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Journal of Community Medicine

Open Access | Research Article

Social and structural vulnerability to HIV infection in Uganda: A multilevel modelling of AIDS indicators survey data, 2004-2005 and 2011

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Received: Jul 16, 2018

Accepted: Sep 20, 2018

Published Online: Sep 26, 2018

Journal: Journal of Community Medicine

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Keywords: Uganda; Social-structural; Multi-level modelling; Vulnerability; HIV/AIDS

Abstract

Introduction: Sub Saharan Africa (SSA) continues to exhibit inequalities in HIV epidemic. As of 2017, about 69.5% of people living with HIV, 64% of new infections and 73% HIV-related deaths were in SSA. Most HIV research conducted in the continent has focused on individual-level factors.

Objectives: This research identifies social and structural factors that increase vulnerability to HIV; and estimates the effect of community-level factors in increasing vulnerability to HIV infection.

Methods: Multilevel binary logistic regression is applied to 39,766 individual cases with HIV test results obtained in 887 clusters of Uganda HIV/AIDS Indicators Survey conducted in 2004-2005 and 2011.

Findings: After controlling for individual-level factors, living in a community with a higher proportion of wealthy households (Average Odds Ratio=1.07, CI [1.03–1.11], with more former married individuals (AOR=1.21, CI [1.09–1.33]), with a higher proportion of people drunk with alcohol before unsafe sex (AOR=1.11, CI [1.05–1.18]), and living in a community where a higher proportion of people believe it is okay for a woman to ask her sexual partner to use a condom (AOR=1.08, CI [1.02–1.15]) was significantly associated with being HIV positive. However, living in a community where a higher proportion of men practiced polygamy was associated with reduced vulnerability to the risk of HIV infection (AOR=0.91, CI [0.85–0.98]).

Conclusion: Community factors influence vulnerability to the risk of HIV infection in Uganda. Immediate efforts to prevent HIV infection need to focus on community awareness about the influence of these factors, and long-term efforts need to address the broader determinants of these practices.

Cite this article: Igulot P, Magadi MA. Social and structural vulnerability to HIV infection in Uganda: A multilevel modelling of AIDS indicators survey data, 2004-2005 and 2011. J Community Med. 2018; 2: 1008.

Introduction

The response to HIV/AIDS has been dominated by the individual oriented paradigm [1,2]. The individualistic paradigm views HIV infection risk as a responsibility of the individual. Therefore, to prevent HIV infection, it was necessary to change the (sexual) behaviour of individuals [3,4]. However, much as these interventions have undoubtedly played a major role in the HIV/AIDS response [5], they have been criticized [6]. Critiques argue that an individually oriented HIV response fails to recognize the societal dimensions of vulnerability to HIV infection [7,8].

Structural factors have been defined as "characteristics of the social, economic, legal, and cultural environment that act as determinants of HIV risk for whole populations and how risk is distributed within populations" [5]. Others define structural factors as all those conditions that are beyond the control of the individual but which have influence on the individual. Structural factors can be distinguished into social and structural factors. Social factors are those which include relationships and networks while structural factors are the institutional or patterned social arrangements [2,9].

Social factors

Relationships, especially marital ones, are some of the chief social mechanisms through which people are vulnerable to the risk of HIV infection [10]. Historically, marriage in Africa was enacted for social, economic, and to some extent, political reasons [11]. In a context characterized by lack of opportunities, marriage was the institution through which people's aspirations were objectified and was a pre-condition for adulthood [12] and manhood [13]. Women particularly married to be *cared for* and to have *children* while her family benefited *socially* and *economically* from the new marriage ties [11]. In this arrangement which was based on a patriarchal system, men, unlike women, had *sexual freedom, resources*, and *power* [13,14]. However, in the last five decades or so, conditions have interfered with this structure. For example, marriage has become costly, economic hardships are rampant, modern life is expensive, and men's masculinity, power, and freedom have been *challenged* [14-17]. This social conflict characterizes marital HIV vulnerability [18].

Whereas marriage is still valued, *poverty* is prohibiting young men from marrying [16]. Hunter reports that 80 percent of young African men in South Africa were never married compared to economically better off white men [13]. Marston et al. report that 50% men and women aged 40–44 years in South Africa were never married [19]. The failure of men to marry has made unmarried women to be a destabilizing factor in marriages [17,20]. For instance, among Meru women in northern Tanzania, unmarried women prefer married men. This is well captured by this quote: "the best 'projects' for these women are those married and relatively wealthy men since they can provide more than young and poor men still saving to marry…" [20]. Polygamy which was *formal* is now discouraged and less practiced but married men continue with it in *secretive* and in *risky* ways [17,20]. Widow inheritance [1] which was an alternative marital avenue, is on the decline [21], further narrowing 'opportunities' for widows to get socio-economic support [22].

For men, *high social status* was exhibited by the amount of economic resources, and *women* and children that they had [13,20]. Today, men, especially married ones, desirous to defend their masculinity, continue procuring extra-marital relationships to demonstrate their social status [14]. Previously, men exercised *absolute control* over their wives, but now, this power has been weakened by the Laws on women's rights, which has caused men to be '*frustrated*' [13,14]. Men have also reacted to the loss of control over women by engaging in extra-marital relationships with women who can be *subservient* [17]. Men used to adequately provide for the mainly *basic* needs of their families, but now, men cannot adequately meet the *modern* and *multiple* needs of their families. This is the new *reality* under which vulnerability to the risk of HIV infection is being constructed in Uganda and SSA more widely [23].

Other factors that have been associated with HIV vulnerability are community attitudes towards women's control of their sexuality and general empowerment of women, and polygamy. Negative attitudes and patriarchal power have been reported to limit women's ability to negotiate safer sex and protect themselves from HIV [24,25]. Therefore, positive community attitudes towards women's ability to negotiate safer sex with their spouses should be associated with less vulnerability. Polygamy is an important aspect to study, given the debate around multiple sexual practice and sexual concurrency. As a traditional practice, some people argue that it constitutes an HIV vulnerability practice [26,27]. However, cutting-edge micro and macro-level research has shown that polygamy is negatively associated with HIV vulnerability in SSA [21,28]. More evidence is thus needed to shed light on these social practices.

Structural factors

Alcohol use and abuse is another factor that is understood to be correlated with HIV. Alcohol is associated with domestic violence which triggers practices that increase the risk of HIV infection [29,30]. Poverty as well as wealth, level of educational attainment, peer influence, and having older sexual partners, are some of the mechanisms which precipitate alcohol use [31]. In a review study of young people aged 15–24 years in eastern Africa, Francis et al [32]. report high ever use of alcohol among female sex workers and high current use of alcohol among male sex workers, which corroborates available evidence that alcohol use among commercial sex workers enhances their vulnerability to HIV infection. In a study of 18–44-year-old Tanzanian women engaged in the food and leisure industries, high alcohol use among women was associated with engaging in multiple sexual partnerships and in transactional sex [30]. But the problems of alcohol are structured by politics, economic policies, especially taxation and corporate interests [33,34].

Whereas the role of socio-structural factors is evident, the evidence demonstrating the mechanisms through which they operate is weak [1]. Heisi and Watts for instance argue that despite the acknowledgement of the role of societal factors, scholars and researchers only theorize the pathways through which they are linked to HIV vulnerability [8]. In addition, studies that have investigated socio-structural conditions of vulnerability to HIV in SSA remain limited [35-38]. None of these studies were conducted in Uganda, a country which used to be a global model in the response to HIV/AIDS, but progress has stalled or reversed, with recent national trends showing a rise in HIV prevalence for both men and women [39]. It is in view of this deficiency that this research sets out:

1. To identify community-level social and structural factors that are associated with increased vulnerability to the risk of HIV infection;

2. To estimate the effect of community-level factors in in-

creasing vulnerability to the risk of HIV infection.

Data and methods of analysis

Data

This research is based on secondary analysis of Uganda AIDS Indictors Survey (AIS) conducted in 2004–2005 and in 2011. AIDS Indicator Surveys are part of the Demographic and Health Survey (DHS), an international programme championed by USAID to collect standard demographic and health data in over 80 developing countries [40]. They are standardized to facilitate international comparison. These household-based surveys adopt a two-stage sampling design involving a random selection of clusters (primary sampling units), followed with systematic selection of households within selected clusters. Community as used in this paper refers to clusters. All women of reproductive age (15–49 years) and men aged 15–59 years were eligible to be interviewed and tested for HIV. Further details of Uganda AIS design are available elsewhere [39]. The household response rate was 97.9 percent; that for women was 96.3 percent and that for men was 92.6 percent. Uganda has conducted two AIS, in 2004-2005 and 2011.

Study variables

We first dichotomized the variables analyzed at individual level, before deriving contextual community-level measures based on the proportion of individuals in the community with specific characteristics. For example, current marital status had 4 categories: never been in any sexual union (0); married/living with partner (1); widowed (2); and separated/divorced (3). To establish vulnerability associated with disrupted marriage, we categorized 2 and 3 into 1 and compared it to 0 and 1 categorized 0. Never been in any sexual union and being married are hypothesized to be more protective than disrupted marriages. Multiple sexual partners had 3 categories: 1 partner (0); 2–4 partners (1); and 5 or more partners (2). To predict vulnerability associated with many partners, we re-categorized 1–2 into 1 and 0 into 0. We then predict the likelihood of being infected with HIV for those with 2 or more partners. The list of all variables transformed is contained in Annex 1.

Methods of analysis

We began analysis by exploring the general characteristics of the sample. We then adjust for other community-level factors and finally for both community- and individual-level factors. We also calculate the overall effect of community factors on HIV vulnerability using the Intra-Cluster Correlation (ICC) coefficient. In modelling, analysis predicts the probability of having HIV, represented by 1, against the probability of not having HIV, which was represented by 0 [35]. An extensive list of covariates is used in this analysis because scholars recommend that including such covariates narrows the confounding effect these factors may have on the relationship between specific factors and HIV infection risk [35,41].

To establish the intra-cluster correlation coefficient, we apply the random level estimates from Table 2 to the formula proposed by Tarling [42] and others.

$$p = \frac{uoj}{(uoj + eij)} \qquad (1)$$

Where *p* is the intra-class correlation, *eij* is variation at level 1, which is represented by 3.29 and *uoj* is variation at level 2.

Research findings

Descriptive findings

We analysed 39,766 individual cases aged 15–49 years (women) and 15–59 years (men) with valid HIV test results (46.3% of overall cases from 2004-5 and 53.7% from 2011 Uganda AIS). Sixty five percent of the respondents were under 35 years of age with a mean age of 30.5 years. Female respondents were 55.6% and 72.9% of the sample had primary or no education. There were 82.7% rural residents and 17.3% urban respondents. The sample depicted the distribution in the general population. The overall prevalence of HIV was 6.9%. It was higher among women (7.3%) and urban areas (8.2%) than among men (5.2%) and in rural areas (6.1%). Prevalence was 6.4% in 2004-2005 but increased to 7.3% in 2011 (data not shown).

Table 1 illustrates HIV prevalence rates by social characteristics. HIV prevalence increases with increase in the number of sexual partners among women, men, in rural and urban areas and was worse among women and in urban areas. Prevalence also varies by type of marriage among women, men, in rural and urban areas. Generally, HIV prevalence decreases with increase in age of first sexual initiation and age of first marriage among women, men and in rural and urban areas. Individuals who drink alcohol and become drunk before unsafe sex and people with STIs and those with more HIV/AIDS knowledge had a higher prevalence of HIV compared to those without. Also, using condoms and having favourable attitudes towards women negotiating condom use was associated with higher HIV rates. The differences in HIV prevalence among polygamous and non-polygamous respondents were minimal.

Table 1: Weighted HIV prevalence by social characteristics, UAIS, 2004-2005 & 2011

Parameters	Women		Men		Rural		Urban	
	%HIV+	Cases	%HIV+	Cases	%HIV+	Cases	%HIV+	Cases
Polygamy	ns		ns		*		ns	
No other wise	6.2	9560	6.4	3589	5.7	11353	9.8	1797
≥1 wife	6.7	3968	7.3	6729	6.5	9252	10.7	1446
Multiple sexual partners	*		*		*		*	
1 partner	4.5	7473	1.7	1840	3.6	8041	6.0	1273
2 - 4 partners	10.0	10168	5.1	6172	7.5	13417	11.1	2924
≥5 partners	19.3	1703	9.2	6867	10.6	6934	14.1	1635

Parameters	Women		Men		Rural		Urban	
	%HIV+	Cases	%HIV+	Cases	%HIV+	Cases	%HIV+	Cases
Age at first sex	ns		ns		ns		ns	
≤15 years	9.6	3303	5.5	1760	7.6	4249	11.1	814
16 - 17 years	8.9	5540	7.0	3480	7.3	7314	12.1	1707
18 - 19 years	8.5	3754	6.7	3727	7.2	6188	9.4	1293
≥20 years	7.1	958	7.6	1616	7.0	2087	9.2	488
Age at first marriage	ns		*		ns		*	
≤15 years	8.7	1858	12.4	266	7.9	1858	18.4	266
16 - 17 years	8.1	4373	7.6	937	7.0	4662	15.3	648
18 - 19 years	9.1	3539	7.0	1961	7.8	4775	12.4	725
≥20 years	10.5	1174	5.2	1310	7.1	2150	11.7	334
Can wife ask condom use?	*		ns		*		ns	
No	5.4	4022	4.2	1059	4.8	4584	8.4	498
Yes	8.2	11767	5.3	6855	6.5	15461	10.2	3160
Condom used at last sex?	*		*		*		ns	
No	6.9	14435	6.1	11188	6.0	21982	9.7	3641
Yes	16.1	1426	9.6	1849	12.4	2167	12.5	1110
Had STI in last 12 months?	*		*		*		*	
No	6.6	18268	4.9	15845	5.4	28306	8.0	5808
Yes	14.4	3235	12.7	1603	13.0	3890	17.1	948
Current marital status	*		*		*		*	
Never been in sex union	3.4	4687	1.4	6120	2.0	8168	3.3	2639
Married/cohabiting	6.4	13858	7.0	10334	6.1	20835	10.1	3358
Formerly married/cohabited	19.3	3463	15.1	1307	16.7	3874	24.6	895
Comprehensive AIDS knowledge	*		*		*		ns	
No knowledge	4.5	690	3.3	577	3.5	1174	9.8	92
Low knowledge	5.0	1622	6.0	1024	4.9	2358	9.0	288
Medium knowledge	6.3	5816	5.1	3819	5.3	8284	9.0	1351
High knowledge	8.9	13880	6.0	12343	7.1	21060	9.5	5162
Drunk with alcohol	*		*		*		*	
No	7.4	11463	5.9	9684	6.2	17203	8.9	3944
Yes	8.5	4390	8.6	3350	7.5	6936	17.4	803
Total	7.8	22008	5.7	17763	6.3	32876	9.4	6893

Unadjusted findings

After describing the sample, we then ran variance models. In UAIS, sexually active respondents were asked, "In total, with how many different people have you had sexual intercourse in your life time?" [39]. From this question, life time sexual partners were categorized into ≤1 = 0 and ≥2 = 1. Figure 1A shows that an increase in the proportion of people with multiple sexual partners in a community is associated with a significant increase in the prevalence of HIV (χ2118.204 [1df] p< 0.001).

Polygamy: there was a positive association between polygamy and being infected with HIV; individuals who were in communities with a high proportion of individuals in a polygamous relationship were more likely to be infected with HIV than those who were not. Figure 1B shows an increase in the proportion of individuals in a community who are in a polygamous relationship was associated with an increase in HIV prevalence, (χ2 152.997 [1df] p < 0.001).

Early marriage: there was a positive association between marrying or cohabiting before making 20 years of age and HIV

prevalence compared to marrying at or after making 20 years of age. Figure 1C shows that when the proportion of people who marry or cohabit before reaching 20 years of age increases in a community, HIV prevalence also increases (χ2156.309 [1df] p < 0.001).

Early sex: there was a positive relationship between early or pre-marital sex in a community and HIV prevalence. Initiation of sex before reaching 18 years of age was associated with higher prevalence compared to initiating sex after reaching 18 years. In Figure 1D, we show that when the proportion of people engaging in pre-marital sex increases in a community, HIV prevalence also increases (χ2151.015 [1df] p < 0.001).

Community attitudes: there was a relationship between positive community attitudes on a woman asking her husband to use condoms when necessary e.g. when she knows that her partner has an STI or is infected with HIV. Figure 1E shows that when the proportion of people having such attitudes increases in a community, HIV prevalence increases (χ2 154.216 [1df] p < 0.001). This was a counter intuitive finding.

Condom use: this research finds a positive relationship between using condoms and being infected with HIV; in communities where people used condoms, individuals were more likely to be infected with HIV. Figure 1F shows that an increase in the proportion of people in a community who used condoms at their last risky sex was associated with an increase in the prevalence of HIV (χ2 136.865 [1df] p < 0.001). This was also a counter intuitive finding.

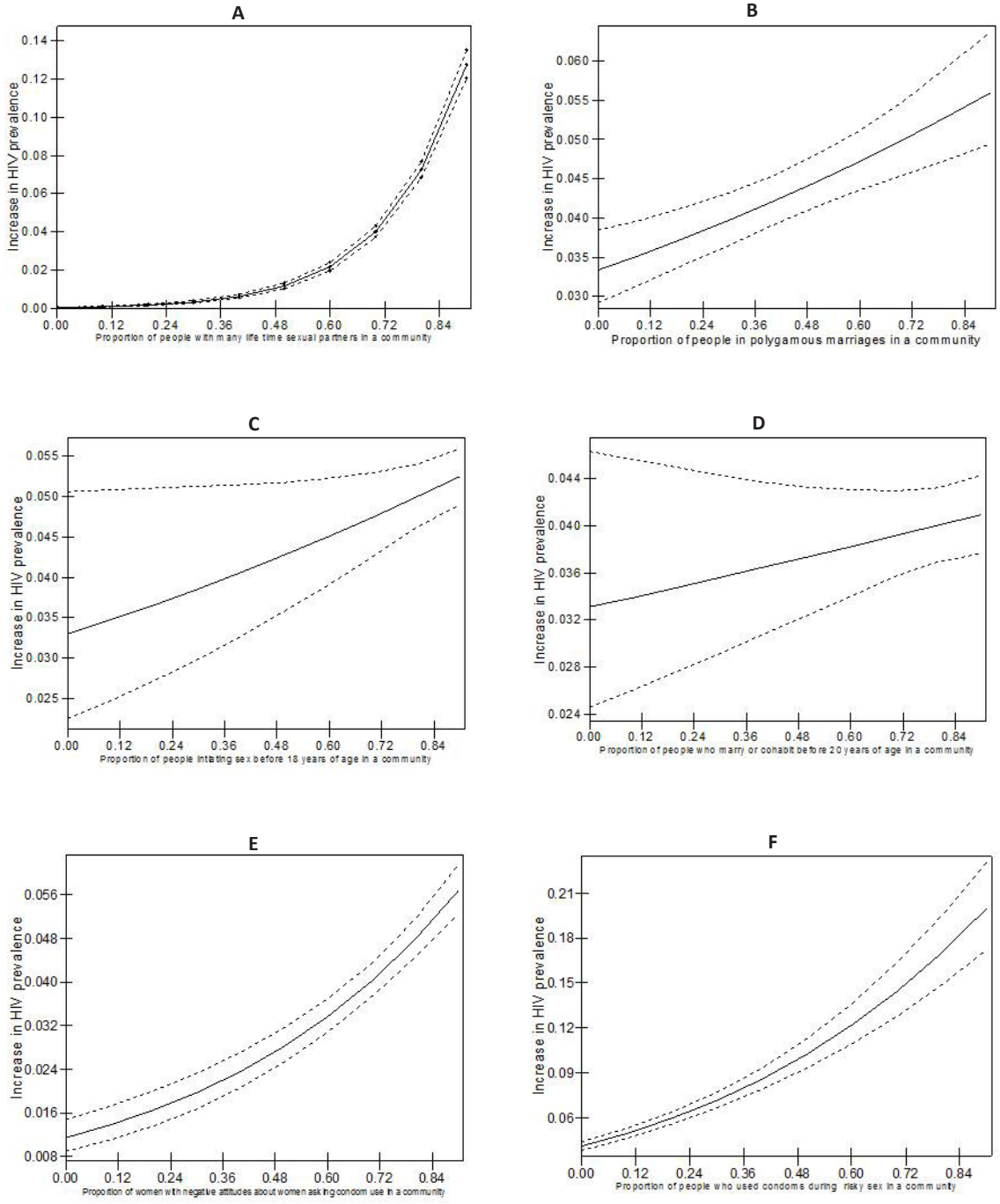

Figure 1: Weighted HIV prevalence by social characteristics, UAIS, 2004-2005 & 2011

In terms of HIV/AIDS knowledge, we found a positive relationship between having comprehensive [1] HIV/AIDS knowledge and being infected with HIV. Compared to individuals with low knowledge (knowing 2 or none of the 3 methods), those with comprehensive knowledge (knowing all the 3 key methods) had a higher likelihood of being infected with HIV. Figure 2G shows that an increase in the proportion of people with comprehensive HIV/AIDS knowledge in a community was associated with an increase in HIV prevalence (χ^2 150.537 [1df] $p <$ 0.001). This was a counter intuitive finding. For formerly married or cohabited respondents, Figure 2H shows that an increase in the proportion of formerly married and cohabited people in a community was significantly associated with an increase in the prevalence of HIV, χ^2 112.293 [1df] $p<$ 0.001.

Regarding STIs, we observed a positive relationship between reporting a history of STI and being infected with HIV. Figure 2I illustrates that when the proportion of people with STIs increases in a community, HIV prevalence increases (χ^2 154.216 [1df] $p <$ 0.001). The case for being drunk with alcohol was likewise. In Figure 2J, we illustrate that when the proportion of people who drink alcohol and become drunk before having unsafe sex in a community increases, HIV prevalence significantly increases (χ^2 168.777, [1df] $p<$ 0.001).

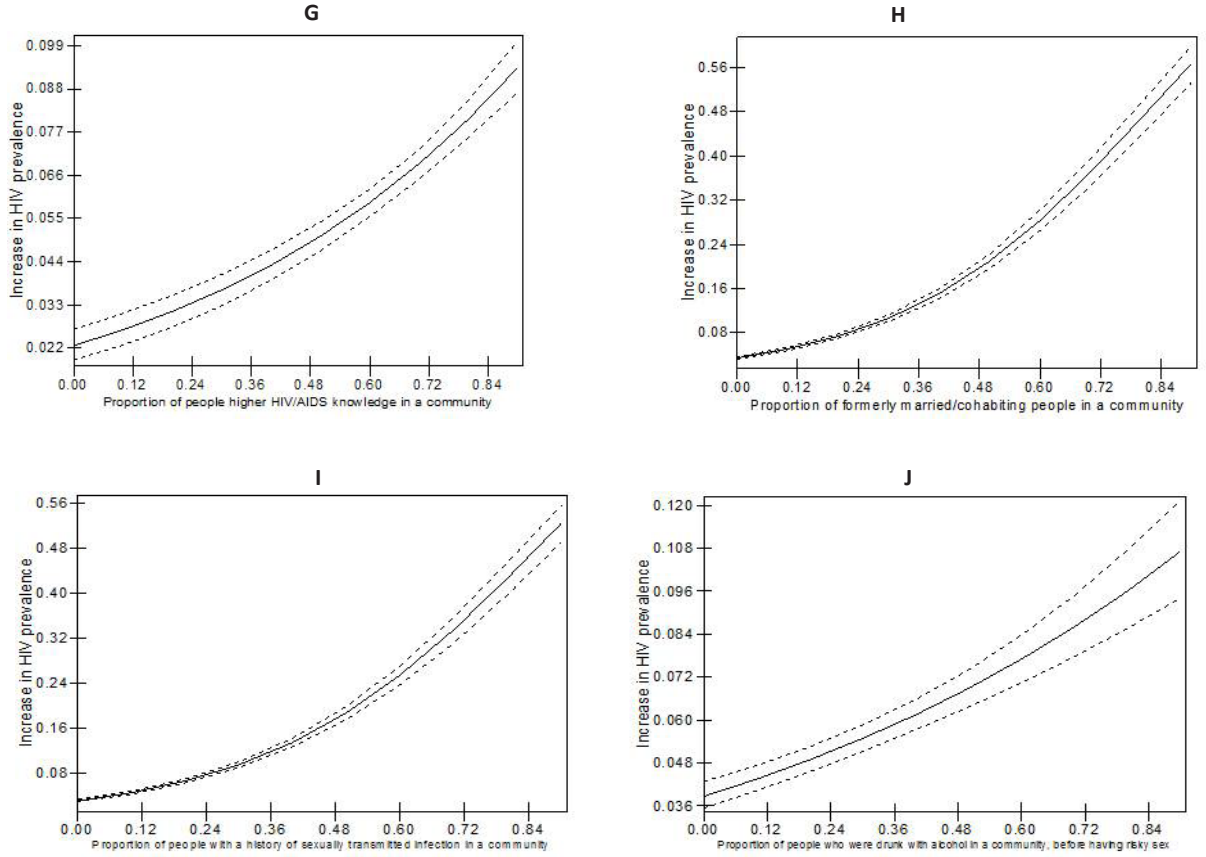

Figure 2: Community HIV prevalence by comprehensive HIV/AIDS knowledge (G), formerly married or cohabiting (H), sexually transmitted infections (I), and alcoholism (J), (n= 39766 individuals, n=887 clusters, UAIS, 2004-5 & 2011.

In the next step of analysis, possible confounding factors were considered. Seven community-level factors, (in order of the magnitude of the coefficient) remained positive and significant including living in a community with a higher proportion of people: who were formerly married; who use condoms during risky sex; who had comprehensive HIV/AIDS knowledge; who were drunk or whose spouse was drunk or who were both drunk with alcohol before risky sex; who initiate sex early; and, who had many people living in the highest ranked wealth households. When all eleven variables were included in the model, educational attainment, polygamy, age at first marriage at the community level and attitudes towards women asking their husbands/sexual partners to use condoms, became non-significant.

Adjusting for community- and individual-level factors

In the final step of analysis, we run models that controlled for individual-level factors. Table 2 shows that many of the community effects observed in the analysis adjusting for community factors alone persisted, though some effects that were previously significant were lost and other factors that were not positive (in model 2) became positive (in model 3). There were only three community-level factors that remained robust to both specifications: they are communities with high proportions of formerly married respondents, communities with a high proportion of wealthy households, and communities with a high proportion of respondents who reported they or their spouses or both were drunk with alcohol before their last risky sexual encounter.

There are several points that can be gleaned from these findings: first, factors operating at the proximate level substantially influence vulnerability to HIV infection more than those that are distant when measured at the community level. When all eleven variables were included in the model, educational attainment, polygamy, age at first marriage at the community level,

and attitudes towards women asking their sexual partners to use condoms, became non-significant. Knowledge was no longer significant in the model which controlled for individual level factors (Table 2). Second, traditional practices such as polygamy which are normally assumed to be positively associated with HIV (as the unadjusted results in Figure 1B show), were negative at the community level, but were only statistically significant in Model 3. Thirdly, household wealth is important in influencing vulnerability at the community level; living in a community where more households belong to the highest 40% wealthy households is associated with increased vulnerability to HIV infection in Model 3.

Table 2: Odds ratios of HIV by community factors, after controlling for individual-level factors (n=39,766), UAIS, 2004-05 and 2011.

	Model 1		Model 2		Model 3	
Parameters	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**
Fixed effects						
Model 1: Null						
Model 2: Community factors						
Proportion of households categorised in wealthiest 40%			1.03	[1.00 - 1.05]*	1.07	[1.03 - 1.11]*
Proportion of individuals having secondary or higher education			1.02	[0.98 - 1.07]	0.94	[0.88 - 1.00]
Proportion of people less than 18 years old at first sex			1.07	[1.00 - 1.15]*	1.07	[0.99 - 1.15]
Proportion of people more than 20 years old at first marriage			0.89	[0.75 - 1.05]	0.91	[0.76 - 1.08]
Proportion of men who had 2 or more wives			0.99	[0.93 - 1.06]	0.91	[0.85 - 0.98]*
Proportion of proportion of people formerly married			1.42	[1.30 - 1.56]*	1.21	[1.09 - 1.33]*
Proportion of people drunk with alcohol before last risky sex			1.09	[1.03 - 1.14]*	1.11	[1.05 - 1.18]*
Proportion of people with more than 1 life time sexual partner			1.06	[1.00 - 1.12]*	0.97	[0.92 - 1.02]
Proportion of people with high HIV/AIDS knowledge			1.16	[1.08 - 1.24]*	1.06	[0.98 - 1.15]
Proportion of people who used condoms during last risky sex			1.20	[1.07 - 1.34]*	1.10	[0.98 - 1.23]
Proportion of people who believe women can ask condom use			0.98	[0.95 - 1.00]	1.08	[1.02 - 1.15]*
Model 3: Individual-level factors						
Wealth (Ref: Lowest quintile)						
Second					1.02	[0.88 - 1.18]
Middle					0.99	[0.85 - 1.15]
Fourth					0.98	[0.84 - 1.15]
Highest					1.04	[0.88 - 1.23]
Education (Ref: No education)						
Incomplete primary					1.08	[0.94 - 1.24]
Complete primary					1.13	[0.96 - 1.34]
Incomplete secondary					0.91	[0.77 - 1.08]
Complete secondary & higher					0.62	[0.49 - 0.80]*
Missing					1.45	[0.40 - 5.23]
Sex of respondent (Ref: Men)						
Women					1.58	[1.41 - 1.77]*
Age of respondent (Ref: 45–59 years)						
15-24 years					1.11	[0.93 - 1.32]
25-34 years					1.73	[1.51 - 2.00]*
35-44 years					1.79	[1.55 - 2.05]*
Area of residence (Ref: Urban)						
Rural					0.55	[0.42 - 0.73]*
Sex of household head (Ref: Male)						

	Model 1		Model 2		Model 3	
Parameters	**OR**	**CI**	**OR**	**CI**	**OR**	**CI**
Female					1.18	[1.05 - 1.32]*
Current marital status (Ref: Never)						
Married/living together					2.38	[1.93 - 1.93]*
Widowed					7.67	[6.01 - 9.78]*
Divorced/separated					3.49	[2.82 - 4.33]*
Drunk with alcohol before unsafe sex (Ref: No)						
Drunk					1.24	[1.11 - 1.39]*
Not applicable					0.31	[0.02 - 4.72]
Condom use during unsafe sex (Ref: No)						
Used condom					2.21	[1.91 - 2.56]*
Not applicable					4.94	[0.33 - 74.56]
Number of life time sexual partners (Ref: 1 partner)						
2-4 partners					2.00	[1.74 - 2.30]*
>4 partners					3.51	[2.98 - 4.14]*
Not applicable					0.80	[0.58 - 1.13]
Comprehensive HIV/AIDS knowledge (Ref: No)						
Lowest knowledge					1.08	[0.76 – 1.52]
Medium knowledge					1.05	[0.76 – 1.44]
Highest knowledge					1.25	[0.92 – 1.71]
Year (Ref: UG5 (2004-5)						
UG6 (2011)					2.56	[1.72 - 3.82]*
Random effects						
Cluster constant	0.518	0.046*	0.335	0.036*	0.355	0.039*
Clusters	887		887		887	
Individuals	39766		39766		39766	

OR: odds ratio; CI: Confidence intervals; (*) Significant at 95% confidence intervals

For intra-cluster correction coefficient, results based on formula 1 (see methods of analysis) were used to calculate the intra-cluster correlation coefficient as follows:

Model 1: $$p = \frac{0.518}{3.625} = 0.143$$

Model 2: $$p = \frac{0.335}{3.625} = 0.092$$

Model 3: $$p = \frac{0.335}{3.625} = 0.092$$

The ICC for the final model was 0.092 which suggests that 9.2% of unexplained vulnerability in HIV infection in Uganda was attributable to unobserved community-level factors.

Discussion

Social factors of vulnerability to the risk of HIV infection

The negative polygamy-HIV association is an important finding in view of the debate about multiple sexual partnerships and partner concurrency. After controlling for other community- and individual-level variables, the study revealed that living in a community where higher proportions of married men are in polygamous relationships is associated with significantly reduced vulnerability to HIV infection (AOR=0.91; 95%CI [0.85–0.98]) (Table 2, Model 3). These findings agreed with previous research in SSA. Using data from 19 SSA countries, evidence showed that in countries as well as in regions within countries where polygamy was highly prevalent, HIV prevalence was low [21,43]. This scenario is attributed to the exclusive nature of a polygamous sexual network and the lower rate of sexual intercourse in polygamous relationships [21], and restricted access to sexual partners for young men [28]. Living in a community with limited access to women by young men ultimately affects the level of sexual activity and consequently, the level of vulnerability to the risk of HIV infection.

A positive association between the community-level belief that a woman is right to ask her husband/other sexual partner to use a condom when she knows that he has a sexually transmitted infection is an unusual finding. One would expect communities with higher proportions of respondents who believe that women can ask for condom use to be associated with a lower rate of HIV prevalence. This counter intuition is most likely due to post infection effect, a situation where people in high HIV prevalence settings become aware of the importance of a woman asking her husband to use a condom after experiencing or witnessing HIV infection. It may also signal inability of individuals to prevent HIV infection (especially women who answered this question),

despite their knowledge that women should be free to ask their husbands to use condoms.

These findings depart from previous ones by Uthman et al. [44] and Antai [45] that showed that women and men had attitudes that supported violence against women. As suggested earlier, this may be due to awareness/education, especially in HIV/AIDS care settings. In HIV/AIDS clinics and organisations, HIV patients are sensitized and counselled on a range of issues including condoms use. Through these sessions, people become aware of the need for women to be sexually assertive. Beside AIDS care settings, favourable community attitudes supporting women to ask their husbands to use condoms could also be related to community AIDS awareness campaigns in Uganda over the last three decades. It is likely that these AIDS campaigns have had positive impact on people's knowledge about gender-power imbalance.

Structural factors of vulnerability to the risk of HIV Infection

Overall, after controlling for other contextual- and individual-level covariates in Table 2, living in a community where more households are in the wealthiest 40% category is associated with increased vulnerability to HIV infection. These findings are consistent with previous empirical evidence elsewhere in Sub Saharan Africa. For example, Ishida and colleagues observe a similar relationship – people in higher SES communities had higher HIV prevalence rates than those in lower SES areas [46]. However, these findings differ from those in a Zambian study by Gabrysch et al. using composite measures of community wealth which found that young women (15–24 years) living in low and medium SES communities had a higher prevalence of HIV infection than those in higher SES areas [47].

This finding highlights the complex nature of the relationship between wealth, socio-economic inequality and vulnerability to the risk of HIV infection. Previous research has shown the impact of differential wealth status on vulnerability to the risk of HIV infection. Using DHS data of 170 regions in 16 SSA countries, Fox showed that living in a wealthy country or region was associated with increased vulnerability of poor people to HIV infection, while living in a poor country or region was associated with increased vulnerability of rich people to the likelihood of being infected with HIV [48]. The relationship between wealth and HIV prevalence in SSA has also been observed to vary by urban/rural residence – wealth being associated with increased HIV risk in rural areas, while poverty is associated with increased vulnerability in urban areas [49,50]. Vescio et al. in a Cameroonian study found that variation of wealth in a region was associated with greater vulnerability to HIV infection among men and women [51]. Relatedly, a population-level study among young women aged 15–24 years in Malawi found that economic inequalities at the district and community levels were associated with a higher likelihood of being infected with HIV, engaging in extra-marital, early sexual initiation, and a lower chance of sexual abstinence [52]. Researching 15–24-year-old urban women in Mbale, Uganda, Nicholas concluded that "although young women were informed and motivated to prevent HIV, poverty and inequality were significant barriers limiting their power to protect themselves".

Counter-intuitive community-level determinants of vulnerability

This research also revealed counter intuitive findings. We observed that using condoms, having comprehensive HIV/AIDS knowledge, and having positive attitudes towards women being able to negotiate condom use were associated with an increased likelihood of being infected with HIV; one would expect a negative relationship between these variables and HIV infection. Counter intuitive findings in HIV/AIDS research is now an emerging and important phenomenon that has also been reported in Tanzania [53] and across SSA [54]. These and such findings have the potential to distort conclusions, recommendations, and policies and should be interpreted cautiously.

Counter intuition associated with HIV/AIDS awareness may be attributable to the fact that, since the analysis is done on HIV positive individuals, it is highly likely that these individuals become enlightened during or after accessing HIV services. Studies in South Africa demonstrate that people who had tested for HIV had higher HIV/AIDS knowledge than those who had not [55]. Secondly, this unusual but now established trend strongly suggests that whereas people have these expected positive practices/attributes, they adopt them after becoming infected [55]. Thirdly, counter intuition also points to a possible influence of other normative factors such culture and religion [56].

Conclusions and recommendations

The first objective of this research was to examine the association between community-level social and structural factors and HIV infection. There is empirical evidence that community-level factors are associated with vulnerability to the risk of HIV infection. Some of the community-level factors associated with vulnerability to the risk of HIV infection include living in a community where a higher proportion of people: are formerly married; and where people engage in drinking and becoming drunk with alcohol before engaging in unsafe sex. The other factors although counter-intuitive were: living in a community where a higher proportion of people used condoms during their last unsafe sex and living in a community where a higher proportion of people have comprehensive HIV/AIDS knowledge. After controlling for other community-level factors and individual-level factors, we observe that living in a community with a higher proportion of households categorized as wealthy was associated with an increase in vulnerability to the risk of HIV infection and living in a community where a higher proportion of people who drink and become drunk with alcohol prior to engaging in unsafe sex remains associated with an increase in HIV prevalence.

The second objective sought to estimate the effects of community-level factors in increasing vulnerability to the risk of HIV infection. We observed that 9.2% of unexplained variance in HIV infection is due to unobserved community-level factors. This suggests that besides contextual factors considered in our analysis, other community-level factors significantly influence vulnerability to the risk of HIV infection in Uganda. Based on this, several implications can be deduced.

First, these findings call for intensified and effective implementation of Combination HIV Prevention, Uganda's national HIV prevention strategy that encompasses the provision of biomedical and psychosocial services and implementation of activities that tackle the social and structural drivers of HIV vulnerability in Uganda. Specifically, community awareness campaigns containing messages and other interventions about HIV vulnerability associated with social and structural factors, especially the influence of being formally married or cohabiting marital status and partnerships, alcoholism, community wealth, etc. is

necessary.

Second, policies and programmes aiming to alter the underlying causes of these causes e.g. on production, distribution and consumption of alcohol, policies and programmes addressing economic inequalities, etc. need to form part of an effective AIDS response in Uganda. Overall, an effective AIDS response ought to address societal aspects of vulnerability such as relationships, services, and various forms of resources that drive these practices. These findings also call for improvement in indicators in population health surveys for better assessment of community effects on vulnerability to HIV and ill health.

Some data limitations that may have impact on our findings are worth acknowledging. First, this research utilized cross sectional data which have a known limitation of being unable to determine the direction of causation in HIV research. Secondly, the data do not have many explicit community-level indicators, which makes the assessment of community effects of HIV vulnerability cumbersome. Third, there is limited research evidence of community-level effects on HIV vulnerability, which limited our ability to compare results. Nevertheless, much as the data were cross sectional, they allowed us to accurately measure the association between factors of interest and HIV infection. Also, although the data lacked reliable community-level variables, we derived reliable measures from existing individual-level variables which enabled us to estimate accurately community-level effects. Finally, the limited community-level evidence base justifies the need for more research in different contexts. Future research is necessary to validate these novel Ugandan findings which were part of a larger research for PhD in Sociology [57].

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Acknowledgement

MEASURE DHS and Ministry of Health, Uganda, for the data,and City, University of London, for a 3-year full PhD studentship to the primary author, both which made this research possible.

Division of labour

Patrick Igulot conceptualized the study, performed analysis and prepared the manuscript. Monica Magadi provided technical guidance to the conceptualisation and analysis of the data and revised the manuscript. Both authors approved the final article.

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