrarian communities (1·11, 95% CI 1·04–1·18).

The demographic composition differed in agrarian, trading, and fishing communities (table 1). In fishing communities a greater proportion of participants were men, of prime working age (20–39 years), and previously married than in either agrarian or trading communities; people in fishing villages had less formal education and the women were more likely to be involved in bar and restaurant work, and the men in fishing-related occupations.

Community HIV prevalence ranged from 9% to 43% across RCCS communities. Fishing communities had a significantly higher median HIV prevalence (42%, range 38–43) than trading (17%, 11–21) and agrarian communities (14%, 9–26; figure 2A). In a sensitivity analysis with inverse probability weighting to account for differences in study participation, weighted community HIV prevalence estimates were not significantly different (appendix p 1). An interpolated map of HIV prevalence throughout the Rakai region revealed high HIV prevalence along Lake Victoria and patchy HIV prevalence in the interior of the district, with areas of intermediate-to-high HIV prevalence frequently adjacent to areas with low HIV prevalence (figure 2B). Although the areas with highest HIV prevalence were along the Lake Victoria coast, the preponderance of people living with HIV were concentrated inland within major trading centres along the international highways, where population density is greatest (figure 2C).

HIV prevalence in young women (15–24 years) and men (20–29 years) in fishing communities was higher than in those residing in other Rakai communities (figure 3). In fishing communities, the highest HIV prevalence was noted among women aged 35–39 years (62%, 95% CI 56–68) and among men aged 30–34 years (45%, 41–50).

Higher levels of HIV risk behaviours occurred in communities with higher HIV prevalence (tables 2 and 3). The proportion of sexually active adults and the prevalence of high-risk sexual behaviours in both men and women were highest in fishing communities, intermediate in trading communities, and lowest in agrarian communities. For example, 22% of sexually active women in the fishing communities reported more than one sexual partner in the past year compared with 12% in trading communities and 7% in agrarian communities. Findings were similar when analyses

	Agrarian (n=5416)	Trading (n=1940)	Fishing (n=1859)	Age-adjusted prevalence risk ratio (95% CI)		
				Trading *vs* agrarian	Fishing *vs* agrarian	Fishing *vs* trading
Sexually active in the past year	4383 (81%)	1633 (84%)	1702 (92%)	1·04 (0·98–1·10)	1·13 (1·07–1·19)	1·09 (1·02–1·16)
More than one partner*	295 (7%)	193 (12%)	367 (22%)	1·73 (1·44–2·07)	3·15 (2·71–3·68)	1·83 (1·54–2·18)
Used alcohol before sex*	789 (18%)	307 (19%)	574 (34%)	1·08 (0·94–1·23)	1·93 (1·74–2·15)	1·80 (1·57–2·07)
Sex with partner outside the community*	961 (22%)	450 (28%)	350 (21%)	1·25 (1·12–1·40)	0·93 (0·82–1·05)	0·75 (0·65–0·86)
At least one non-marital partner in the past year among married women*	158/3223 (5%)	90/1098 (8%)	193/1176 (16%)	1·66 (1·27–2·14)	3·21 (2·60–3·96)	1·97 (1·54–2·55)
Consistent condom use with non-marital sexual partners†	299/1331 (22%)	116/616 (19%)	133/684 (19%)	0·84 (0·68–1·04)	0·87 (0·71–1·06)	1·03 (0·81–1·33)
Symptoms of genital ulcer disease in the past 12 months	602 (11%)	214 (11%)	416 (22%)	0·99 (0·85–1·16)	2·02 (1·78–2·28)	2·03 (1·72–2·40)
HIV seropositive	888 (16%)	368 (19%)	907 (49%)	1·18 (1·05–1·33)	2·99 (2·73–3·28)	2·55 (2·26–2·88)
ART use among HIV seropositive women	295/888 (33%)	139/368 (38%)	164/907 (18%)	1·22 (0·99–1·49)	0·65 (0·54–0·79)	0·53 (0·42–0·66)

Data are number (%) or n/N (%), unless otherwise specified. ART=antiretroviral therapy. *In sexually active women. †In sexually active women reporting sex with a non-marital partner.

***Table 2*: Sexual behaviours, sexually transmitted infection symptoms, HIV prevalence, and HIV treatment and prevention uptake in women**

	Agrarian (n=4515)	Trading (n=1378)	Fishing (n=2011)	Age-adjusted prevalence risk ratio (95% CI)		
				Trading *vs* agrarian	Fishing *vs* agrarian	Fishing *vs* trading
Sexually active in the past year	3436 (76%)	1152 (84%)	1849 (92%)	1·10 (1·03–1·18)	1·16 (1·10–1·23)	1·07 (1·00–1·16)
More than one partner*	1043/3142 (33%)	466/1031 (45%)	1023/1668 (61%)	1·35 (1·21–1·51)	1·85 (1·70–2·02)	1·36 (1·22–1·52)
Used alcohol before sex†	1343 (39%)	390 (34%)	950 (51%)	0·90 (0·80–1·01)	1·33 (1·22–1·44)	1·49 (1·33–1·68)
Sex with partner outside the community†	1295 (38%)	548 (48%)	892 (48%)	1·24 (1·12–1·37)	1·28 (1·18–1·39)	1·01 (0·91–1·13)
At least one non-marital partner in the past year among married men‡	695/2363 (29%)	321/760 (42%)	697/1241 (56%)	1·42 (1·24–1·62)	1·85 (1·67–2·06)	1·31 (1·15–1·50)
Consistent condom use with non-marital partners*§	614/1749 (35%)	220/710 (31%)	352/1285 (27%)	0·88 (0·76–1·03)	0·77 (0·68–0·88)	0·86 (0·73–1·02)
Symptoms of genital ulcer disease in the past 12 months	335 (7%)	115 (8%)	397 (20%)	1·12 (0·91–1·38)	2·62 (2·27–3·04)	2·37 (1·93–2·93)
HIV seropositive	486 (11%)	148 (11%)	691 (34%)	1·01 (0·84–1·21)	2·99 (2·66–3·36)	3·01 (2·53–3·61)
ART use among HIV seropositive men	131/486 (27%)	35/148 (24%)	90/691 (13%)	0·89 (0·60–1·27)	0·55 (0·42–0·72)	0·64 (0·44–0·97)
Circumcised non-Muslim men	1250/3943 (32%)	466/1093 (43%)	334/1627 (21%)	1·35 (1·21–1·50)	0·64 (0·56–0·72)	0·48 (0·42–0·55)

Data are number (%) or n/N (%), unless otherwise specified. ART=antiretroviral therapy. *In sexually active men who were not in polygamous marriages. †In sexually active men. ‡In men in monagomous or polygamous marriages. §In sexually active men reporting sex with a non-marital partner.

***Table 3*: Sexual behaviours, sexually transmitted infection symptoms, HIV prevalence, and HIV treatment and prevention uptake in men**

were restricted to married women only (table 2). 2532 (39%) of 6437 sexually active men reported more than one sexual partner in the past year compared with 855 (11%) of 7718 women. Excluding married polygamous men, 1023 (61%) of 1668 sexually active men in fishing communities had more than one sexual partner compared with 466 (45%) of 1031 in trading communities (adjusted PRR 1·36, 95% CI 1·22–1·52), and 1043 (33%) of 3142 in agrarian communities (1·85, 1·70–2·02). The proportion of married men reporting non-marital partnerships was also higher in fishing and trading communities than agrarian communities. Male and female self-reported consistent condom use with non-marital partners was low in all communities, and was significantly lower among men in fishing communities than in agrarian communities. Findings did not change substantially when analyses were stratified by HIV serostatus; men and women in fishing communities had increased risk behaviours regardless of whether or not they were infected with HIV (appendix pp 2–5). At the individual level, fishing community residents were significantly less likely to report ART use and non-Muslim men in these communities were less likely to report being circumcised than were individuals

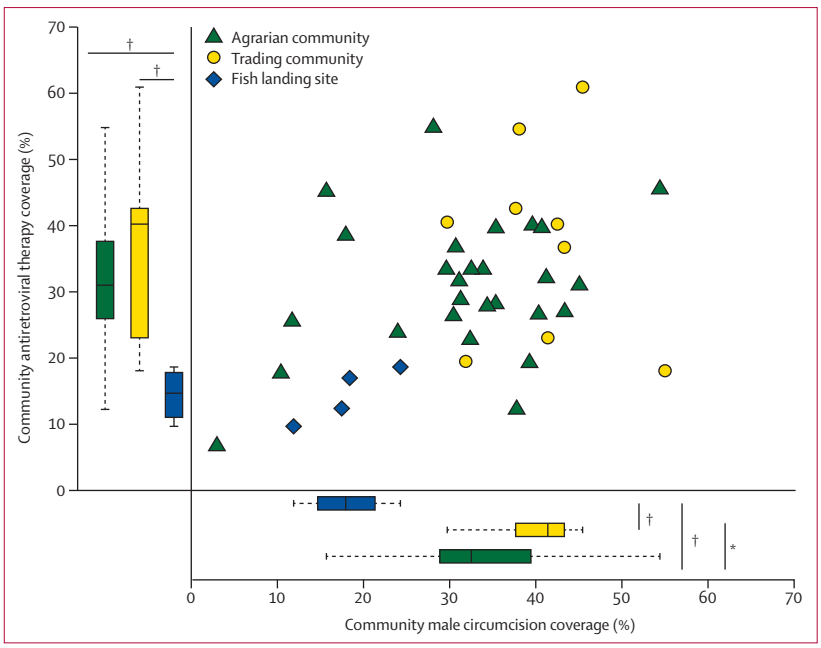

Figure 4: **Rakai Community Cohort Study community antiretroviral therapy and male circumcision coverage in non-Muslim men**

Box and whiskers plots show medians (lines within boxes) and IQRs (boxes) and the lowest and highest datum within 1·5 of the IQR (whiskers). *p<0·05. †p<0·01.

in agrarian or trading communities (tables 2 and 3). At the community level, ART coverage among people living with HIV was 7–61% and male circumcision coverage 3–55%. Community ART coverage was highest in trading communities (median 40%, IQR 23–43), compared with 31% in agrarian communities (IQR 26–38) and 15% in fishing communities (12–17). Community male circumcision coverage was significantly higher in trading (median 41%, IQR 38–43) and agrarian communities (33%, IQR 29–39) than in fishing communities (median 18%, IQR 16–20). Overall, communities with higher ART coverage also had higher male circumcision coverage (Spearman correlation coefficient 0·337; p=0·01; figure 4).

Discussion

In Rakai, Uganda, substantial heterogeneity exists in HIV prevalence, risk factors, and service coverage. In particular, Lake Victoria fishing communities had a high HIV burden, high-risk behaviours, and low use of combination HIV prevention services. To our knowledge, this is the first study to directly compare HIV epidemiology and service uptake between fishing and inland communities by use of population-based data.

The median HIV prevalence in the four RCCS fishing communities (41%) is higher than in previous reports from similar communities on Lake Victoria (range 20–37%).[15–19] The HIV burden in many agrarian and trading communities in this study was also substantial, and these communities, which had larger populations according to the WorldPop database, had the greatest numbers of people living with HIV. There was also substantial variation in HIV prevalence within agrarian and trading community types, which shows the difficulty in defining characteristics that can be used to identify higher risk communities.

Although HIV behavioural risk factors were common in all study community strata, consistent with previous findings,[20–22] fishing communities had higher rates of risk behaviours than others.[15,23] With complex structural factors that have affected fishing communities (eg, a recently built fish factory and improved road infrastructure probably attracted a large influx of migrants) and the recent scale-up of HIV prevention and treatment services, ongoing research will be needed to understand the evolving HIV epidemic in these settings.

UNAIDS, WHO, PEPFAR, and The Global Fund to Fight AIDS, Tuberculosis, and Malaria have called for targeting of resources to populations with the greatest need (ie, a population-location approach) based in part on the assumption that high-prevalence hotspots disseminate infection into lower risk populations.[1,3,24] In this study, we found that fishing communities were HIV hotspots compared with most inland communities. However, how many infections are transmitted from these hotspots to lower risk populations is unclear. We found that the highest burden of HIV in terms of case counts for people living with HIV were located in the larger, lower risk populations. Where need is greatest could be defined by high HIV seroprevalence (ie, a hotspot focus) or by high HIV case counts (ie, the largest populations of people living with HIV). Where best to target scarce resources remains unclear and model-based and empirical impact evaluations are needed. We believe a clear HIV public health emergency exists in the fishing communities that demands urgent action, but the HIV service needs of lower prevalence populations with numerically larger caseloads should not be neglected.

ART and male circumcision coverage were significantly lower in fishing communities than agrarian or trading communities, probably in part because these populations had poor access to HIV services before 2011. By contrast with the fishing communities, the highest HIV service coverage was in trading centres, which probably had greater access to HIV services. In 2013, Uganda changed its national ART guidelines to include fisherfolk as a key population eligible to receive ART at the time of diagnosis, irrespective of CD4 count (ie, test and treat).[25] The effectiveness of this targeted approach in increasing ART coverage and its effect on HIV transmission needs to be monitored.

In this study, detailed epidemiological data were available to provide an in-depth understanding of a multifaceted HIV epidemic, an understanding that would have been obscured by district-level or national-level aggregate statistics. Although requests for granular HIV data have been made,[2] how finely resolved such data

should be, what resources are needed to implement detailed HIV surveillance at scale, and the effect of targeting interventions based on these detailed data remain unclear.[24] For example, this study provides more granular data than the recent location-population UNAIDS report,[3] which used first and second subnational administrative data only. As a consequence, we believe that our inferences regarding the HIV epidemic in this part of south-central Uganda are more detailed and should help in the development of programmes to provide focused, community-specific HIV responses. Since many other regions of sub-Saharan Africa also contain diverse community types in close proximity, these findings also have broader relevance. Further research into HIV heterogeneity in other settings and how these differences affect HIV epidemic dynamics would be informative.

This study has several limitations. First, communities and participants in the cohort might not be fully representative of the regional HIV epidemic, and treatment and prevention estimates might not accurately reflect the heterogeneity in other national epidemics. However, the participation rates in this study were comparable with or higher than those in similar community cohort studies in Africa,[26,27] cohort findings were largely consistent with Uganda DHS data on HIV prevalence and risk factors for the larger south-central region of Uganda,[11] and other countries seem to have similarly complex HIV epidemics.[28] This study also used self-reports of behaviours, ART, and male circumcision, which might be subject to respondent desirability bias. Additionally, for this analysis, we used cross-sectional survey data collected over 2 years and results might have been subject to secular changes. Finally, assumptions and inferences on missing data were necessary for interpolation of HIV prevalence and case counts.

In conclusion, we identified a marked diversity in HIV disease burden, sexual behaviours, and treatment and prevention service coverage across communities in close proximity. The extensive heterogeneity in the HIV epidemic probably has crucial implications for targeted treatment and prevention programmes in sub-Saharan Africa. Strong local HIV surveillance programmes, a better understanding of the HIV transmission links between high-risk and lower risk populations, and assessment of targeted HIV interventions are needed to reduce the burden of HIV in these communities.

Contributors

LWC and MKG conceptualised and designed the study. RS, FN, GK, BN, TCQ, SJR, RHG, DS, and MJW oversaw data collection and laboratory testing. MKG, JL, and SMM did the statistical analysis. All authors participated equally in revising and the final approval of the manuscript.

Declaration of interests

We declare no competing interests.

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