Behavioral, Biological, and Demographic Risk and Protective Factors for New HIV Infections Among Youth in Rakai, Uganda

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Background: Prevalence of HIV infection is considerable among youth, although data on risk factors for new (incident) infections are limited. We examined incidence of HIV infection and risk and protective factors among youth in rural Uganda, including the role of gender and social transitions.

Methods: Participants were sexually experienced youth (15–24 years old) enrolled in the Rakai Community Cohort Study, 1999–2008 (n = 6741). Poisson regression with robust standard errors was used to estimate incident rate ratios (IRR) and 95% confidence intervals (CI) of incident HIV infection.

Results: HIV incidence was greater among young women than young men (14.1 vs. 8.3 per 1000 person-years, respectively); this gender disparity was greater among teenagers (14.9 vs. 3.6). Beyond behavioral (multiple partners and concurrency) and biological factors (sexually transmitted infection symptoms), social transitions such as marriage and staying in school influenced HIV risk. In multivariate analyses among women, HIV incidence was associated with living in a trading village (adjusted IRR (aIRR) = 1.48; 95% CI: 1.04 to 2.11), being a student (aIRR = 0.22; 95% CI: 0.07 to 0.72), current marriage (aIRR = 0.55; 95% CI: 0.37 to 0.81), former marriage (aIRR = 1.73; 95% CI: 1.01 to 2.96), having multiple partners, and sexually transmitted infection symptoms. Among men, new infections were associated with former marriage (aIRR = 5.57; 95% CI: 2.51 to 12.36), genital ulceration (aIRR = 3.56; 95% CI: 1.97 to 6.41), and alcohol use (aIRR = 2.08; 95% CI: 1.15 to 3.77).

Conclusions: During the third decade of the HIV epidemic in Uganda, HIV incidence remains considerable among youth, with young women particularly at risk. The risk for new infections was strongly shaped by social transitions such as leaving school, entrance into marriage, and marital dissolution; the impact of marriage was different for young men than women.

Key Words: youth, Uganda, HIV, incidence, risk factors, education

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INTRODUCTION

Youth (15–24 y) face considerable risk for HIV infection, representing 40% of all new cases among persons of reproductive age.[1] Although some of the most prominent predictors for HIV infection in youth are similar to those in the adult population [eg, number of sexual partners, sexual concurrency, commercial sex work, use of barrier protection, and presence of other sexually transmitted infections (STI)],[2,3] the social and developmental context of youth appears to influence risk as well.[1] These include educational and vocational opportunities, partnership formation and power dynamics within relationships, behaviors such as sexual initiation, and biological factors such as pubertal timing and circumcision.[3–5]

In Sub-Saharan Africa (SSA), youth are particularly at risk of HIV. Approximately 80% of the 5 million youth living with HIV reside in SSA.[6] Additional drivers of HIV risk among youth in SSA include high community HIV prevalence, limited health care infrastructure, and practices such as marriage to older partners and sexual concurrency.[3,5,7]

To-date, however, most studies of HIV among youth in SSA have been cross-sectional and have only measured prevalence.[3,5] These studies are unable to distinguish between factors associated with new and long-term HIV infection. Understanding risk factors for acquisition of HIV is important for informing and evaluating prevention programs for youth.[5,8]

In this study, we focus on Ugandan youth. Although Uganda made notable progress in reducing HIV prevalence in the late 1980s and 1990s,[3,9–11] there has been little improvement since 2004.[12,13] Youth continue to face considerable risk

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of HIV infection in Uganda. Among young women, HIV prevalence in 2011 was 2.8% in 15–19 year olds and 6.3% in 20–24 years olds.[13] HIV prevalence was 1.1% in men 15–19 years old and 3.2% in men 20–24 years old.[13] We used a longitudinal study design to investigate HIV incidence among youth in rural Uganda focusing on behavioral, biological, and demographic factors including social transitions in schooling and marriage.

METHODS

Study Setting

The study population was sexually experienced youth participating in the Rakai Community Cohort Study (RCCS) between March 1999 and April 2008. The RCCS is an open cohort of residents 15–49 years of age from 50 communities in the Rakai district of southwestern Uganda; it has been described elsewhere.[14,15] Briefly, communities are censused and surveyed approximately annually. Before each survey round, participants and other community members receive HIV prevention education and information at the community mobilization sessions. At each survey round, participants are consented, interviewed, and asked to provide biological specimens for HIV and STI testing. For minors, assent and parental/guardian consent for research participation is obtained. Voluntary counseling and testing for HIV is also offered in the study communities. RCCS questionnaires are administered via face-to-face interviews, which are conducted in private by same-sex interviewers. The RCCS achieves over 85% coverage among all residents. Among consenting participants, 99% respond to the full questionnaire and over 90% agree to specimen collection.

Institutional review board (IRB) approvals for the current analysis and RCCS were obtained from Uganda Virus Research Institute's Science and Ethics Committee, Uganda National Council for Science and Technology, and from IRBs at Columbia University and Johns Hopkins University and Western IRB in the United States.

Study Design and Sample

Using a prospective longitudinal study design, we examined the demographic, behavioral, and biological correlates of incident HIV infection.

Between March 1999 and April 2008, there were 7 RCCS survey rounds and 15,904 participants aged 15–24 years who ever had sexual intercourse. Over 7 survey rounds, the average proportion of sexually experienced 15–19 year olds was 59% in men and 72% in women and for 20–24 year olds was 95% in men and 99% in women.

To ascertain HIV acquisition, we restricted our analyses to initially HIV-negative sexually experienced youth who were followed up at 1 or more study visits with no more than 1 survey round missing between them (n = 6741). HIV status was determined by 2 separate enzyme-linked immunosorbent assay tests and confirmed by HIV-1 western blot, as previously described.[16]

Information on potential risk and protective factors was gathered exclusively from the RCCS questionnaire at the time of study visit. The majority of questions relevant to our analyses were asked consistently across RCCS surveys rounds.

Communities were characterized as either rural or trading villages. Marital status (never/currently/formerly) was determined by 2 questions: if a participant had ever been married (tradition, civil, religious, or consensual union) and if he/she was currently married. Whether a participant was currently a student was based on whether he/she chose "Student" from a list of occupations. For highest level of school attended, a variable was constructed using all available data. All participants were asked about the level of school attended at their baseline study visit, but follow-up data were only available for RCCS survey rounds conducted after February 2001 and only for participants aged 21 years or younger. For our analyses, if no follow-up data on level of schooling was available, the variable was coded as the response given in the previous study visit. A sensitivity analysis without imputed values found similar levels of association.

Sexual concurrency, multiple partners, and condom use variables were constructed based on detailed questions about sexual partnership(s) in the last year. The RCCS questionnaire assessed up to 2 partners until February 2001 and up to 4 partners after that time. Sexual concurrency was defined as reporting 2 or more partners at the time of interview. Condom use was classified as "always" if the participant responded as such for all partners for whom there was information.

STI symptoms were based on participants' response to the question "In the past 12 months have you had any of the following health problems?"—followed by a description of each symptom. For self-assessment of HIV risk, participants were asked to rate the likelihood that they had been exposed to HIV at each follow-up study visit.

Statistical Analyses

Incidence rates were estimated per 1000 person-years. We used Poisson regression with robust standard errors to calculate incidence rate ratios (IRR) and 95% confidence intervals (CI).[17] All analyses were stratified by gender.

We first calculated unadjusted IRRs for each potential risk factor. Then, multivariate analyses were conducted with variable selection in steps. First, domain-specific models were constructed based on the unadjusted results and included all statistically significant variables ($P \leq 0.05$) within each of the following domains: demographic, sexual behaviors, alcohol use, and STI symptoms. Next, backward selection was used for each domain with the least significant factors removed until the smallest Akaike Information Criterion value was reached. Akaike Information Criterion measures the relative goodness of fit with a penalty on the model complexity.[18] The remaining statistically significant factors from the domain-specific models were tested, and the backward selection process was applied to estimate the final multivariate model. This process ensured a parsimonious well-fitted model. Self-assessment of HIV risk was not included in the multivariate models, because it is likely to be a mediating variable.

TABLE 1. HIV Incidence Rates by Characteristic among Sexually Experienced Youth 15–24 years old, Rakai District, Uganda, 1999-2008

	Men			Women		
	No. Incident HIV Cases	py	Rate Per 1000 py (95% CI)	No. Incident HIV Cases	py	Rate Per 1000 py (95% CI)
Total	56	6772	8.27 (6.25 to 10.74)	148	10,520	14.07 (11.89 to 16.53)
Age (yrs)						
15–19	7	1969	3.56 (1.43 to 7.33)	39	2614	14.92 (10.61 to 20.40)
20–24	49	4803	10.20 (7.55 to 13.49)	109	7907	13.79 (11.32 to 16.63)
Community type						
Rural	43	5554	7.74 (5.60 to 10.43)	107	8489	12.60 (10.33 to 15.23)
Trading village	13	1217	10.68 (5.69 to 18.26)	41	2031	20.18 (14.48 to 27.38)
Marital status						
Never married	22	4480	4.91 (3.08 to 7.43)	43	2681	16.04 (11.61 to 21.60)
Currently married	24	2100	11.43 (7.32 to 17.00)	86	7434	11.57 (9.25 to 14.29)
Formerly married	10	191	52.31 (25.09 to 96.20)	19	405	46.94 (28.26 to 73.30)
Highest level of schooling attended						
No schooling	1	155	6.44 (0.16 to 35.88)	8	433	18.48 (7.98 to 36.41)
Primary schooling	46	4483	10.26 (7.51 to 13.69)	97	6532	14.85 (12.04 to 18.12)
Secondary schooling	9	2084	4.32 (1.98 to 8.20)	43	3505	12.27 (8.88 to 16.53)
Tertiary schooling	0	50	—	0	26	—
Current student						
No	55	5519	9.97 (7.51 to 12.97)	145	9676	14.99 (12.65 to 17.63)
Yes	1	1253	0.80 (0.02 to 4.45)	3	844	3.55 (0.73 to 10.39)
Drank alcohol in last 30 days						
No	19	4250	4.47 (2.69 to 6.98)	108	8112	13.31 (10.92 to 16.07)
Yes	37	2522	14.67 (10.33 to 20.23)	40	2407	16.62 (11.87 to 22.63)
No. sexual partners in past 12 months						
0	2	752	2.66 (0.32 to 9.61)	5	480	10.42 (3.38 to 24.31)
1	16	3172	5.04 (2.88 to 8.19)	122	9545	12.78 (10.61 to 15.26)
2	19	1766	10.76 (6.48 to 16.80)	18	444	40.53 (24.02 to 64.06)
3+	19	1082	17.56 (10.57 to 27.43)	3	52	58.02 (11.96 to 169.55)
No. sexual partners from outside the community in past 12 months						
0	27	4105	6.58 (4.34 to 9.57)	107	8656	12.36 (10.13 to 14.94)
1	12	1768	6.79 (3.51 to 11.86)	38	1736	21.89 (15.49 to 30.05)
2+	17	898	18.93 (11.02 to 30.30)	3	129	23.26 (4.80 to 67.96)
Concurrent partnership at time of interview						
No	36	5492	6.55 (4.59 to 9.07)	141	10,318	13.66 (11.50 to 16.12)
Yes	20	1279	15.63 (9.55 to 24.14)	7	202	34.67 (13.94 to 71.43)
Condom use in past 12 months						
Never or inconsistently	44	4658	9.45 (6.86 to 12.68)	137	9431	14.53 (12.20 to 17.17)
Always	12	2113	5.68 (2.93 to 9.92)	11	1086	10.13 (5.06 to 18.12)
STI symptoms in past 12 months						
Genital ulcer	21	646	32.52 (20.13 to 49.71)	31	1179	26.29 (17.86 to 37.32)
Genital discharge	10	331	30.24 (14.50 to 55.62)	63	2991	21.07 (16.19 to 26.95)
Vaginal discharge	—	—	—	58	2489	23.30 (17.69 to 30.12)
Vaginal itching symptoms	—	—	—	95	4081	23.28 (18.83 to 28.46)
Unpleasant vaginal odor	—	—	—	24	1018	23.59 (15.11 to 35.10)
Frequent urination	5	123	40.74 (13.23 to 95.08)	25	1031	24.26 (15.70 to 35.81)
Painful urination	14	636	22.01 (12.03 to 36.93)	33	1174	28.11 (19.35 to 39.47)
Pain during intercourse	4	164	24.35 (6.64 to 62.35)	19	1070	17.75 (10.69 to 27.72)
Bleeding during intercourse	0	35	—	3	117	25.74 (5.31 to 75.23)
Lower abdominal pain	7	378	18.49 (7.44 to 38.11)	53	3291	16.11 (12.06 to 21.07)
Genital warts	2	64	31.20 (3.78 to 112.72)	12	250	47.94 (24.77 to 83.75)

(*continued on next page*)

TABLE 1. (*Continued*) HIV Incidence Rates by Characteristic among Sexually Experienced Youth 15–24 years old, Rakai District, Uganda, 1999-2008

	Men			Women		
	No. Incident HIV Cases	py	Rate Per 1000 py (95% CI)	No. Incident HIV Cases	py	Rate Per 1000 py (95% CI)
Self-assessment of HIV risk						
Not at all	1	468	2.14 (0.05 to 11.90)	5	824	6.35 (2.06 to 14.82)
Low	30	4041	7.42 (5.01 to 10.60)	66	6117	11.16 (8.63 to 14.20)
Medium	18	1899	9.48 (5.62 to 14.98)	51	2965	18.44 (13.73 to 24.25)
High	4	202	19.79 (5.39 to 50.66)	13	758	20.44 (10.88 to 34.94)
Don't know	3	162	18.57 (3.83 to 54.28)	13	456	31.17 (16.60 to 53.31)

RESULTS

There were 207 new HIV infections detected among 15–24 year olds between 1999 and 2008, which represented 30.7% of all new infections among 15–49 year olds in the RCCS during this period. Virtually all new HIV infections (n = 204) occurred among youth who reported sexual experience. All 3 incident HIV cases denying sexual experience were young women, attending school, and younger than 19 years of age. One incident case had reported sexual experience at a previous study visit. All analyses were limited to youth who reported being sexually experienced.

HIV incidence was 14.1 per 1000 person-years in young women and 8.3 per 1000 person-years in young men (Table 1). Gender disparity was greatest in 15–19 year olds, among whom incidence was over 4 times greater in women than men (14.9 vs. 3.6 per 1000 person-years).

Factors Associated With HIV Incidence

Results are stratified by gender and explained below by factor type. Table 1 presents the incidence rates. Table 2 contains the unadjusted and multivariate analyses IRRs.

Demographic Factors

Among young men, the HIV incidence rate in the 20–24 year olds (10.2 per 1000 person-years) was greater than the 15–19 year olds (3.6 per 1000 person-years) (Table 1). HIV incidence differed substantially by young men's marital status. The highest incidence rate was in formerly married men (52.3 per 1000 person-years). Young men who were current students had the lowest incidence rate of 0.8 per 1000 person-years.

In the unadjusted analysis, young men were at an increased risk of HIV if they were older (IRR = 2.87; 95% CI: 1.30 to 6.32), currently married (IRR = 2.33; 95% CI: 1.31 to 4.14) or formerly married (IRR = 10.65; 95% CI: 5.14 to 22.07) (Table 2). Men were at a lower risk if they had attended secondary school (IRR = 0.42; 95% CI: 0.21 to 0.86) or were currently a student (IRR = 0.08; 95% CI: 0.01 to 0.58). Among these factors, only marital status was selected for the multivariate model. No difference was detected by community type.

Among young women, HIV incidence differed by community type. Incidence in rural areas was 12.6 per 1000 person-years vs. 20.2 per 1000 person-years in trading villages (Table 1). Similar to men, the incidence rate among formerly married women was high (46.9 per 1000 person-years) and the rate among current students was low (3.6 per 1000 person-years).

In the unadjusted and multivariate analyses, the incidence rate among young women living in trading villages was statistically significantly higher than those in rural areas (multivariate IRR = 1.48; 95% CI: 1.04 to 2.11). HIV incidence also differed by marital status, wherein being formerly married was associated with an increased risk (multivariate IRR = 1.73; 95% CI: 1.01 to 2.96) and being currently married was associated with a decreased risk (multivariate IRR = 0.55; 95% CI: 0.37 to 0.81). Current students were at lower risk of HIV acquisition (multivariate IRR = 0.22; 95% CI: 0.07 to 0.72). No significant relationship was seen with age in young women.

Alcohol Use

In young men, having drunk alcohol in the last 30 days was associated with an increased risk of HIV infection (multivariate IRR = 2.08; 95% CI: 1.15 to 3.77, Table 2). Although the incidence rate was higher in women who had drank in the last 30 days than those who had not (13.3 vs. 16.6 per 1000 person-years, Table 1), the association was not statistically significant.

Sexual Behaviors

In young men and women, incidence rates were high among youth with the greatest number of partners in the last 12 months, the greatest number of partners outside the community, with concurrent partnerships, and youth who did not use condoms consistently (Table 1). In the unadjusted analyses, all these characteristics were associated with HIV risk except for condom use (Table 2). Number of partners in the last 12 months was selected for the multivariate model for both young men and women, although it was only statistically significant in young women.

Although concurrency was not selected for the multivariate model, there was a high degree of overlap with multiple sexual partnerships. The average percentage of young men and women with multiple partners in the last year who reported concurrency at the time of interview was 45% and 40%,

TABLE 2. Bivariate and Multivariate Models of Associations With Incident HIV Among Sexually Experienced Youth, Rakai District, Uganda, 1999–2008

	Men		Women	
	Unadjusted IRR (95% CI)	**Multivariate IRR* (95% CI)**	**Unadjusted IRR (95% CI)**	**Multivariate IRR* (95% CI)**
Age (yrs)				
15–19	1	—	1	—
20–24	2.87 (1.30 to 6.32)	—	0.92 (0.64 to 1.33)	—
Community type				
Rural	1	—	1	1
Trading village	1.38 (0.75 to 2.55)	—	1.60 (1.12 to 2.28)	1.48 (1.04 to 2.11)
Marital Status				
Never married	1	1	1	1
Currently married	2.33 (1.31 to 4.14)	1.64 (0.90 to 2.99)	0.72 (0.50 to 1.04)	0.55 (0.37 to 0.81)
Formerly married	10.65 (5.14 to 22.07)	5.57 (2.51 to 12.36)	2.93 (1.73 to 4.94)	1.73 (1.01 to 2.96)
Highest level of schooling attended				
No schooling	0.63 (0.09 to 4.45)	—	1.24 (0.61 to 2.53)	—
Primary schooling (ref)	1	—	1	—
Secondary schooling	0.42 (0.21 to 0.86)	—	0.83 (0.58 to 1.18)	—
Tertiary schooling				
Current Student				
No	1	—	1	1
Yes	0.08 (0.01 to 0.58)	—	0.24 (0.08 to 0.74)	0.22 (0.07 to 0.72)
Drank alcohol in last 30 days				
No	1	1	1	—
Yes	3.28 (1.89 to 5.69)	2.08 (1.15 to 3.77)	1.25 (0.87 to 1.79)	—
No. sexual partners in past 12 months				
0	0.53 (0.12 to 2.29)	0.64 (0.15 to 2.75)	0.82 (0.34 to 1.98)	0.59 (0.21 to 1.60)
1 (ref)	1	1	1	1
2	2.13 (1.10 to 4.13)	1.56 (0.78 to 3.14)	3.17 (1.96 to 5.12)	2.27 (1.36 to 3.81)
3+	3.48 (1.80 to 6.73)	1.85 (0.87 to 3.93)	4.54 (1.49 to 13.81)	2.16 (0.82 to 5.70)
No. sexual partners from outside the community in past 12 months				
0	1	—	1	—
1	1.03 (0.52 to 2.03)	—	1.77 (1.23 to 2.55)	—
2+	2.88 (1.58 to 5.24)	—	1.88 (0.61 to 5.84)	—
Concurrent partnership at time of interview				
No	1	—	1	—
Yes	2.38 (1.39 to 4.10)	—	2.54 (1.21 to 5.31)	—
Condom use in past 12 months				
Never or inconsistently	1	—	1	—
Always	0.60 (0.32 to 1.13)	—	0.70 (0.38 to 1.28)	—
STI symptoms in past 12 months				
Genital ulcer	5.69 (3.34 to 9.69)	3.56 (1.97 to 6.41)	2.10 (1.42 to 3.09)	—
Genital discharge	4.23 (2.17 to 8.28)	—	1.87 (1.35 to 2.57)	—
Vaginal discharge	—	—	2.08 (1.50 to 2.88)	—
Vaginal itching symptoms	—	—	2.83 (2.03 to 3.94)	2.32 (1.63 to 3.29)
Unpleasant vaginal odor	—	—	1.81 (1.18 to 2.78)	—
Frequent urination	5.31 (2.19 to 12.90)	—	1.87 (1.22 to 2.86)	—
Painful urination	3.10 (1.70 to 5.64)	—	2.22 (1.52 to 3.26)	1.59 (1.07 to 2.36)
Pain during intercourse	3.09 (1.13 to 8.45)	—	1.30 (0.81 to 2.09)	—
Bleeding during intercourse	—	—	—	—
Lower abdominal pain	2.41 (1.10 to 5.27)	—	1.23 (0.88 to 1.71)	
Genital warts	3.88 (0.97 to 15.41)	—	3.62 (2.05 to 6.39)	2.57 (1.43 to 4.61)

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TABLE 2. (*Continued*) Bivariate and Multivariate Models of Associations With Incident HIV Among Sexually Experienced Youth, Rakai District, Uganda, 1999–2008

	Men		Women	
	Unadjusted IRR (95% CI)	Multivariate IRR* (95% CI)	Unadjusted IRR (95% CI)	Multivariate IRR* (95% CI)
Self-assessment of HIV risk				
Not at all	1	—	1	—
Low	3.48 (0.47 to 25.47)	—	1.76 (0.71 to 4.34)	—
Medium	4.44 (0.59 to 33.22)	—	2.90 (1.17 to 7.24)	—
High	9.27 (1.05 to 81.85)	—	3.22 (1.16 to 8.94)	—
Don't know	8.70 (0.91 to 83.25)	—	4.91 (1.77 to 13.64)	—

py, person-years; IRR, incidence rate ratio; CI, confidence interval; ref, referent category.
*All characteristics with IRR reported are entered into one model.

respectively, and correlation between number of sex partners and concurrency was relatively high (r = 0.52 for young men; r = 0.47 for young women).

STI Symptoms

STI symptoms were associated with greater HIV incidence (Tables 1 and 2). In men, the only symptom selected for the multivariate model was genital ulcer (multivariate IRR = 3.56; 95% CI = 1.97 to 6.41). In women, vaginal itching, painful urination, and genital warts were all selected and were statistically significant in the multivariate model (Table 2).

HIV Risk Assessment

Compared with those who assessed their HIV risk as "Not at all," all other categories of self-assessment were associated with an increased risk of HIV acquisition in both young men and women. The strength of the association appeared to be greater in men.

DISCUSSION

During this third decade of the HIV epidemic in Uganda, we found a considerable rate of new infection in youth living in the Rakai District and identified factors that placed youth at greater risk for HIV acquisition. Young women were at greater risk for HIV acquisition than men, particularly among 15–19 year olds. Behavioral and biological factors commonly associated with HIV and other STIs were prominent risk factors, including multiple partners, concurrency, alcohol use, and evidence of other STIs. The risk for new infections was strongly shaped by social transitions such as leaving school and marital dissolution.

Gender and age disparities in HIV prevalence have been previously documented throughout SSA, wherein young women are at higher risk for HIV and prevalence rises with increasing age.[5,19,20] In our study, gender disparities decreased with increasing age, as HIV risk in men increased more rapidly with age compared with women. In fact, the risk of HIV acquisition increased with age among sexually experienced young men, but not women. The lack of an impact of age among young women is not reassuring; rather, it suggests that HIV risk is high as soon as young women initiate sexual intercourse. Age is a frequent risk factor in studies examining HIV prevalence; in those studies, age may be a marker for cumulative infections.

Among the Rakai youth, sexual behaviors and STI symptoms were associated with HIV acquisition, similar to the general population of SSA[21,22] and Uganda.[16,19,23] Higher incidence rates were seen in young men and women with multiple partnerships, partners from another community, and concurrent partnerships. Considerable debate has surrounded the issue of sexual concurrency[24–27]; we found an impact of concurrency in our unadjusted results, despite using a measure of concurrency that underestimates the full impact of this behavior pattern. Our multivariate models suggested that the number of partners in the last 12 months was the most strongly indicative of increased risk, but multiple partnerships may be concurrent and collinearity could affect these results.

Previous studies have suggested that marriage itself may be a risk for HIV infection among young women,[28–31] particularly in studies examining prevalent infections. Our data do not support this idea and instead reflect the findings of the adult RCCS cohort wherein marriage was protective against HIV.[16] In young men, current marriage appeared to be a risk factor for HIV, but this was not statistically significant in the multivariate model, suggesting confounding by other risk factors such as multiple partnerships. In understanding differences in findings between prevalence and incidence studies, one needs to consider time within marriage and time sexually active before marriage, and the risk presented by marital partners and nonextramarital partners—before and during marriage.

We found that being formerly married significantly increased the risk of HIV acquisition for both young men and women in Rakai, similar to the studies that focused on prevalent infection. A recent qualitative study of young women in Rakai suggests that previously married women are more likely than their married or never married counterparts to have had multiple partnerships, to communicate poorly about HIV with sexual partners, to have experienced domestic violence and infidelity, to experience loss of family financial and social support, and to rely on partners for financial support.[32] Although previously married youth represent only a small proportion of youth in our cohort, our findings suggest the importance of HIV prevention for this high-risk group and of further study to disentangle the risk from widowhood versus marital separation.

In the Rakai youth, currently being a student significantly decreased the risk for of HIV infection in men and women. In SSA in general, there has been a shift in the relationship between educational attainment and HIV infection. Early studies suggested that higher educational attainment was a risk for HIV infection, probably reflecting greater wealth and a greater number of sexual partners. More recent studies indicate an association between higher educational levels and lower HIV infection.[33,34] Our findings suggest that a focus on enhancing school attendance as a method of HIV prevention in youth is justified. The difficultly of staying in school is reflected in the low proportions currently in school. Thus, innovative conditional cash transfer interventions and others that encourage school retention appear warranted.[35,36]

Living in a trading village significantly increased young women's likelihood of acquiring HIV, but not young men's. The latter may be an artifact of sparse data. Trading villages may experience more sexual mixing given increased migration and contact with traders, and exposure risk is greater given higher HIV prevalence in trading villages.

Alcohol consumption seems to be a gendered experience among the youth in Rakai, which may be related to expressions of masculinity[37] and cultural practice. Young men were more likely to consume alcohol, and its consumption increased the HIV risk. Previous research shows an association between behavioral disinhibition of alcohol use and greater sexual risk taking.[38,39] This suggests the importance of focusing on substance use as an HIV prevention strategy among young men in particular.

Self-assessment of HIV risk was strongly related to HIV acquisition and may be an important marker. Previous research has linked HIV risk assessment and risk behaviors,[7,40,41] but few studies have examined the association between perceived risk and HIV acquisition.[42] Our findings suggest that youth have a fairly pragmatic sense of their HIV risk. Complementary qualitative work in Rakai shows that youth self-assessments of HIV risk are based on their own behaviors and the surmised behaviors of their partners.[33,43] Youth self-assessment of HIV risk may be a useful tool for prevention and treatment efforts.

Lastly, our findings suggest that the youth in Uganda are willing to disclose sensitive information on their sexual practices. We found virtually no HIV acquisition among youth who reported no sexual activity. This not unimportant in a society were laws penalize underage sexual activity.[44] Less clear is the extent of underreporting of multiple partnerships in Rakai, which has been reported elsewhere in SSA.[45]

Our study was conducted within a long-running cohort study with high participation rates, and incidence infection was detected by biologic assays. However, our analysis was not without limitations. Information on potential risk factors for HIV acquisition was obtained through self-report, and most characteristics were reported for the preceding 12 months. Such data may be affected by social desirability bias and recall error. These biases are likely to be nondifferential because the participants in this analysis were either HIV negative or newly infected and not yet informed of their HIV status at the time of interview. Therefore, the impact of bias and recall error would be toward not finding an association. Of all our measures, error may have had the strongest impact on condom use because we were limited to a fairly simple and dichotomous measure that may have been subject to confounding.[16] Finally, for characteristics measured over the last 12 months, such as STI symptoms, we are not able to determine temporal order for characteristics and HIV seroconversion during those 12 months.

By focusing on HIV incidence, our findings suggest avenues for strengthening HIV prevention among young people in resource-poor settings. In addition to efforts to curtail number of partners and increase condom use, our findings support efforts to increase school retention, to reduce alcohol consumption in young men, and to target previously married youth and youth who are leaving school.

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