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The burden of HIV, syphilis and schistosome infection and associated factors among adults in the fishing communities in northwestern Tanzania

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Abstract

OBJECTIVES To quantify the burden of HIV, syphilis and schistosome infection and associated risk factors among adults living in seven fishing communities of Lake Victoria in northwest Tanzania.

METHODS Cross-sectional study conducted between 2015 and 2016 in the selected communities. In each community, we randomly selected a sample of adults from the general population and from three putative risk groups including the following: (i) fishermen, (ii) fish processors and traders, and (iii) women working in the recreational facilities. Participants were interviewed to obtain information about potential risk factors, and venous blood was collected for detection of HIV, syphilis and schistosome infections. We used logistic regression models to quantify the associations between potential risk factors and HIV, and also between schistosome infection and HIV.

RESULTS We enrolled 1128 people from selected fishing communities. The overall prevalence of HIV, syphilis and schistosome infection was 14.2%, 15.6% and 83.1%, respectively. Female recreational facility workers had the highest prevalence of HIV (30.4%) and syphilis (24%). The odds of being HIV infected were generally higher in all age categories. Transactional sex was commonly reported and especially receiving gifts for sex was found to be strongly associated with HIV (adjusted OR = 2.50; 95% CI: 1.44–4.34, $P = 0.008$). Confirmed serological syphilis was associated with increased odds of having HIV infection. HIV was not associated with schistosome infection in a combined dataset and when we examined this separately for men and women alone.

CONCLUSIONS We observed a high burden of HIV, syphilis and schistosome infections in the fishing communities. Targeted efforts to treat and control infections have the potential to improve health among their residents.

keywords HIV/AIDS, schistosomiasis, syphilis, Tanzania, epidemiology, prevention and control

Sustainable Development Goals (SDGs): 3.3.3, 3.d

Introduction

Fishing communities in both Africa and Asia have HIV infection prevalence rates 4 to 14 times higher than the national average, indicating that this epidemic disproportionately affects fishermen, fish traders and others involved in fishing activities [1]. Risk-taking behaviour is

common in these population groups. Previous research has shown that transactional sex is common, and residents frequently report multiple sex partners [2]. HIV infection risk is exacerbated by a range of individual and structural factors, including high mobility among fishermen, whose occupation often requires living away from their families, and by peer norms which frequently

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include alcohol use and other risk-taking behaviours [1–3]. Limited access to healthcare facilities and fatalistic attitudes towards their risk of death, both while fishing and due to acquiring HIV, may also play a role [4]. While studies regarding the prevalence of HIV infection and associated risk behaviours have been reported from communities situated on the shores of Uganda and Kenya, data from Tanzania, which comprises one of the largest fishing populations in East Africa, are lacking [5–8].

Given the high background prevalence of HIV infection in fishing communities, compounded by further spread of HIV when fishermen return home [2], efforts to identify modifiable factors associated with HIV transmission or acquisition are a major public health priority. In particular, schistosome infections have been associated with increased risk of HIV acquisition in women in longitudinal studies in Zambia and Tanzania [9, 10]. In contrast, in Lake Victoria fishing communities where only *S. mansoni* is hyper-endemic, an association between *S. mansoni* and HIV was found neither in a cross-sectional nor in a longitudinal study [11, 12]. Interestingly, the longitudinal study in Uganda did find an increased risk of HIV acquisition in individuals who reported not having been treated for schistosome infections in the past two years [12]. Other causes of genital tract disease, such as bacterial sexually transmitted infections (STIs), are also known to be associated with increased risk of HIV and their treatment and prevention holds potential to control HIV transmission in these communities.

We conducted a cross-sectional study to quantify the burden of HIV and associated infections, and to assess risk-taking behaviours among adults living in selected fishing communities of Lake Victoria in northwest Tanzania. This was done in preparation for future intervention studies to address HIV and improve health in lakeshore communities. We hypothesised that we would observe a high community prevalence of HIV associated with a substantial burden of potentially treatable infections (such as syphilis and schistosomiasis). We further sought to investigate the relationship between schistosome infection and HIV in the study setting in which the prevalence of both infections was expected to be high.

Methods

Study settings and data collection procedures

We conducted a cross-sectional study in three districts (Muleba, Sengerema and Ukerewe) along Lake Victoria in Tanzania, which were selected due to their large fishing populations. Within these districts, we purposefully

selected seven fishing communities (Figure 1) with the following characteristics: a large number of men involved in fish catching and trading activities; large concentration of bars, hotels and other recreational facilities where alcohol is served; and a large number of women involved in fish processing and as workers in recreational facilities. In each community, we randomly selected a sample of adults from the general population and from three putative risk groups including the following: (i) fishermen and boat crews, (ii) fish processors and traders, and (iii) women working in the recreational facilities listed above. Participants selected in any of the three risk groups were excluded from the general population sample. In each population group, those aged ≥ 18 years who were willing to provide written informed consent and participate in the study procedures were eligible to join the study.

Before data collection started, we organised meetings with community representatives to provide information about the study and research procedures. Later, we invited potential participants to attend a meeting in a central community location to receive detailed information about the study. Those interested in participating provided written informed consent before being interviewed by interviewers of the same sex in a private setting. During the interviews, we collected information about socio-demographic characteristics, sexual behaviours, male circumcision status, STI-related symptoms, history of STI diagnosis and treatment, and other potential risk factors. After the interview, HIV/STI counselling was provided before venous blood was collected for HIV and syphilis testing, and long-term storage.

Among those who reported STI-related symptoms, clinical examination was performed to confirm reported symptoms objectively. All those with STI syndromes and laboratory-confirmed syphilis were treated following national management guidelines. Partners of study participants with confirmed STI syndromes and/or syphilis were also invited (using invitation slips delivered by the index study volunteer) to come to the study site for treatment which was provided at no cost.

Laboratory methods

Point-of-care HIV-1 testing was done by certified research staff using rapid test kits following Tanzanian national diagnostic algorithms. Determine™ HIV1/2 (Alere Medical Co. Ltd., Mitsudo-shi, Chiba, Japan) was used as a first-line test, and negative results were recorded as such. Positive samples were confirmed by Uni-Gold™ HIV (Trinity Biotech, Plc, Bray, Co. Wicklow, Ireland). In case of discrepant results, HIV 1/2 STAT-PAK® (Chembio

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Figure 1 Map showing the fishing communities included in this study. [Colour figure can be viewed at wileyonlinelibrary.com]

Diagnostic Systems, Medford, NY, USA) was performed as a tie-breaker.

Syphilis was tested on the spot using a rapid *Treponema pallidum* haemagglutination assay (TPHA), and remaining blood was processed in a central laboratory in Mwanza with the Rapid Plasma Reagin (RPR) card test. Study subjects were considered to have confirmed syphilis if both TPHA test was positive and RPR titre was greater than 1:8.

Schistosome testing was performed on stored serum samples approximately 1.5 years after sample collection by quantifying circulating anodic antigen (CAA) with a lateral flow (LF) assay utilising an upconverting phosphorescent (UCP) label as previously described [13]. A CAA value ≥ 30 pg/mL was considered positive [14], and results were stratified into low to moderate intensity (30 – 2999.99 pg/mL) or high intensity (≥ 3000 pg/mL) [15].

Statistical methods

We estimated the prevalence (and corresponding 95% confidence interval (CI)) of HIV, syphilis and schistosome infection separately for each of the four population groups outlined above. The burden of HIV was also summarised by (i) socio-demographic characteristics, (ii) self-reported sexual behaviours and (iii) clinical

factors including circumcision (men only), syphilis status and other STI symptoms. The associations between these potential risk factors and HIV were also summarised using crude and adjusted odds ratios from univariate and multivariable logistic regression, respectively. The multivariable analysis sought to estimate the independent associations with HIV after adjusting for the potentially confounding effects of sex, age and population group. The analysis of associations with clinical factors was further adjusted by self-reported sexual behaviours with strong univariate associations with HIV. Finally, we investigated the independent association between schistosome infection and HIV using multivariable logistic regression adjusted for the same potential confounders as in the analysis of associations between HIV and other infections. Analyses were performed in men and women separately. We also modelled the relationship between HIV and CAA in a logistic regression with the (log) CAA concentration included as a linear term for each sex.

Ethical considerations

Permission for the conduct of this study was obtained from the Tanzania National Institute for Medical Research (NIMR/MR/53/100/339), and exemption for

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the analysis of de-identified data was obtained from Weill Cornell Medicine (#1709018560). All study participants provided written informed consent for participation and were offered free treatment for themselves and their partners as indicated for infections that were diagnosed during the study. Results were available to study participants within 1–2 h and were provided within the context of post-test counselling. HIV-infected participants were referred to HIV/AIDS care and treatment centres for free standard of care treatment. In these fishing communities in which most people have near-daily exposure to contaminated water, anti-schistosome praziquantel treatment is routinely provided free of charge through community programmes supported by the Ministry of Health. Participants also agreed to de-identified storage of blood samples for future testing related to HIV infection.

Results

Characteristics of the study population

Between August 2015 and September 2016, we enrolled 1121 people from seven fishing communities, including 253 (22.6%) from the general population; 355 (31.7%) fishermen and boat crew; 227 (20.2%) fish processors and traders; and 286 (25.5%) female recreational facility workers (Table 1). About half of the study participants were male, the median age was 33 years, 80% were Christian, 56% were married or cohabiting and 86% had completed only primary education or below. The median age at first sex was 16 and 18 years for women and men, respectively. During the past year, about 48% reported to have three or more sex partners and 67% reported to have received or given a gift in exchange for sex. About 22% reported to have experienced abnormal genital discharge during the past year, and the majority of men (92%) included in the study reported to be circumcised.

Of note, among the total study population, 79% of participants reported having been tested previously for HIV infection: 37% in the past year, 36% between one and five years ago, and 6% more than five years ago. Among those who had previously sought HIV testing, the median reported walking time to reach the nearest testing site was between 31 and 60 min, and 47% reported that the nearest site was greater than one-hour walk away.

Prevalence of HIV and syphilis and associated factors

The overall proportions with HIV and syphilis in the study sample were 14.2% (95% CI: 12.2–16.4) and 15.6% (95% CI: 13.5–17.8), respectively. Female recreational facility workers had the highest prevalence of

Table 1 Socio-demographic characteristics of the study population among fishing communities around Lake Victoria in NW Tanzania

	N	(%)
Sex		
Male	584	52.7
Female	537	47.9
Population group		
General population	253	22.6
Fishermen or boat crew	355	31.7
Fish processors & traders	227	20.2
Recreational facility workers	286	25.5
Religion		
Christian	895	79.8
Muslim	115	10.3
Other	111	9.9
Age group		
18–24 years	180	16.3
25–29 years	220	19.9
30–39 years	437	39.5
40–49 years	200	18.1
≥50 years	69	6.2
Marital status		
Married or cohabiting	624	55.7
Widowed	31	2.8
Separated or divorced	347	30.9
Single – never married	119	10.6
Education		
No formal schooling	103	9.2
Incomplete primary school	251	22.4
Completed primary school	608	54.2
Incomplete secondary (form 1–4)	92	8.2
Secondary or higher education	67	6.0
Sexual partners (in the last year)*		
Zero or one	279	30.3
Two	202	21.9
Three or four	242	26.3
Five or more	198	21.5
Male circumcision (men only)†		
Circumcised	534	91.6
Not circumcised	49	8.4

*Missing from 200 participants who reported not to be sexually active in the past 12 months.

†This information was obtained from men only.

HIV (30.4%; 95% CI: 25.1–36.1) and syphilis (24%; 95% CI: 19.2–29.4) (Table 2). The prevalence of HIV was higher among females (22%) than males (7%), driven by the very high prevalence among women working in the recreational facilities. Muslims (22%) and those widowed (39%) or separated/divorced (27%), and those in their late 20s and 30s also had a higher observed HIV prevalence, as did those with little formal education (Table 3), although the effect of education was no longer

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evident after adjusting for sex, age and population group. The odds of being HIV infected were generally higher in all age categories when compared to those age 18–24 years.

Generally, the risk of HIV infection decreased with age at first sex and increased with the number of sexual partners; however, neither of these factors remained independently associated with HIV after adjusting for sex, age and population group. Transactional sex (as measured by self-report of whether participants had received or given gifts for sex in the last year) was commonly reported and receiving gifts was especially found to be strongly associated with HIV, including in the adjusted model (adjusted OR = 2.50; 95% CI: 1.44–4.34, $P = 0.008$). We found a strong association in the unadjusted analysis between frequent condom use and HIV infection, but this was no longer associated with HIV after adjusting for sex, age and population group.

The prevalence of HIV was not associated with reported circumcision status among men. Combined, 49% (547/1121) of volunteers had experienced symptoms related to genital infections and/or were diagnosed to have an STI during the past year; however, despite evidence of univariate associations with HIV, only syphilis remained strongly associated after adjusting for demographic and behavioural factors. Confirmed serological syphilis was associated with more than doubling of the risk of the odds of having HIV infection with an adjusted odds ratio of 2.38 (95% CI: 1.34–4.22).

Prevalence of schistosome infection and association with HIV

Schistosome infection was detected in 924 out of 1112 (83.1%; 95% CI: 80.8–85.3) people tested (Table 2).

The prevalence of schistosome infection ranged from 77% among female recreational facility workers to 90% among fishermen or boat crew. The prevalence of schistosome infection was higher in males than females (85% *vs* 80%). Study participants who were aged 50 years and above, and those with the highest monthly income, had relatively lower prevalence of schistosome infection when compared to other study participants (data not shown). In Table 3, we present the associations between HIV and intensity of schistosome infection. In general, a consistent trend towards a higher HIV prevalence among those with higher intensity of schistosome infection was observed when we examined this in a combined dataset of women and men, and when we examined this separately for men and women alone. However, none of this was statistically significant after we adjusted for demographic and behavioural factors. In addition, schistosome infection was not significantly associated with a history of genital discharge, genital sore or a diagnosis of STI in the past 12 months, nor was it associated with current genital itch (data not shown).

In an exploratory analysis restricted to male participants only, we found a significant association between CAA and HIV infection (OR = 1.12; 95% CI: 1.01–1.24, $P = 0.035$) for each unit increase in (log) CAA (Figure S1). However, among female participants we found no evidence of an association between CAA and HIV (OR = 1.00; 95% CI: 0.94–1.07, $P = 0.939$).

Discussion

Our results indicate the enormous burden of treatable infections currently afflicting residents of the rural fishing communities surrounding Lake Victoria in Tanzania. We document rates of HIV infection in fishing communities

Table 2 Prevalence of HIV, syphilis and schistosome infections by population group among fishing communities around Lake Victoria in NW Tanzania ($N = 1121$).

	Total	%	HIV*		Syphilis*		Schistosome Infection*	
			Cases	Prevalence % (95% CI)	Cases	Prevalence % (95% CI)	Cases	Prevalence % (95% CI)
All	1121	53	159	14.2 (12.2–16.4)	175	15.6 (13.5–17.8)	924	83.1 (80.8–85.3)
Recreational facility workers†	286	0	87	30.4 (25.1–36.1)	69	24.0 (19.2–29.4)	214	77.3 (71.9–82.1)
Fishermen or boat crew	355	99	29	8.2 (5.5–11.5)	51	14.3 (10.9–18.4)	319	89.9 (86.2–92.8)
Fish processors & traders	227	41	19	8.4 (5.1–12.8)	27	11.8 (8.0–16.8)	182	80.2 (74.4–85.2)
General population‡	253	54	24	9.5 (6.2–13.8)	28	11.0 (7.4–15.5)	209	81.6 (76.3–86.2)

*Data on HIV, syphilis and schistosomiasis infections were missing for seven participants, 4 and 16 participants respectively.

†Female staff working in bars, hotels or guesthouses.

‡Sampled from a random selection of households.

S. Kapiga *et al.* HIV, syphilis and schistosome infection in NW Tanzania**Table 3** Associations between HIV infection and socio-demographic, behavioural and clinical factors among fishing communities around Lake Victoria in NW Tanzania

	N	HIV+ n (%)	Odds ratio (95% CI)	P	Adjusted odds ratio (95% CI)†	P
Socio-demographic factors						
Sex						
Male	584	43 (7)	1	<0.001	1	0.040
Female	537	116 (22)	3.47 (2.39–5.03)		2.01 (1.03–3.90)	
Population group						
General population	253	24 (9)	1	<0.001	1	<0.001
Fishermen or boat crew	355	29 (8)	0.85 (0.48–1.50)		1.12 (0.56–2.26)	
Fish processors and traders	227	19 (8)	0.87 (0.46–1.64)		0.71 (0.37–1.37)	
Recreational facility workers	286	87 (30)	4.17 (2.56–6.81)		3.11 (1.73–5.61)	
Religion						
Christian	895	119 (13)	1	0.053	1	0.039
Muslim	115	25 (22)	1.81 (1.12–2.94)		1.96 (1.16–3.30)	
Other	111	15 (14)	1.02 (0.57–1.82)		1.22 (0.66–2.25)	
Age group						
18–24 years	180	15 (8)	1	0.012	1	0.017
25–29 years	220	45 (20)	2.83 (1.52–5.27)		2.75 (1.45–5.23)	
30–39 years	437	64 (15)	1.89 (1.04–3.41)		2.72 (1.47–5.05)	
40–49 years	200	26 (13)	1.64 (0.84–3.21)		3.05 (1.49–6.24)	
≥50 years	69	7 (10)	1.24 (0.48–3.19)		2.54 (0.95–6.82)	
Marital status						
Married or cohabiting	624	43 (7)	1	<0.001	1	<0.001
Widowed	31	12 (39)	8.53 (3.89–18.7)		6.36 (2.67–15.1)	
Separated or divorced	347	94 (27)	5.02 (3.40–7.41)		2.87 (1.72–4.76)	
Single – never married	119	10 (8)	1.24 (0.60–2.54)		1.62 (0.72–3.63)	
Education						
No formal schooling	103	21 (20)	1	0.117	1	0.821
Incomplete primary school	251	39 (16)	0.72 (0.40–1.29)		0.90 (0.47–1.73)	
Completed primary school	608	84 (14)	0.63 (0.37–1.07)		0.87 (0.48–1.59)	
Incomplete secondary (form 1–4)	92	11 (12)	0.53 (0.24–1.17)		0.80 (0.34–1.90)	
Secondary or higher education	67	4 (6)	0.25 (0.08–0.76)		0.49 (0.15–1.58)	
Behavioural factors						
Age at first sex						
13 years or younger	78	12 (15)	1	0.015	1	0.489
14–15 years	207	41 (20)	1.36 (0.67–2.75)		1.38 (0.64–2.97)	
16–17 years	276	45 (16)	1.07 (0.54–2.14)		1.25 (0.59–2.64)	
18–20 years	419	52 (12)	0.78 (0.39–1.54)		1.12 (0.53–2.34)	
21 years or older	102	6 (6)	0.34 (0.12–0.96)		0.61 (0.20–1.79)	
Sexual partners (in the last year)						
Zero or one	279	30 (11)	1	0.219	1	0.403
Two	202	22 (11)	1.01 (0.57–1.82)		1.04 (0.55–1.96)	
Three or four	242	29 (12)	1.13 (0.66–1.94)		1.03 (0.54–1.94)	
Five or more	198	33 (17)	1.66 (0.98–2.83)		1.58 (0.83–3.00)	
Sex while drunk (in last month)						
No	749	94 (13)	1	0.012	1	0.707
Yes	211	41 (19)	1.68 (1.12–2.52)		1.09 (0.70–1.71)	
Gifts for sex (in the last year)						
No gifts given or received	373	33 (9)	1	<0.001	1	0.008
Yes, received	287	81 (28)	4.05 (2.61–6.29)		2.50 (1.44–4.34)	
Yes, given	324	26 (8)	0.90 (0.53–1.54)		1.23 (0.63–2.40)	
Yes, received and given	133	19 (14)	1.72 (0.94–3.14)		1.28 (0.66–2.51)	
Frequency of condom use						
Never	418	40 (10)	1	<0.001	1	0.312

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Table -0003 (Continued)

	N	HIV+ n (%)	Odds ratio (95% CI)	P	Adjusted odds ratio (95% CI)†	P
Sometimes	349	41 (12)	1.26 (0.79–1.99)		1.18 (0.71–1.97)	
Most of the time	287	61 (21)	2.55 (1.66–3.93)		1.59 (0.92–2.74)	
Always	63	17 (27)	3.49 (1.83–6.65)		1.73 (0.82–3.65)	
Clinical factors						
Circumcision (men only)						
Circumcised	534	37 (7)	1	0.179	1	0.467
Not circumcised	49	6 (12)	1.87 (0.75–4.69)		1.63 (0.44–6.12)	
Genital sores (in the last year)						
No	937	121 (13)	1	0.006	1	0.093
Yes	184	38 (21)	1.76 (1.17–2.63)		1.65 (0.92–2.95)	
Abnormal discharge (in last year)						
No	873	106 (12)	1	<0.001	1	0.222
Yes	248	53 (21)	1.97 (1.36–2.83)		1.42 (0.81–2.49)	
Genital itching currently						
No	975	128 (13)	1	0.013	1	0.339
Yes	143	30 (21)	1.76 (1.13–2.74)		1.41 (0.70–2.88)	
STI diagnosis in the past year						
No	936	125 (13)	1	0.065	1	0.076
Yes	183	34 (19)	1.48 (0.98–2.25)		1.72 (0.95–3.14)	
Syphilis						
Negative	944	116 (12)	1	<0.001	1	0.003
Positive	175	41 (23)	2.18 (1.46–3.26)		2.38 (1.34–4.22)	
Schistosome infection (all)*						
Negative	190	22 (12)	1	0.489	1	0.392
Low to moderate	484	68 (14)	1.25 (0.75–2.09)		1.29 (0.63–2.65)	
Highly positive	434	66 (15)	1.37 (0.82–2.29)		1.65 (0.78–3.46)	
Schistosome infection (males)*						
Negative	86	2 (2)	1	0.091	1	0.130
Low to moderate	238	16 (7)	3.03 (0.68–13.4)		3.54 (0.43–29.0)	
Highly positive	258	25 (10)	4.51 (1.05–19.4)		6.64 (0.80–55.4)	
Schistosome infection (females)*						
Negative	104	20 (19)	1	0.715	1	0.813
Low to moderate	246	52 (21)	1.13 (0.63–2.00)		0.98 (0.42–2.31)	
Highly positive	176	41 (23)	1.28 (0.70–2.32)		1.24 (0.50–3.08)	

Variables with missing data were: *age* (15 participants), *age at first sex* (39), *number of sexual partners in the past year* (200), *sex while drunk* (161), *gifts* (4), *condom use* (4), *genital itching* (3), *STI diagnosis* (2) and *syphilis* (2). CI, Confidence Interval.

*Schistosomiasis infection intensity evaluated using CAA (Circulating Anodic Antigen) concentration (Negative: 0–29.99 pg/mL; low to moderate: 30–2999.99 pg/mL; highly positive: ≥ 3000 pg/mL).

†All associations were adjusted for *sex* (pooled analysis for males and females), *population group* and *age*. In addition, associations with clinical factors were adjusted for behavioural factors.

that are over six times higher than the national HIV prevalence of 4.6% for women working in recreational facilities [16], and double the national prevalence for other community members including fishermen, fish processors or traders, and local residents. Syphilis prevalence in all occupation groups was also markedly higher than the prevalence of 2.5% to 5.4% reported from antenatal clinics [17, 18]. Additionally, the observed community prevalence of schistosome infection of 83% is among the highest reported globally.

We report the alarming finding that more than 15% of adults residing in Tanzanian fishing communities on Lake Victoria have syphilis infection, a treatable STI that poses major risks for neonatal mortality and is associated with an increased risk of HIV acquisition [19]. Syphilis was documented in approximately 1 in 10 community members and 1 in 4 female recreational facility workers. Primary syphilis, during which a genital ulcer is present, is likely the time of greatest risk of HIV acquisition and also of onward HIV transmission due to increased HIV-1

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genital viral shedding and the compromised mucosal barrier [20, 21]. Although we did not collect data about the history of treatment, a meta-analysis suggests that a majority of East Africans with syphilis remain untreated thereby remaining with high-titre, ongoing disease [22]. Prophylactic doxycycline in high-risk populations, either daily or used as post-exposure prophylaxis, has been reported to have significantly decreased the incidence of syphilis and other bacterial STIs [23, 24]. Daily doxycycline would also have the benefit of treating latent syphilis given its status as a second-line agent against *T. pallidum* [25]. Multiple trials are currently ongoing to assess the utility of doxycycline prophylaxis among high-risk populations such as men who have sex with men [26]. Our data further identify fishing communities as another important target group to consider for such interventional studies.

We further report that one in five participants had never been screened for HIV infection and an additional 25% of study participants had not been screened in the previous five years and that the median transport time to the closest HIV testing site was up to one hour. These data highlight the urgent need to improve community health in these fishing areas, communities with extremely high burdens of treatable infections. Given the high prevalence of disease in these communities as compared to others, they may represent the areas of greatest potential impact on HIV care. Therefore, our data highlight the critical need to strengthen accessible, targeted health-care services for the vulnerable fishing communities surrounding Lake Victoria.

Consistent with other studies in fishing communities [11, 12], we did not observe a statistically significant association between schistosome and HIV infections in persons of either sex. Notably, our findings diverge from longitudinal studies in Tanzania and Zambia that were conducted among populations with a greater prevalence of *S. haematobium* infection and varying levels of HIV risk behaviour, in which incident HIV was associated with prior schistosome infection [9, 10]. While not specifically delineated in our study, it is likely that the vast majority of infections we observed were caused by *S. mansoni* and not *S. haematobium* as this is the pathogen prevalent in this region [11, 27]. Although our study did find a significant positive association between the intensity of schistosome infection and HIV prevalence in men in the univariate analysis, we found no evidence of such an association in women. An association between HIV infection and intensity of schistosome infection has been previously reported in women [13]. Taken together, these findings suggest that there may be some

interactions between schistosome and HIV infections but that they may be of relatively low consequence in contexts in which other genital infections and high-risk sexual behaviour more strongly drive ongoing HIV transmission.

This study has some limitations. Given the cross-sectional design, we were unable to determine causality or to document temporal trends, such as RPR titres or CAA levels. This information could provide insight into infection acquisition and treatment patterns. Further, it is difficult to assess schistosome infection as a risk factor in a setting where over 80% of people have schistosome infections. In areas of such high endemicity, those who are not schistosome-infected may have some unique immunologic or epidemiologic factor that causes them to remain uninfected [28–30]. It is also possible that reporting bias led to underestimation of the effects of STI symptoms or risky sexual behaviour on HIV infection in this community. Several known HIV risk factors including age at first sex, condom use and exchanging gifts for sex trended towards positive associations but did not reach significance in the multivariable model.

In conclusion, we have identified a high burden of treatable infectious diseases including HIV, syphilis and schistosome infections in both men and women living in fishing communities. Targeted efforts to treat and control infections among residents of these communities have the potential to improve not only the health of those entire communities, but additionally to prevent the spread of diseases to other lower-risk communities when seasonal fishing workers return home to their families. Our data suggest that studies to determine the most effective ways to implement prophylactic and treatment interventions should be strong priorities for these vulnerable communities.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Odds of HIV infection per unit increase of serum schistosome Circulating Anodic Antigen (CAA).

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