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ORIGINAL PAPER

Bisexual and Bidirectional: Assessing the Potential for HIV Bridging in Mozambique

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Abstract
African men who have sex with men (MSM) frequently, and often concurrently, have female partners, raising concerns about HIV sexual bridging. We explored potential HIV transmission in Mozambique from and to female partners of MSM focusing on preferred anal sex role and circumcision status. Data collected in a respondent-driven sampling study of MSM in 2011 in Maputo and Beira. Men who had oral or anal sex with other men 12 months prior completed a questionnaire and consented for HIV testing. Statistical analysis explored demographic/risk characteristics and associations among circumcision status, anal sex with men, sexual positions during anal sex with men and vaginal or anal sex with women. We identified 326 MSM in Maputo and 237 in Beira with both male and female partners 3 months before the study. Of these, 20.8% in Maputo and 36.0% in Beira had any receptive anal sex with men 12 months prior, including 895 unprotected sexual acts with males in Maputo and 692 in Beira. Uncircumcised and exclusively insertive males, 27.7% of the sample in Maputo and 33.6% in Beira, had the most unprotected sex with females: 1159 total acts in Maputo and 600 in Beira. Sexual bridging between MSM and women likely varies geographically and is probably bi-directional, occurring within a generalized epidemic where HIV prevalence is higher among reproductive-age women than MSM. Prevention strategies emphasizing correct and consistent condom use for all partners and circumcision for bisexual men should be considered.

Keywords Mozambique · Sexual bridging · MSM · HIV risk behavior · HIV transmission · Bisexuality

Introduction

The HIV epidemic in sub-Saharan Africa (SSA) was initially characterized as heterosexual; however, it is now recognized that this profile of HIV in SSA was oversimplified [1–6]. Key populations, such as men who have sex with men (MSM) are severely affected by the HIV epidemic and may be important factors in generalized epidemics. African MSM frequently, and often concurrently, have female sexual partners [6–14]. Bisexual concurrency, defined as ongoing, stable partnerships with both sexes, is a concern for sexual bridging because it facilitates linkages of sexual networks with different risks [15–19]. Research on sexual bridging in the developing world has been limited to concentrated epidemics among MSM in Asia and South America, where the focus is on HIV transmission from beyond a higher-prevalence key population into the lower-prevalence general population [18, 20–25]. Published studies exploring the implications of sexual bridging in SSA are non-existent and research has focused on unprotected intercourse between MSMW and their male and female partners [26, 27]. Although this provides useful information as a proxy for potential sexual bridging, African studies have not explored key factors that increase the risk of HIV transmission or acquisition from both male and female partners, including preferred anal sex role with male partners (insertive or receptive) and circumcision status.

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Unprotected anal sex is the most efficient means of sexual HIV transmission and role preference has public health significance with a lower HIV acquisition risk for insertive partners and a higher acquisition risk for receptive partners [28–33]. MSM in one study had approximately a ten-fold higher risk of infection as the receptive HIV-uninfected partner compared to the insertive partner [32]. Circumcision status also deserves consideration in sexual bridging. There are conflicting data about the protective effect of circumcision by anal sex role (circumcision is probably not an effective intervention for insertive MSM and it is not protective for the receptive partner) [29, 34–37]; however, randomized clinical trials showed that male circumcision reduces the risk of heterosexually acquired HIV infection by approximately 60% [38–40].

In Mozambique, an integrated biological and behavioral survey (IBBS) of MSM documented that in the country's three largest urban areas a considerable proportion of MSM (36.2–63.0%) also had sex with women [41]. This finding prompted our analysis of the potential HIV transmission risk from MSM to female partners and from female partners to MSM taking HIV prevalence in each group, anal sex role with male partners and circumcision status into consideration.

Methods

Study Design and Population

The Mozambique IBBS methods have been described comprehensively elsewhere [42]. In brief, we conducted cross-sectional surveys using respondent-driven sampling (RDS) between July and November 2011 in three sites: Maputo, Beira and Nampula/Nacala. MSM were eligible to participate in the study if they: were 18 years of age or older; engaged in oral or anal sex with another male in the past 12 months; lived, worked or socialized in one of the areas in the past 6 months; possessed a valid referral coupon given to them by a peer; and had not previously participated in the study.

Study Procedures

We began RDS in sites with the purposeful selection of "seeds," or initial participants [42]. These seeds completed the survey and were instructed to refer three MSM from their social networks. The MSM recruited by seeds formed the first wave of recruitment and were also instructed to refer three to five MSM. Recruitment continued in this manner with a goal of enrolling 500 eligible MSM in each site. Sample size calculations assumed a design effect of 2.0.

Study staff screened potential participants for eligibility before an interviewer administered a computer-assisted survey. The standardized survey was adapted from other African MSM study questionnaires and contained the following domains: demographics, sexual history, condom use, healthcare access, healthcare-seeking behavior, and alcohol/drug use [43]. Circumcision status was self-reported using a visual aid with photographs of circumcised and non-circumcised penises.

After the interview, participants received optional HIV counseling and rapid testing with results returned. Additionally, all participants were asked to provide blood samples for centralized HIV testing. Screening was conducted with Vironostika HIV Uniform II *plus* O (Biomerieux SA, Marcy l'Etoile, France). Reactive samples were confirmed with Murex HIV 1.2.O (Murex Biotech Limited, Kent, Great Britain). Discordant results were retested using Genscreen HIV 1/2 Version 2 (Bio-Rad, Marnes-la-Coquette, France). These test results are reported here.

Measures

This analysis explores the possibility of HIV transmission through sexual bridging either from MSM to women or from women to MSM. Because the greater risk of sexual HIV acquisition in men from men is through receptive anal sex and being uncircumcised poses the greater acquisition risk to men from women, we classified MSM into two mutually exclusive risk categories: (1) uncircumcised men who had only insertive sex with men (i.e., more likely to acquire HIV from vaginal or anal sex with females than from their receptive male partners and potentially transmit HIV to their receptive male partners); and (2) men, regardless of circumcision status, who had any receptive sex (i.e., more likely to acquire HIV from male insertive partners than from female partners and potentially transmit HIV to female partners). Nampula/Nacala data are excluded as there were limited MSM who met these definitions.

Sexual behavior was measured using detailed questions for each of the most recent partners (maximum of five) in the 12 months prior to the survey. Questions included partner type, type of sex, anal sex position, frequency of sex and frequency of condom use.

Statistical Analysis

Survey, coupon distribution and HIV result data were merged into a single database; however, each of the sites was analyzed independently. The database was verified and cleaned using R version 2.15 (R Core Team, Vienna, Austria). The current sub-analyses were conducted using SAS version 9.3 (SAS Institute, Cary, North Carolina) and RDS Analyst (RDSA) version 1.7 [44]. RDS-adjusted

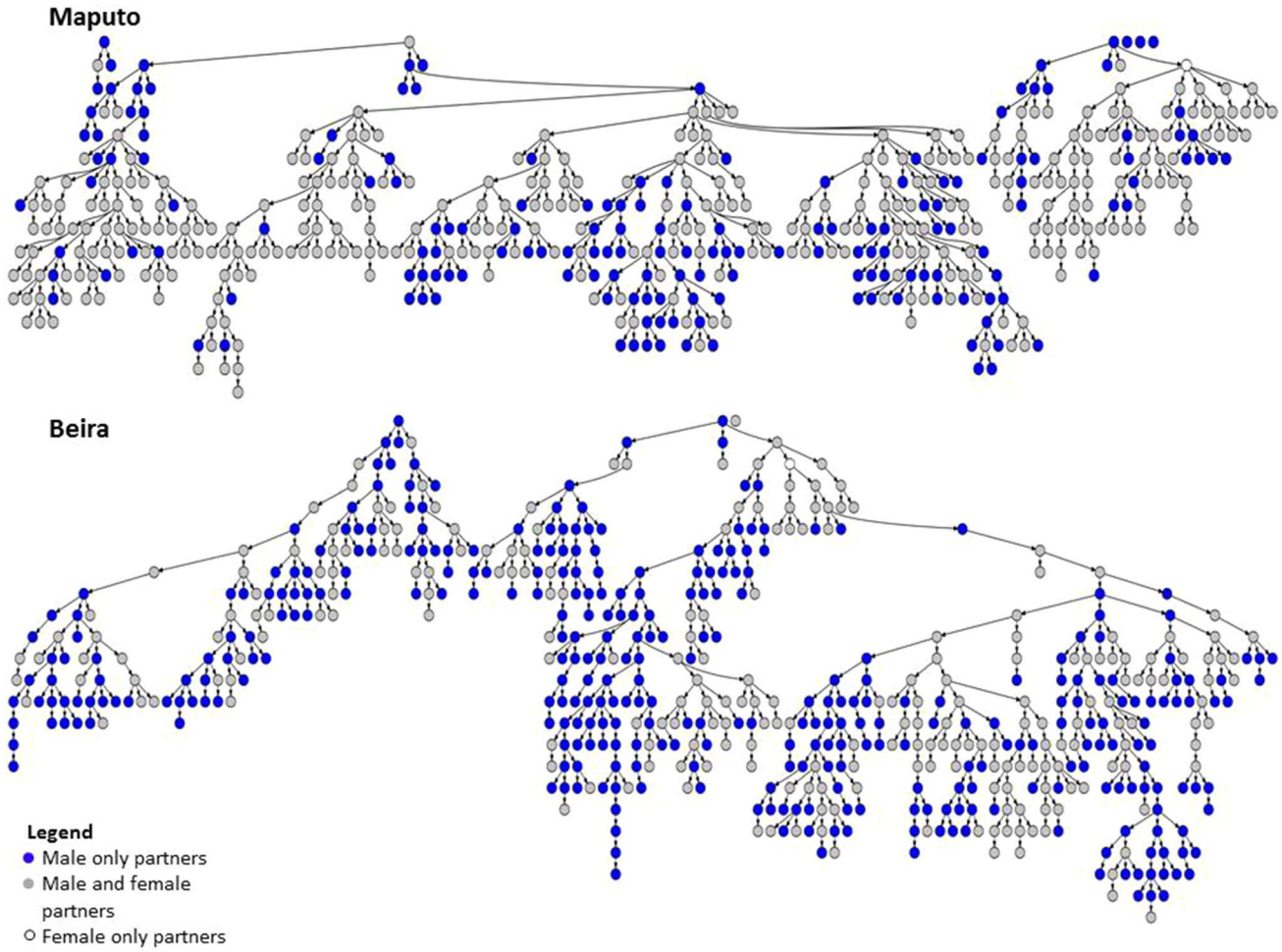

Fig. 1 Recruitment tree plot by gender of sexual partners of men who have sex with men in Maputo and Beira, Mozambique, 2011

analyses utilized the RDS-II estimator included in RDSA. We report unadjusted and RDS-adjusted demographic and behavioral characteristics by study site. We use unadjusted data for analyses of sub-sets of the entire study database, including MSM who had any receptive sex with men, and those who only were the insertive partner. Sub-sets do not retain the recruitment links necessary for RDS adjustment (i.e., too many recruiter-recruit links are broken when examining the smaller number of MSM by sub-groups). We used the χ^2 test to detect associations between selected demographic/risk characteristics and being a receptive or uncircumcised insertive MSM for both RDS-adjusted and unadjusted analyses. Both RDS-adjusted and unadjusted proportions appear in each table. Results described below are RDS-adjusted analyses, unless otherwise noted.

Incentives, Ethical Review and Approval

Participants received an HIV prevention kit, mobile phone credit to assist with recruitment and transportation reimbursement as a primary incentive (valued at ~ $8 USD) and additional mobile phone credit (~ $2 USD) as a secondary incentive for each eligible peer referred and enrolled in the study. Participants provided written informed consent. The study was approved by the National Bioethics Committee for Health of Mozambique, the Committee on Human Research of the University of California, San Francisco, and the Center for Global Health in the Centers for Disease Control and Prevention.

Results

Recruitment lasted 18 weeks and began with six seeds in Maputo and three in Beira; coupon return rates were 20 and 39%, respectively. MSM with coupons were screened for

Table 1 Unweighted and RDS weighted demographic characteristics and circumcision status, men who have sex with men (MSM) in Maputo and Beira, Mozambique, 2011

Variable	Maputo (n = 496)				Beira (n = 583)			
	Crude		Weighted[a]		Crude		Weighted[a]	
	N	%	%	95% CI	N	%	%	95% CI
Age								
18–19	176	35.5	36.2	31.3, 41.1	200	34.3	37.9	34.5, 41.4
20–24	209	42.1	43.9	40.5, 47.4	256	43.9	42.4	34.9, 49.8
25–29	74	14.9	12.6	6.3, 18.9	92	15.8	15.1	10.8, 19.4
≧ 30	37	7.5	7.3	0, 14.6	35	6.0	4.6	0, 10.3
Gender								
Male	489	98.6	99.4	98.9, 99.8	580	99.5	99.2	98.3, 100.0
Female/transgender	7	1.4	0.6	0.16, 1.1	3	0.5	0.8	0.8, 1.7
Educational level								
None/primary	73	14.7	17.4	13.4, 21.3	57	9.8	9.7	6.5, 12.8
Secondary	383	77.2	74.5	69.4, 79.6	471	80.8	83.2	79.3, 87.1
Post-secondary	40	8.06	8.1	3.7, 12.5	55	9.4	7.1	4.5, 9.5
Religion								
Christian	411	82.9	82.6	80.0, 85.2	486	83.4	83.4	79.4, 87.4
Muslim	35	7.1	7.9	4.1, 11.9	45	7.7	8.2	5.1, 11.2
Other	50	10.1	9.4	6.2, 12.5	52	8.9	8.4	5.5, 11.3
Employment past 12 months								
Yes	327	65.9	66.4	60.9, 71.9	302	51.8	46.3	40.9, 51.6
No	169	34.1	33.6	28.1, 39.1	281	48.2	53.7	48.4, 87.4
Homosexual/gay	140	28.2	19.1	17.0, 21.3	307	52.7	51.4	45.7,57.1
Bisexual	240	48.4	52.5	48.6, 56.4	197	33.8	32.1	29.4, 34.8
Heterosexual	65	13.1	18.7	12.7, 24.7	29	4.9	6.1	3.6, 8.6
Other	51	10.3	9.6	4.1, 15.1	50	8.6	10.4	4.3, 16.5
Circumcision								
Yes	312	62.9	58.6	52.5, 64.8	265	45.5	43.5	38.2, 48.8
No	184	37.1	41.4	35.2, 47.5	318	54.6	56.5	51.2, 61.8
HIV status								
HIV+	50	10.1	8.4	3.2, 13.5	53	9.1	10.2	6.8, 13.5
HIV−	397	80.0	82.7	78.0, 87.4	528	90.6	89.7	86.4, 93.1
Missing[b]	49	9.9	8.9	5.5, 12.4	2	0.3	0.1	0, 0.2

[a]RDS-II estimator

[b]Refused to provide dried-blood spot for HIV testing

eligibility resulting in 496 enrolled participants in Maputo and 583 in Beira. Figure 1 depicts recruitment based on the sex of partners in the prior 12 months. The median participant age was 22 years in Maputo and 21 years in Beira. The majority of MSM in both Maputo (82.6%) and Beira (90.3%) had completed high school/secondary education or higher; however, greater than one-third of MSM in Maputo and half in Beira were unemployed. More than half (52.5%) of MSM in Maputo and nearly one-third (32.1%) in Beira identified as bisexual; 19.1% of MSM in Maputo and 51.4% in Beira identified as gay/homosexual. Circumcised MSM comprised 58.6% of the MSM population in Maputo and 45.5% in Beira. In our study, 8.4% (95% CI 3.2–13.5) of MSM in Maputo and 10.2% (95% CI 6.8–13.5) in Beira were HIV-infected compared to 12.3% of 15–49-year-old males in Maputo City and 12.6% in Sofala Province, where Beira is the provincial seat and largest city [45]. Key demographics are presented in Table 1. The estimated population size of MSM in Maputo was 10,121 (1.5% of adult men) and 2624 in Beira (1.8% of adult men) [46].

In Maputo, 75.7% of MSM had both male and female partners in the 3 months prior to the survey while 42.2% of MSM in Beira had partners of both sexes (see Table 2). Greater than 90% of participants in both sites had more than one male partner in the past 12 months compared to 75.5 and 47.6% with more than one female partner during the same period in Maputo and Beira, respectively. We estimate that 70.2% of MSM in Maputo and 59.5% in Beira were

Table 2 Unweighted and RDS weighted behavioral characteristics, men who have sex with men (MSM) in Maputo and Beira, Mozambique, 2011

Variable	Maputo (n = 496)				Beira (n = 583)			
	Crude		Weighted[a]		Crude		Weighted[a]	
	N	%	%	95% CI	N	%	%	95% CI
Gender of partners past 3 months								
Male only	169	34.1	23.9	19.7, 28.3	345	59.2	57.8	57.2, 58.5
Female only	1	0.2	0.3	0, 0.9	1	0.2	0	-
Both	326	65.7	75.7	71.3, 80.1	237	40.7	42.2	42.2, 42.2
None	0	0	0	0	0	0	0	-
Number of male partners past 12 months (anal sex)								
0	35	7.1	9.5	4.1, 14.9	6	1.0	0.8	0, 5.1
1	249	50.2	54.4	50.7, 58.3	301	51.6	54.1	48.9, 59.3
2	134	27.0	25.0	18.7, 31.2	162	27.8	27.8	26.6, 28.9
≧ 3	78	15.7	11.1	7.0, 15.1	114	19.6	17.3	11.9, 22.6
Number of female partners past 12 months (vaginal/anal sex)								
0	164	33.1	24.6	18.2, 29.9	308	52.8	52.4	47.4, 57.3
1	107	21.6	22.2	16.9, 27.4	140	24.0	27.0	23.2, 30.7
2	121	24.4	29.6	24.4, 34.8	51	8.8	9.1	4.5, 13.8
≧ 3	104	20.9	23.7	18.7, 28.6	84	14.4	11.5	4.9, 18.0
Anal sex role with men								
Exclusively receptive	39	7.9	5.6	2.7, 8.5	31	5.3	5.7	0, 11.5
Either receptive or insertive	107	21.6	15.2	11.1, 19.2	170	29.2	30.4	26.8, 33.9
Exclusively insertive	311	62.7	70.2	66.7, 73.7	337	57.8	59.5	56.6, 62.5
N/A	39	7.9	9.0	3.2, 17.8	45	7.7	4.4	0, 9.4
Prior 5 sex partners								
Had IAI with men	481	96.9	85.4	80.9, 89.9	507	86.9	89.9	85.9, 93.9
Had UIAIM	153	30.8	30.5	24.9, 36.1	145	24.9	27.4	22.5, 32.3
Had RAI	146	29.4	20.8	13.6, 27.9	201	34.5	36.0	30.7, 41.4
Had URAI	62	12.5	9.6	6.2, 13.0	60	10.3	12.1	8.0, 16.1
Had IVI	308	62.1	71.9	66.3, 77.5	190	32.6	36.7	31.4, 41.9
Had UIVI	199	40.1	48.7	42.5, 55.2	74	12.7	12.7	8.9, 16.5
Had IAI with women	123	24.8	26.4	21.3, 31.4	57	9.8	9.6	6.3, 12.9
Had UIAIW	55	11.1	11.0	7.5, 14.5	16	2.7	3.1	1.2, 5.1
MSM, uncircumcised and exclusively insertive	111	22.4	27.7	21.1, 34.2	191	32.8	33.6	28.2, 38.9
MSM and had any receptive sex with men	146	29.4	20.8	15.8, 25.7	201	34.5	36.0	30.9, 41.2

IAI insertive anal intercourse, *UIAIM* unprotected insertive anal intercourse with men, *RAI* receptive anal intercourse, *URAI* unprotected receptive anal intercourse, *IVI* insertive vaginal intercourse, *UIVI* unprotected insertive vaginal intercourse, *UIAIW* unprotected insertive anal intercourse with women

[a]RDS-II estimator

exclusively insertive partners with other males in the prior 12 months; 5.6% of MSM in Maputo and 5.7% in Beira were exclusively receptive with their male partners. Unprotected intercourse was common: 30.5% of MSM in Maputo and 27.4% in Beira had unprotected insertive anal intercourse with men (UIAIM) and 48.7% of MSM in Maputo and 12.7% in Beira had unprotected vaginal intercourse (UVI) in the prior 12 months. Unprotected, receptive anal intercourse (URAI) and unprotected anal intercourse with women (UAIW) occurred less frequently in both sites. Focusing on our primary analysis, 27.7% of MSM in Maputo and 33.6% in Beira were uncircumcised and exclusively insertive partners with men and had vaginal or anal sex with women; whereas 20.8% of MSM in Maputo and 36.0% in Beira had any receptive anal sex.

In Maputo, an almost equal proportion of receptive and uncircumcised, exclusively insertive MSM were between the ages of 18–24 years (76.1% vs. 79.2%) ($\chi^2 = 0.6$, $p = 0.9$) (as shown in Table 3). The majority of receptive MSM identified as gay/homosexual (53.4%) compared to uncircumcised insertive MSM who largely identified as bisexual (56.7%) ($\chi^2 = 45.6$, $p < 0.0001$). Among receptive MSM, 42.5% had both male and female partners in the prior three months, while 83.8% of uncircumcised insertive MSM had sexual

Table 3 Unweighted demographic and risk variable comparison of men who have sex with men (MSM) that had any receptive sex with men and those that were uncircumcised and had exclusively insertive sex with men in Maputo and Beira, Mozambique, 2011

Variable	Maputo (n = 257)					Beira (n = 392)				
	Receptive (n = 146)		Uncircumcised insertive (n = 111)			Receptive (n = 201)		Uncircumcised insertive (n = 191)		
	N	%	N	%	χ^2, p	N	%	N	%	χ^2, p
Age					0.6, 0.9					10.8, 0.01
18–19	48	32.9	40	36.0		75	37.3	49	25.7	
20–24	63	43.2	48	43.2		85	42.3	97	50.8	
25–29	23	15.8	16	14.4		23	11.4	35	18.3	
≧30	12	8.2	7	6.3		18	8.9	10	5.2	
Gender					2.5, 0.1					0.2 (Fisher's exact)
Male	140	95.9	110	99.1		198	98.5	191	100.0	
Female/transgender	6	4.1	1	0.9		3	1.5	0	0	
Educational level					14.4, 0.0008					0.12, 0.9
None/primary	14	9.6	28	25.2		21	105	18	9.4	
Middle	116	79.5	79	71.2		167	83.1	160	83.8	
Superior	16	10.9	4	3.6		13	6.5	13	6.8	
Religion					3.5, 0.2					6.1, 0.04
Christian	117	80.1	96	86.5		163	81.1	164	85.9	
Muslim	14	9.6	4	3.6		20	9.9	7	3.7	
Other	15	10.3	11	9.9		18	8.9	20	10.5	
Employment, past 12 months					2.9, 0.09					1.3, 0.3
Yes	89	60.9	79	71.2		100	49.8	106	55.5	
No	57	39.0	32	28.8		101	50.3	85	44.5	
Sexual orientation					45.6, < 0.0001					5.9, 0.1
Homosexual/gay	78	53.4	19	17.1		121	60.2	97	50.8	
Bisexual	46	31.5	63	56.7		46	22.9	64	33.5	
Heterosexual	6	4.1	21	18.9		10	4.9	11	5.8	
Other	16	10.9	8	7.2		24	11.9	19	9.9	
Female partners past 12 months (vaginal/anal sex)					47.9, < 0.0001					6.1, 0.1
0	83	56.9	18	16.2		124	61.7	95	49.7	
1	30	20.6	30	27.0		39	19.4	45	23.6	
2	19	13.0	31	27.9		19	9.5	23	12.0	
≧ 3	14	9.6	32	28.8		19	9.5	28	15.7	
Male partners past 12 months (anal sex)					7.5, 0.06					
0	3	2.1	2	1.8		0	0	3	1.6	
1	58	39.7	62	55.9		82	40.8	107	56.0	13.7, 0.003
2	45	30.8	29	26.1		65	32.3	48	25.1	
≧ 3	40	27.4	18	16.2		54	26.9	33	17.3	
Gender of partners past 3 months					44.9, < 0.0001					6.1, 0.01
Male only	84	57.5	18	16.2		133	66.2	103	53.9	
Female only	–	–	–	–		–	–	–	–	
Both	62	42.5	93	83.8		68	33.8	88	46.1	
HIV status					4.1, 0.13					0.6, 0.4
HIV+	24	16.4	9	8.1		25	12.4	19	9.9	
HIV-	109	74.7	89	80.2		176	87.6	172	90.1	
Missing[a]	13	8.9	13	11.7		–		–	–	

[a]Refused to provide dried-blood spot for HIV testing

partners of both sexes ($\chi^2 = 44.9$, $p < 0.0001$). More receptive MSM reported zero female partners (56.9%) or one (20.6%) in the past 12 months, whereas 83.7% of uncircumcised insertive MSM reported at least one female partner, of which 27.9% had two female partners and 28.8% had three or more female partners in the prior 12 months ($\chi^2 = 47.9$, $p < 0.0001$). Receptive MSM were more likely to have two or more male partners in the past 12 months (58.2%) compared to uncircumcised insertive MSM (42.3%) ($\chi^2 = 7.5$, $p = 0.06$). HIV prevalence in Maputo was 16.4% among receptive MSM and 8.1% among uncircumcised insertive MSM ($\chi^2 = 4.1$, $p = 0.13$).

In Beira, nearly equal proportions of receptive and uncircumcised insertive MSM were 24 years or younger (79.6% vs. 76.5%) ($\chi^2 = 10.8$, $p = 0.01$) and self-identified as either gay/homosexual or bisexual (83.1% vs. 84.3%) ($\chi^2 = 5.9$, $p = 0.1$). More receptive MSM (66.2%) reported only male partners compared to 53.9% of uncircumcised insertive MSM; however, greater than one-third had both male and female sex partners three months prior ($\chi^2 = 6.1$, $p = 0.1$). Receptive MSM were more likely to have two or more male partners in the past 12 months (59.2%) compared to uncircumcised insertive men (42.4%) ($\chi^2 = 13.7$, $p = 0.003$), and 50% or more of MSM reported that they did not have any female partners during the same period. The difference in HIV prevalence between the two groups in Beira, 12.4% for receptive MSM and 9.9% for uncircumcised insertive MSM, was not statistically significant ($\chi^2 = 0.6$, $p = 0.4$).

Table 4 describes the number of unprotected sexual acts in the prior 12 months by role preference and circumcision status, representing 82.7 and 89.2% of all sexual encounters for our subset of MSM in Maputo and Beira, respectively. The 146 receptive MSM in Maputo had 1175 (mean = 8.0) unprotected sexual acts and, of these, 76.2% were with men (n = 895, mean = 6.1). Receptive MSM had a significantly greater mean number of unprotected sexual acts with males than either uncircumcised insertive MSM or all MSM in the larger study (F = 5.4, $p = 0.005$). However, nearly 25% (n = 280, mean = 1.9) of their unprotected sexual acts were with female partners, including 6% (not shown) that were anal. Of the 111 uncircumcised insertive MSM in Maputo, there were 1371 (mean = 12.4) unprotected sexual acts in the previous 12 months. This represents a higher, although not significant, average, of unprotected sex than either receptive MSM or all MSM. Uncircumcised insertive MSM also had a significantly higher proportion (84.5%) and number of unprotected sex acts with females (n = 1159, mean = 10.4) (F = 3.6, $p = 0.03$), with 0.8% of these (not shown) anal. Beira receptive MSM had 958 unprotected sexual acts, 72.2% (n = 692, mean = 3.4) with men. This was significantly more than uncircumcised insertive MSM and all MSM (F = 6.6, $p = 0.001$). The remaining unprotected sexual acts with female partners (27.8%) included 21% (not shown) that were anal. Uncircumcised insertive MSM in Beira had 778 total unprotected sexual acts, including 77.1% (n = 600, mean = 3.1) with women; 11% were anal (not shown). Figure 2 illustrates the relative frequency of unprotected sexual acts.

Discussion

Our analysis explored behaviors and associated risk for HIV transmission or acquisition among receptive MSM and uncircumcised, exclusively insertive MSM to assess potential sexual bridging with females in two Mozambican cities. Our findings suggest that sexual bridging may vary geographically with differences in the "width" of the bridge

Table 4 Unprotected sex acts of MSM with female and male partners by anal sex role and circumcision status, Maputo and Beira, Mozambique, 2011

Population	Total unprotected		Unprotected with females		Unprotected with males	
	N	Mean (SD)	N (%)	Mean (SD)	N (%)	Mean (SD)
Maputo						
All MSM (n = 496)	4272	8.6 (30.0)	2999 (70.2)	6.0 (25.6)	1273 (29.8)	2.6 (16.0)
Uncircumcised, exclusively insertive MSMW (n = 111)	1371	12.4 (35.3)	1159 (84.5)	10.4 (34.5)	212 (15.5)	1.9 (7.2)
Ever receptive MSMW (n = 146)	1175	8.0 (26.7)	280 (23.8)	1.9 (9.5)	895 (76.2)	6.1 (28.5)
		F 1.1, $p = 0.3$		F 3.6, $p = 0.03$		F 5.4, $p = 0.005$
Beira						
All MSM n = 583	2793	4.8 (19.9)	1780 (63.7)	3.0 (18.2)	1033 (36.9)	1.8 (8.1)
Uncircumcised exclusively insertive MSMW (n = 191)	778	4.1 (16.3)	600 (77.1)	3.1(16.1)	178 (22.8)	0.9 (2.2)
Ever receptive MSMW (n = 201)	958	4.8 (15.9)	266 (27.8)	1.3 (8.7)	692 (72.2)	3.4 (13.2)
		F 2.1, $p = 0.8$		F 1.7, $p = 0.2$		F 6.6, $p = 0.001$

F tests and p values are for comparison between uncircumcised, exclusively insertive MSMW and ever receptive MSM, by type of unprotected sex act

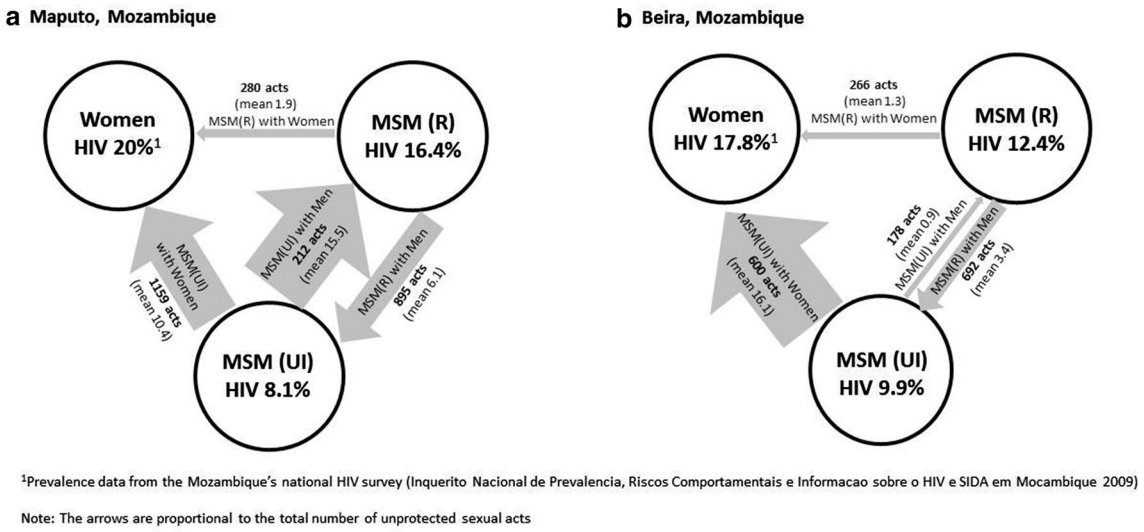

Fig. 2 Unprotected sex acts across the bi-sexual bridge among MSM in Maputo and Beira, Mozambique, 2011

between MSM and women in the general, Mozambican population. Sexual bridging also is likely bi-directional, occurring within a generalized epidemic where HIV prevalence of reproductive-age women is higher than MSM. Mozambique's latest National AIDS Indicator Survey (2009) reported women 15–49 years in Maputo Province had a 20% HIV prevalence, which is substantially higher than the 8.1% prevalence for uncircumcised insertive MSM in this study [45]. In Sofala Province, prevalence was 17.8% among 15–49-year-old women in contrast to 9.9% for uncircumcised insertive MSM in Beira. Low circumcision among MSM contributes to heterosexual acquisition risk. In Maputo, uncircumcised insertive MSM have frequent unprotected sex with females from a population with considerably higher HIV prevalence, resulting in a greater risk of HIV acquisition without the partial protection of circumcision. Subsequently, uncircumcised insertive MSM potentially transmit HIV to Maputo receptive MSM who in turn use condoms < 25% of the time with their female partners. In Beira, which also has a higher background prevalence for reproductive-age women, uncircumcised insertive MSM have more unprotected sex with females than with male partners. Alternatively, receptive MSM have more unprotected sex with males and possibly infect their female partners. Collectively, these data demonstrate that the greater risk of HIV sexual bridging is to uncircumcised insertive MSM in Maputo from female partners and from receptive MSM in Beira to female partners. The width of the bridge is "wider" in Maputo and statistically significant. In Beira, the bridge is "narrower" and not statistically significant.

This interpretation is strengthened by data describing unprotected sex among MSM in Maputo and Beira which ranged from 22.8 to 76.2% with male partners and 23.8–77.1% with females. In both cities, uncircumcised insertive MSM had more unprotected sex with females and receptive MSM had more unprotected sex with male partners. Intercourse with females also included unprotected anal sex, which was reported more frequently in Beira and by receptive MSM. This is concerning given the HIV prevalence in our sample and the efficiency of anal HIV transmission.

We also observed risks based on the mixing of male and female sexual partners, which contributes to potential sexual bridging. In the three months prior to the study, 33.8–83.8% of all MSM in Maputo and Beira had both male and female sexual partners. The fluidity of partnering across sexes, combined with the number of sexual partners and frequency of unprotected sexual acts, may facilitate the transmission and acquisition of HIV among MSM and their male and female partners, particularly in Maputo.

We recognize our study's limitations. The sample was not necessarily representative of all Mozambican MSM. Unweighted analysis suggests that younger and more educated MSM are overrepresented. Further, observed differences in Maputo and Beira may be a result of recruitment that accessed different MSM networks with varying behavioral risks. Social desirability bias may have resulted in under-reported risk behaviors and over-reported condom use. Recall bias may have been another factor in misreporting of sexual partnerships and details. Participants also self-reported their circumcision status, possibly resulting in misclassification. Additionally, our analysis did not include the HIV status of partners, which potentially misrepresented risk.

Despite these limitations, our results are the product of rigorous recruitment and data analysis that highlight HIV

infection risk both to female partners of MSM and to MSM from female partners. The risk of bridging observed in Maputo and Beira is consistent with study findings reported from other countries. Specifically, the overlap of both male and female sexual partners during the study reporting periods and frequent unprotected sex, particularly with female partners, also have been noted in China, India, Thailand, Peru and various cities in the United States [47–52]. The majority of these bridging studies were conducted in locations where or among populations in which homosexuality is highly stigmatized or criminalized, as it is in Mozambique. This socio-cultural similarity may encourage MSM in all of the locations to hide their sexuality, placing them and their partners at greater risk of HIV acquisition and transmission. Our data underscore a need for targeted interventions to address the complex sexual relationships of Mozambican MSM, tailored by sexual identity and role preference. Communication targeting Mozambican MSM should accurately and clearly articulate risk: the indirect risk posed to female partners (including wives and girlfriends) through unprotected anal sex with MSM, particularly men who were receptive partners with other men; and the risk posed by unprotected sex with female partners in high HIV prevalence settings. In both circumstances, there are erroneous beliefs that may explain our findings. A qualitative study conducted in Maputo found that some MSM believe HIV infection occurs only through vaginal sex with a woman and not anal intercourse with a man [53]. Given documented misperceptions, our data emphasize the need to strengthen evidence-based, HIV prevention interventions. Correct and consistent condom and water-based lubricant use for any anal and vaginal sex must be stressed as part of comprehensive services for MSM. Although there is no clear evidence supporting a protective effect for MSM, promoting circumcision for bisexual men is important given their number of female sexual partners, higher prevalence of HIV among women, unclear role preferences and low coverage of circumcision in Mozambique. This is particularly so in Maputo where we found a greater likelihood that females transmit HIV to MSM and a high proportion of uncircumcised insertive MSM who would benefit from the partial protection of HIV acquisition from female partners.

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