Sexual Partner Types and Incident HIV Infection Among Rural South African Adolescent Girls and Young Women Enrolled in HPTN 068: A Latent Class Analysis

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Background: Sexual partners are the primary source of incident HIV infection among adolescent girls and young women (AGYW) in sub-Saharan Africa. Identifying partner types at greatest risk of HIV transmission could guide the design of tailored HIV prevention interventions.

Methods: We conducted a secondary analysis of data from AGYW (aged 13–23 years) enrolled in a randomized controlled trial of cash transfers for HIV prevention in South Africa. Annually, AGYW reported behavioral and demographic characteristics of their 3 most recent sexual partners, categorized each partner using prespecified labels, and received HIV testing. We used latent class analysis (LCA) to identify partner types from reported characteristics, and generalized estimating equations to estimate the relationship between both LCA-identified and prespecified partner types and incident HIV infection.

Results: Across 2140 AGYW visits, 1034 AGYW made 2968 partner reports and 63 AGYW acquired HIV infection. We identified 5 LCA partner types, which we named monogamous HIV-negative peer partner; one-time protected in-school peer partner; out-of-school older partner; anonymous out-of-school peer partner; and cohabiting with children in-school peer partner. Compared to AGYW with only monogamous HIV-negative peer partners, AGYW with out-of-school older partners had 2.56 times the annual risk of HIV infection (95% confidence interval: 1.23 to 5.33), whereas AGYW with anonymous out-of-school peer partners had 1.72 times the risk (95% confidence interval: 0.82 to 3.59). Prespecified partner types were not associated with incident HIV.

Conclusion: By identifying meaningful combinations of partner characteristics and predicting the corresponding risk of HIV acquisition among AGYW, LCA-identified partner types may provide new insights for the design of tailored HIV prevention interventions.

Key Words: adolescent girls and young women, HIV incidence, sexual partners, latent class analysis

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BACKGROUND

Adolescent girls and young women (AGYW) in sub-Saharan Africa are disproportionately affected by HIV, accounting for 20% of new HIV infections in 2017, despite being just 10% of the population.[1,2] Sexual partners play a critical role in HIV acquisition among AGYW by

determining their position within a sexual network,[3–6] directly exposing AGYW to HIV[7] and facilitating risk behaviors that increase the risk of transmission given exposure.[8,9] Identification of partner types at greatest risk of HIV transmission, coupled with a clear understanding of the key characteristics defining each partner type, could guide the design of tailored HIV prevention interventions.

Current partner classification methods use the following 3 main approaches: (1) isolation of the effect of single partner factors on HIV risk (eg, partner age) and/or the effect of multiple partner factors in a single model holding all other factors constant[7,10]; (2) development of risk scores, which consider multiple partner and individual factors together to identify people at greatest risk of HIV acquisition[11–14]; and (3) sexual partner characterization using prespecified labels (eg, main partner and casual partner).[2,13,15] Each of these approaches has clear limitations. The isolation approach fails to capture the cumulative impact of partner factors on HIV risk.[9] Risk scores typically treat risk factors as exchangeable (a partner simply needs to meet a threshold to be considered "high risk") and additive, rather than potentially interactive. Furthermore, risk scores often incorporate both individual (eg, age and number of sexual partners) and partner factors (eg, partner age and partner concurrency), limiting their ability to discern different types of sexual partners for interventions tailored to a particular partner context. Finally, commonly used partner labels are not explicitly tied to specific partner risk factors[4,9,16] and may be interpreted and applied variably.[17–20]

Latent class analysis (LCA) is a person-centered, data-driven approach that can be used to identify patterns of correlated risk factors and classify people based on these patterns.[21,22] LCA has been used to examine sexual behavior[23–31] and identify sexual partner types,[20,32] but has not been applied to the relationship between sexual partner types and HIV acquisition. We used LCA to identify latent sexual partner types from a set of partner characteristics self-reported by AGYW in rural South Africa and examine the relationship between both LCA-identified and commonly used partner labels and incident HIV infection.

METHODS

Study Setting, Population, and Data Collection

We used longitudinal data from the HIV Prevention Trials Network (HPTN) 068 study, a randomized, controlled trial of cash transfers for HIV prevention among 2533 unmarried AGYW, aged 13–23 years, who were enrolled in school at enrollment.[33,34] Data were collected from March 2011 to March 2015 from AGYW living in rural Mpumalanga Province, South Africa, in households situated in the Agincourt Health and Demographic Surveillance System.[35]

AGYW were seen at baseline and approximately 12, 24, and 36 months until the study completion date or their expected high school completion, whichever came first. Using audio computer-assisted self-interview at each visit, AGYW reported on their 3 most recent sexual partners in the past 12 months and a range of other items, including demographics and behavioral risk factors. AGYW were tested for HIV infection at baseline and each follow-up visit using 2 parallel rapid tests [the Determine HIV-1/2 test (Alere Medical Co., Matsudo-shi, Chiba, Japan) and the US Food and Drug Administration (FDA)-cleared Uni-gold Recombigen HIV test (Trinity Biotech, Bray, County Wicklow, Ireland)]. Additional details about the parent study inclusion criteria and HIV testing can be found in the main publication.[33] The present analysis includes only AGYW who were HIV negative at baseline and reported at least one recent sexual partner during follow-up.

Ethics approval for the parent study was obtained from the University of North Carolina Institutional Review Board, University of the Witwatersrand Human Subjects Ethics Committee, and Mpumalanga Departments of Health and Education. Assent and informed consent were obtained from each participant and her parent/legal guardian at study enrollment. Ethics approval for this secondary analysis was obtained from the University of North Carolina Institutional Review Board.

Sexual Partner Classification

Sexual partner type was measured using 2 approaches. First, AGYW categorized each of their sexual partners using the following prespecified labels: main partner/boyfriend, regular casual sex partner, nonregular casual sex partner, sex work client, or other. The following analysis focuses on the 3 most common partner types (main partner/boyfriend, regular casual sex partner, and nonregular casual sex partner). We excluded sex work and "other" partner types because they were too rare to allow for examination of their associations with HIV infection.

Second, we used LCA to identify sexual partner types based on the following 10 partner characteristics self-reported by the index AGYW for each partner: age ($\geq$5 vs. $<$5 years older than the index); school enrollment (yes/no); children with index (yes/no); children with other women (yes/no/do not know); cohabit with index (yes/no); sex with index only 1 time (yes/no); always uses condom with index (yes/no); HIV-positive (yes/no/do not know); concurrent sexual partners (yes/no/do not know); and transactional sex with index (defined as index feeling obligated to have sex after receiving money or gifts; yes/no). Additional details about the measurement and coding of partner characteristics are available in Table 1, Supplemental Digital Content, http://links.lww.com/QAI/B335.

Statistical Analysis

We generated descriptive statistics by estimating the relative frequencies, means, and SDs for AGYW-level variables at the first visit an AGYW reported a sexual partner and partner-level variables across all study visits.

We used PROC LCA in SAS to identify sexual partner types using the 10 partner characteristics described above.[36] We considered LCA models with 2–8 classes, starting with a 2-class model and increasing the number of classes until the

Akaike Information Criterion (AIC), Bayesian Information Criterion in text (BIC), and G^2 stopped decreasing. We examined the conditional probabilities and latent class prevalences to select the best fitting and most interpretable model with classes large enough to support further analyses, and only considered models where the mean and median posterior probabilities (the probabilities of membership in each latent class given a certain response pattern) were >0.70. We assessed model identification using 100 random start values and examined whether the smallest log-likelihood value corresponded to the modal value.[22]

After model selection, we assigned sexual partners to the partner type for which they had the highest posterior probability of membership. We calculated the relative frequency of each of the 10 partner characteristics by LCA-identified sexual partner type and used these frequencies to interpret and name the sexual partner types (see Supplemental Digital Content, http://links.lww.com/QAI/B335).

To examine the relationship between sexual partner type and incident HIV infection, we created a visit-specific exposure variable for each partner type by looking across all reported partners for a given AGYW at a given visit. An AGYW was considered exposed to a partner type at a given visit if any of her reported partners (of the prior 12 months) included the partner type (yes/no). Because AGYW could report more than one sexual partner type per visit, we defined the referent for the prespecified partner label analyses as having only main partner(s)/boyfriend(s) and the referent for the LCA partner type analysis as having only "monogamous HIV-negative peer partner(s)" (see Results for LCA partner types).

To address the possible limitation of not knowing which partner infected an AGYW if she reported multiple partners at a visit, we conducted a sensitivity analysis where we restricted the data set to AGYW with only one sexual partner at a visit.

We used generalized estimating equations with an exchangeable correlation matrix, binomial distribution, robust variance, and log link to estimate annual risks, risk ratios (RRs), and 95% confidence intervals (CIs) for the relationship between sexual partner type (past 12 months) and incident HIV infection (seroconversion observed at the current visit), controlling for the presence of each other partner type. AGYW entered this analysis on the first visit at which they reported a partner and were censored following seroconversion if they acquired HIV infection. To adjust for confounding, we constructed a directed acyclic graph and identified and adjusted for baseline values of the following minimally sufficient adjustment set: intervention arm, age (in years), school enrollment (yes, no), food insecurity (ever vs. never worrying about having enough food for oneself or family in the past 12 months), depression (score of ≥ 16 vs. <16 on the Center for Epidemiologic Studies Depression Scale[37]), low relationship power (assessed using the South African adaptation of the Sexual Relationship Power Scale[38,39]), intimate partner violence (assessed using the World Health Organization instrument[40]; any vs. no violence by a partner in the past 12 months), alcohol consumption (ever vs. never drinking alcohol), drug use (ever vs. never using drugs), early sexual debut (vaginal or anal sex before age 15 years; yes/no), and number of sexual partners in the past 12 months. In addition, we adjusted for days since the last follow-up visit to account for AGYW who were seen before/after their scheduled annual follow-up visit. All analyses were conducted using SAS (Version 9.4, Cary, NC).

RESULTS

Description of AGYW

Of the 2533 AGYW enrolled in HPTN 068, 1034 tested HIV negative at baseline and reported having sex with at least one sexual partner during follow-up, making them eligible for this analysis. At the visit when they reported their first sexual partner, AGYW were 17.5 years of age on average, most (95%) were enrolled in school, and nearly all reported 3 or fewer partners in the past 12 months (99%), suggesting that the questionnaire captured the majority of AGYW's sexual partners (Table 1). Nearly 70% of included AGYW completed more than one study visit (37.5% completed 2 visits, 25.6% 3 visits, and 6.8% 4 visits) after study entry.

Description of Sexual Partners

Over the course of follow-up, these 1034 AGYW reported 2968 sexual partners (hereafter referred to as partner reports because the same sexual partner could be reported at multiple follow-up visits, and linkage of partner identities across visits was not possible). Nearly half of partner reports (47%) described partners who were not enrolled in school, and 19% of partner reports described partners who were ≥ 5 years older than the AGYW index (Table 2). Nearly a quarter (23%) of partner reports involved partners who had children with the index, and 12% involved partners who had children with other women. One-tenth (11%) were partners who cohabited with the index, whereas one-fifth (19%) were one-time sexual encounters. AGYW reported always using condoms (22%) and transactional sex (26%) in about a quarter of partner reports. Nearly a quarter of partner reports (22%) described partners with concurrent sexual partners, and only 6% of all partner reports were believed to be HIV-positive.

Partner Types Based on LCA

We selected a 5-class latent class model for sexual partner type based on our assessment of model fit, model identification, interpretability over larger models, and class size (see Tables 2–4, Supplemental Digital Content, http://links.lww.com/QAI/B335). These sexual partner types differed with respect to partner sociodemographic and behavioral characteristics, allowing us to name partner types accordingly (Table 2). The 5 sexual partner types, from most to least common, were monogamous HIV-negative peer partner (53% of partner reports); one-time protected in-school peer partner (20%); anonymous out-of-school peer partner (13%); out-of-school older partner (10%); and cohabiting with children in-school peer partner (4%). Only one partner type was composed primarily of older partners

(out-of-school older partners). In 2 partner types, the majority of partners were not enrolled in school (out-of-school older partners and anonymous out-of-school peer partners). Consistent condom use was low across all partner types, except for one-time protected in-school peer partners.

AGYW reported having only monogamous HIV-negative peer partner(s) at 49% of AGYW visits. This label was based on the relatively high proportion of partners believed to not have HIV infection (88%) and not have additional partners concurrent with the index partnership (64%) or children with other women (89%). Most of these partners were less than 5 years older (91%) (Table 2). One-time protected in-school peer partners were reported at 24% of AGYW visits. These partners were similar in age (95%), most were enrolled in school (70%), and many index AGYW reported having sex with these partners only one time (61%) and always using a condom (74%). Out-of-school older partners were reported at 12% of AGYW visits. Most of these partners were ≥5 years older (91%) and not enrolled in school (99%). Anonymous out-of-school peer partners were reported at 15% of AGYW visits. The "anonymous" aspect of this label was based on the high percentage of these partners for whom AGYW reported not knowing whether they had children with other women (71%), concurrent sexual partners (88%), or HIV infection (78%). A high proportion of these partners were similar in age (79%) but not enrolled in school (69%). Finally, cohabiting with children in-school peer partners were reported at 5% of AGYW visits. Most of these partners were similar in age (74%), enrolled in school (72%), and cohabited (92%) and had children (86%) with the index AGYW.

Transactional sex was rare in one-time protected in-school peer partners and common among cohabiting with children in-school peer partners. A high prevalence of partner concurrency did not directly define any specific partner type, but anonymous out-of-school peer partners had the greatest proportion of partners with unknown concurrency status, whereas monogamous HIV-negative peer partners and cohabiting with children in-school peer partners had the greatest proportion of partners believed to not have other concurrent partners.

Partner Types Based on Prespecified Labels

When asked to categorize partners according to prespecified partner labels, AGYW reported having only main partner(s)/boyfriend(s) at 69% of AGYW visits, at least one regular casual sex partner at 20% of AGYW visits, and at least one nonregular casual sex partner at 8% of AGYW visits. Comparing partner types identified by prespecified partner labels vs. LCA, we found that the label main partner/boyfriend was applied broadly across all LCA-identified partner types: 69%–77% of reported partners were labeled main partner/boyfriend, 13%–20% regular casual sex partner, and 4%–8% nonregular casual sex partner across the 5 latent classes [Figure 1, (see Table 5, Supplemental Digital Content, http://links.lww.com/QAI/B335)].

Sexual Partner Type and Incident HIV Infection

Sixty-three incident HIV infections were observed over the course of follow-up, with an annual risk of 2%–3% in the 2 referent groups (only monogamous, HIV-negative peer partner(s), and only main partner/boyfriend(s)) (Table 3). In our analysis of partner types identified through LCA, we found that AGYW with an out-of-school older partner had more than twice the risk of incident HIV infection [adjusted RR (aRR): 2.56, 95% CI: 1.23 to 5.33] compared to AGYW with only monogamous HIV-negative peer partner(s) (Table 3). Having an anonymous out-of-school peer partner (aRR: 1.72, 95% CI: 0.82 to 3.59) was associated with almost twice the risk of incident HIV infection; however, this estimate was imprecise because of the small number of infections (n = 15) and AGYW visits with this partner type (n = 315). By contrast, AGYW who had cohabiting with children in-school peer partners had one-quarter the risk of incident HIV infection compared to AGYW with only monogamous HIV-negative peer partner(s) (aRR: 0.25, 95% CI: 0.02 to 2.85). Results did not vary substantially in the sensitivity analysis limited to AGYW reporting only one sexual partner at a visit (see Table 6, Supplemental Digital Content, http://links.lww.com/QAI/B335).

In the prespecified partner label analysis, we found no association between partner type and incident HIV. Compared to AGYW with only main partner/boyfriend(s), risk of incident HIV infection was not higher among AGYW with

TABLE 1. Characteristics of HIV-Negative, Sexually Active AGYW Aged 13–23 Years in Rural South Africa at Study Entry, From March 2011 to March 2015 (N = 1034 AGYW)*†

	N (%)
Randomized to intervention arm	523 (50.6)
Enrolled in school	987 (94.5)
Food insecure	293 (28.7)
Double orphan	74 (7.2)
Depression	360 (35.0)
Intimate partner violence in the past 12 mo	292 (28.3)
Low relationship power with most recent sexual partner	258 (25.0)
Visited alcohol outlet in the past 6 mo	445 (44.1)
Ever consumed alcohol	171 (16.6)
Ever used drugs	68 (6.6)
	Mean (SD)
Age	17.5 (1.5)
Grade	10.5 (1.1)
Age at the first sex	15.2 (3.4)
Number of sexual partners in the past 12 mo	1.1 (0.7)
Number of sexual partners in lifetime	2.0 (3.2)

*Study entry defined as the first study visit AGYW reported having sex with a partner in the past 12 months.

†Missing: intervention arm 0; age 0; enrolled in school 0; grade 3; food insecure 14; double orphan 4; depression 4; age at the first sex 10; number of sexual partners in the past 12 months 29; number of sexual partners in lifetime 11; intimate partner violence in the past 12 months 68; low relationship power with most recent sexual partner 5; visited alcohol outlet in the past 6 months 24; ever drank alcohol 5; and ever used drugs 1.

TABLE 2. Characteristics of Sexual Partner Types Identified by LCA Among Sexually Active AGYW Aged 13–23 Years in Rural South Africa, From March 2011 to March 2015 (N = 2968 Partner Reports)*†‡

		Sexual Partner Type Identified by LCA				
	All Partner Reports	Monogamous HIV-Negative Peer Partner	One-Time Protected In-School Peer Partner	Anonymous Out-of-School Peer Partner	Out-of-School Older Partner	Cohabiting with Children In-School Peer Partner
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Sexual partner characteristics						
Partner ≥5 y older						
Yes	557 (18.81)	143 (9.15)	22 (3.74)	80 (21.00)	**281 (90.65)**	31 (26.27)
No	2404 (81.19)	**1420 (90.85)**	**567 (96.26)**	**301 (79.00)**	29 (9.35)	**87 (73.73)**
Partner enrolled in school						
Yes	1569 (52.97)	773 (49.36)	**411 (70.14)**	119 (31.32)	4 (1.29)	**86 (71.67)**
No	1393 (47.03)	793 (50.64)	175 (29.86)	**216 (68.68)**	**306 (98.71)**	34 (29.33)
Children with the index AGYW						
Yes	669 (23.01)	442 (28.81)	2 (0.34)	29 (7.75)	101 (33.01)	**95 (85.59)**
No	2238 (76.99)	1092 (71.19)	580 (99.66)	345 (92.25)	205 (66.99)	16 (14.41)
Partner has children with other women						
Yes	368 (12.42)	129 (8.24)	17 (2.89)	29 (7.59)	116 (37.54)	77 (64.17)
No	2229 (75.20)	**1395 (89.14)**	535 (90.99)	80 (20.94)	178 (57.61)	41 (34.17)
Do not know	367 (12.38)	41 (2.62)	36 (6.12)	**273 (71.47)**	15 (4.85)	2 (1.67)
Partner cohabits with the index AGYW						
Yes	338 (11.40)	142 (9.06)	3 (0.51)	36 (9.45)	47 (15.16)	**110 (92.44)**
No	2628 (88.60)	1425 (90.94)	586 (99.49)	345 (90.55)	263 (84.84)	9 (7.56)
Partner had sex with the index AGYW only once						
Yes	557 (18.85)	93 (5.95)	**356 (60.96)**	68 (17.99)	39 (12.58)	1 (0.83)
No	2398 (81.15)	1470 (94.05)	228 (39.04)	310 (82.01)	271 (87.42)	119 (99.17)
Always use condoms with the index AGYW						
Yes	642 (21.76)	90 (6.35)	**431 (73.55)**	59 (15.69)	53 (17.10)	0 (0.00)
No	2309 (78.24)	1460 (93.65)	155 (26.45)	317 (84.31)	257 (82.90)	120 (100.00)
Partner HIV-positive						
Yes	188 (6.35)	66 (4.23)	43 (7.30)	11 (2.88)	45 (14.56)	23 (19.17)
No	2204 (74.43)	**1370 (87.76)**	460 (78.10)	72 (18.85)	207 (66.99)	95 (79.17)
Do not know	569 (19.22)	125 (8.01)	86 (14.60)	**299 (78.27)**	57 (18.45)	2 (1.67)
Partner has other concurrent sexual partners						
Yes	640 (21.60)	367 (23.45)	98 (16.67)	36 (9.47)	100 (32.26)	39 (32.50)
No	1551 (52.35)	**994 (63.51)**	327 (55.61)	10 (2.63)	139 (44.84)	81 (67.50)
Do not know	772 (26.05)	204 (13.04)	163 (27.72)	**334 (87.89)**	71 (22.90)	0 (0.00)
Transactional sex with the index AGYW						
Yes	766 (25.81)	433 (27.63)	32 (5.43)	68 (17.80)	127 (40.97)	106 (88.33)
No	2202 (74.19)	1134 (72.37)	557 (94.57)	314 (82.20)	183 (59.03)	14 (11.67)

*AGYW could report up to 3 sexual partners at each study visit and may have multiple observations due to repeated visits. Sexual partner frequencies include all sexual partners across all follow-up visits. The same partner could be reported at multiple visits; thus, frequencies represent partner reports, not distinct sexual partners. Percentages are column percents by sexual partner type.

†Missing: partner ≥5 years older 7; partner enrolled in school 6; children with index AGYW 61; partner has children with other women 4; cohabit with index AGYW 2; sex with index AGYW only once 13; always use condoms with index AGYW 17; partner HIV positive 10; partner has other concurrent sexual partners 9; and transactional sex with index AGYW 0.

‡Bold values indicate key defining characteristics of partner types based on low or high proportion of partners with a specific characteristic.

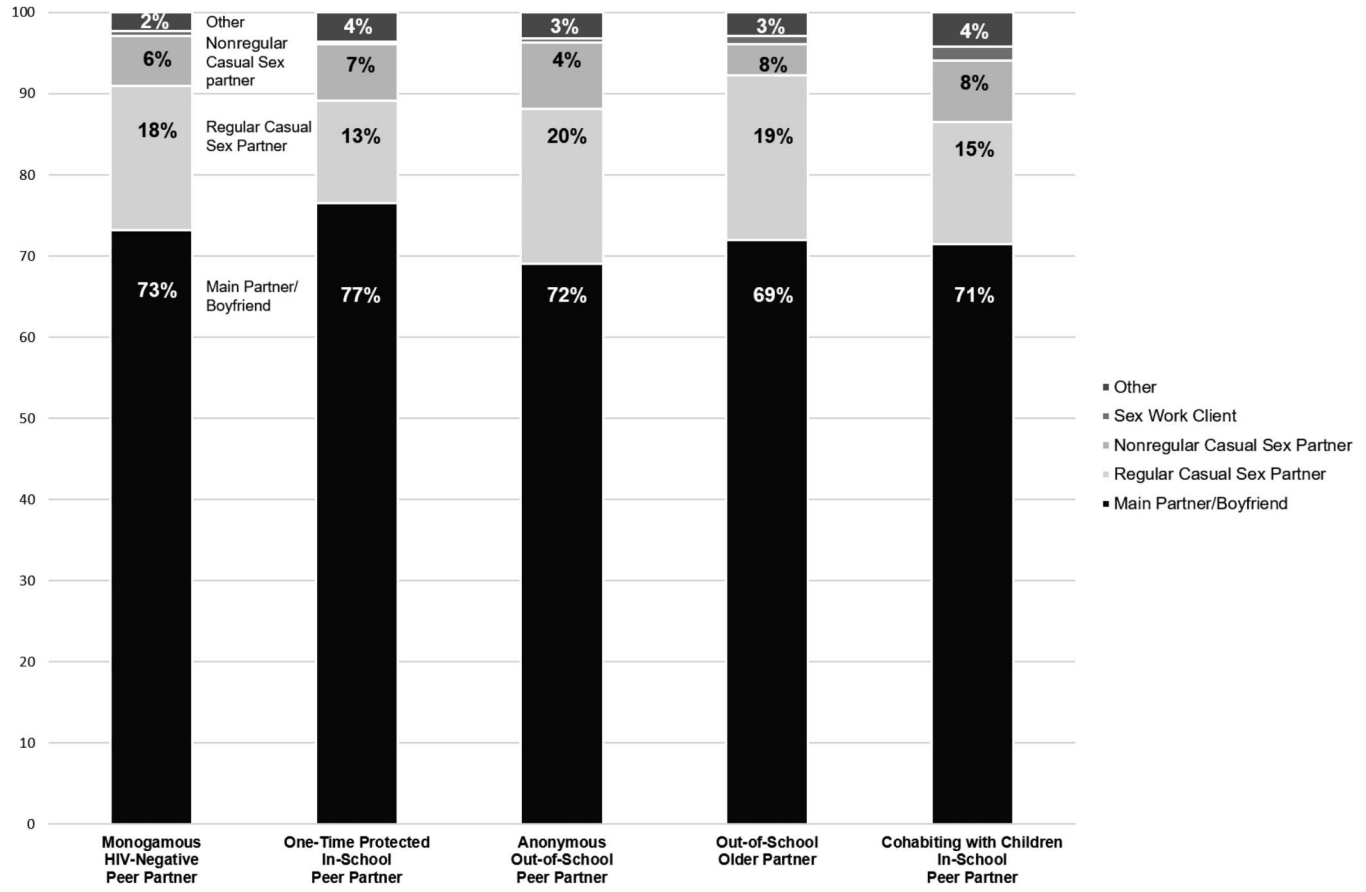

FIGURE 1. Comparison of sexual partner types identified by LCA vs. prespecified partner labels among sexually active AGYW aged 13–23 years in rural South Africa, from March 2011 to March 2015 (N = 2968 partner reports). AGYW could report up to 3 sexual partners at each study visit and may have multiple observations due to repeated visits. Sexual partner frequencies include all sexual partners across all follow-up visits. The same partner could be reported at multiple study visits; thus, frequencies represent partner reports, not distinct sexual partners. Prespecified partner label missing for 7 partners. The figure excludes proportions less than 2% (0.57% of monogamous HIV-negative peer partners; 0.34% of one-time protected in-school peer partners; 0.97% of out-of-school older partners; 0.53% of anonymous out-of-school peer partners; and 1.68% of cohabiting with children in-school peer partners were categorized as sex work clients).

regular casual sex partners (aRR: 1.10, 95% CI: 0.59 to 2.04) or nonregular casual sex partners (aRR: 0.88, 95% CI: 0.34 to 2.30) (Table 3).

DISCUSSION

AGYW in South Africa are at extraordinarily high risk of HIV infection acquisition and urgently need novel HIV prevention approaches. In light of this burden, initiatives to reduce HIV incidence among AGYW, including the DREAMS partnership, have prioritized characterizing sexual partner differences to understand which partners pose the greatest risk of HIV acquisition, and what types of HIV prevention messaging and services are most appealing and effective across different partner contexts. Our study contributes to burgeoning knowledge on sexual partnerships by using rich, partner-level data from multiple sexual partners with a novel, data-driven approach to better characterize and capture the range and complexity of sexual partnerships among rural South African AGYW. This LCA approach allowed us to identify distinct sexual partner types on the basis of explicitly reported partner characteristics and to predict the associated risk of HIV acquisition among AGYW, independent of individual-level risk factors. By contrast, partner types based on commonly used partner labels (eg, main, casual) obscured important differences between partners, with AGYW applying the label main partner/boyfriend broadly to describe a range of partner types identified by LCA. Furthermore, and importantly, these partner labels did not identify AGYW at risk of acquiring HIV infection. These findings provide strong evidence that commonly used partner labels may be a poor proxy for underlying demographic and behavioral differences that influence risk of HIV infection acquisition, and that more descriptive approaches—such as LCA—that are based on clusters of specific, reported characteristics may be more informative and useful for intervention design and allocation.

Using LCA, we found that AGYW with out-of-school older partners had more than twice the risk of incident HIV infection compared to AGYW with only monogamous

TABLE 3. Unadjusted RR, aRR, and 95% CI for the Association Between Sexual Partner Type and Incident HIV Infection Among Sexually Active AGYW Aged 13–23 Years in Rural South Africa, From March 2011 to March 2015 (N = 2140 AGYW Visits)*†

	HIV Infections	AGYW Visits‡	Risk (95% CI)	RR (95% CI)§	aRR (95% CI)‖
Prespecified partner label					
Any regular casual sex partner	16	436	0.035 (0.020 to 0.060)	1.15 (0.62 to 2.12)	1.10 (0.59 to 2.04)
Any nonregular casual sex partner	6	171	0.027 (0.010 to 0.073)	0.89 (0.31 to 2.54)	0.88 (0.34 to 2.30)
Only main partner/boyfriend(s)	43	1470	0.030 (0.022 to 0.041)	1.	1.
LCA-identified sexual partner type					
Any out-of-school older partner	17	266	0.058 (0.035 to 0.097)	2.60 (1.35 to 5.01)	2.56 (1.23 to 5.33)
Any anonymous out-of-school peer partner	15	315	0.039 (0.022 to 0.070)	1.75 (0.86 to 3.57)	1.72 (0.82 to 3.59)
Any one-time protected in-school peer partner	14	515	0.024 (0.013 to 0.044)	1.05 (0.50 to 2.21)	1.11 (0.51 to 2.41)
Any cohabiting with children in-school peer partner	2	97	0.015 (0.0036 to 0.066)	0.69 (0.15 to 3.13)	0.25 (0.02 to 2.85)
Only monogamous HIV-negative peer partner(s)	23	1050	0.022 (0.015 to 0.034)	1.	1.

*Sexual partner type was measured using 2 approaches. Prespecified partner type labels: AGYW were asked to categorize each of their sexual partners using the following labels: main partner/boyfriend, regular casual sex partner, nonregular casual sex partner, sex work partner (data not shown), and other partner (data not shown). LCA-identified sexual partner type: We used LCA to identify 5 sexual partner types: out-of-school older partners, one-time protected in-school peer partners, anonymous out-of-school peer partners, monogamous HIV-negative peer partners, and cohabiting with children in-school peer partners. In all cases, sexual partners were identified based on partner characteristics self-reported by the AGYW.

†Missing: prespecified partner label 4; LCA-identified sexual partner type 0.

‡AGYW could report up to 3 sexual partners at each study visit and may have multiple observations due to repeated study visits. Frequencies represent how often a specific sexual partner type was reported at a specific study visit. Partners were not followed longitudinally; thus, the same partner could be reported at multiple study visits.

§RR and 95% CIs for the association between AGYW having a specific sexual partner type and incident HIV infection were estimated using generalized estimating equations, with an exchangeable correlation matrix, binomial distribution, robust variance, and log link.

‖Models were adjusted for the following confounders to estimate aRR: intervention arm, age, school enrollment, food insecurity, depression, low relationship power, intimate partner violence, alcohol consumption, drug use, early sexual debut, number of sexual partners in the past 12 months, days since the last follow-up visit, and the presence of each other partner type.

HIV-negative peer partner(s). This finding supports the hypothesis that age-disparate partnerships contribute to the rapid spread of HIV infection among young women in Southern and Eastern Africa and are in line with recent longitudinal studies.[41–44] AGYW with these partners are clearly a vulnerable population in need of intervention. At the same time, we note that many characteristics commonly associated with older partners and HIV risk—including partner concurrency,[45] condomless sex,[46–48] and transactional sex[8,46,49–51]—were not unique to older out-of-school partners. Most AGYW reported partners similar in age: peer-aged partners were on average 2–3 years older than AGYW, whereas out-of-school older partners were only 6 years old. Thus, focusing exclusively on partner age as a proxy for other risk behavior may miss AGYW with other partner types who are also at high risk of HIV acquisition. For example, AGYW with similarly aged, anonymous out-of-school peer partners were also at increased risk of incident HIV infection compared to AGYW with only monogamous HIV-negative peer partner(s).

Consistent condom use was generally low across all partner types except for one-time protected in-school peer partners, with whom many AGYW reported having sex only once. These results support earlier findings that AGYW quickly phase out condoms with new sexual partners[7,52–55] and are concerning in their suggestion that condom use does not increase substantially with partners associated with higher risk of HIV acquisition (eg, condom use was similar between lower-risk monogamous HIV-negative peer partners and higher-risk out-of-school older partners). Tailored messaging that encourages condom use along with other combination prevention approaches may be important for AGYW in high-risk partner contexts.

Transactional sex was most commonly reported for cohabiting with children in-school peer partners and out-of-school older partners. Although transactional sex has previously been shown to increase the risk of HIV infection among young women in South Africa,[56–58] we found that having a cohabiting with children in-school peer partner was protective against HIV acquisition, whereas having an out-of-school older partner increased risk of HIV infection. It is possible that AGYW with cohabiting with children peer partners were married and that our measure of transactional sex captured exchanges in the context of a marital relationship, which have been associated with lower HIV incidence.[2] We do not have data on marital status or resources given in the context of cohabiting or coparenting, as living with a parent/guardian and not being married were inclusion criteria for the parent study. Formal marriage is less common among young people in rural South Africa than in other contexts[59,60]; thus, it is also possible that the high probability of transactional sex among cohabiting with children in-school peer partners reflects financial support/"damages" (*inhlawulo*) related to getting an AGYW pregnant.[61] Given that exchanges between sexual partners can take a variety of forms and can be motivated by many different factors (including meeting basic needs, establishing social status, and demonstrating love),[8,49,56,62–67] it is important to consider transactional sex within the context of sexual partnerships, rather than an isolated risk behavior, when examining its relationship with HIV and designing interventions.

Findings from this study should be interpreted considering the following considerations. First, sexual partner types were derived based on AGYW self-reported partner characteristics and may be subject to misclassification, recall, and/or social desirability bias. We minimized these biases by

collecting partner data using audio computer-assisted self-interview and limiting reported partners to the 3 most recent sexual partners in the past year. We also note that because HIV risk is commonly assessed using self-reported information, our approach is relevant to real-world partner identification.

Second, there is a possibility of misattribution of HIV transmission to the wrong partner type if AGYW reported multiple sexual partners in a follow-up interval, particularly because temporality of infection acquisition and partnership initiation within an interval could not be established. In sensitivity analyses, we found that our LCA results were robust when we limited our sample to AGYW who reported only one sexual partner at a given visit, suggesting potential misattribution did not bias our results. We also assigned partners to a type based on the highest posterior probability of class membership, which does not account for the uncertainty of classification present in all latent class analyses and can raise concerns about misclassification of partners. Studies examining the impact of this uncertainty and potential misclassification have shown that the maximum-posterior-probability approach tends to underestimate the association between latent variables and the outcomes of interest.[68,69] Although statistical methods have been derived to account for uncertainty of class assignment in relatively simple regression models, they are not readily extendable to our context of multiple possible partner types for a given AGYW at a given visit, the time-varying nature of the exposure across visits, and generalized estimating equation prediction of incident HIV infection at the AGYW level.

Third, these findings may not be generalizable to other populations or contexts. Most AGYW in this study were enrolled in school, which substantially reduces their risk of HIV infection.[33,70] In addition, LCA is a data-driven approach; thus, findings may be highly specific to this population. We believe that providing highly specific information about partners associated with the greatest risk of HIV infection for school-going AGYW in the study region is valuable because it can inform more tailored interventions for those at greatest risk in this high-burden setting, even if these results do not generalize to other settings. In addition, our data-driven approach allowed us to identify a previously unknown, rare partner type—cohabiting with children in-school peer partners—associated with a low risk of AGYW HIV acquisition even in the presence of suspected partner concurrency and low condom use. Cohabiting and having a child together may reflect a more committed partnership and acceptance by the partner/partner's family,[71] leading to greater social/financial support for the AGYW and reduced HIV risk, at least in the short term. Still, further investigation over a longer time frame may be warranted, as HIV incidence may rise over time as partners age, particularly if low condom use and partner concurrency remain features of these partnerships, and cohabitation was forced by parents.

AGYW in South Africa face significant HIV burden and are a key population in need of intervention. Sexual partners play an important role in HIV transmission but have not been characterized in ways that inform prevention efforts tailored to specific, multifaceted partner types. We found that partner types based on combinations of explicit, reported partner characteristics predicted incident HIV infection among AGYW and may be more informative than traditional, prespecified partner labels, which were not associated with HIV risk. In addition, although older partners were associated with increased risk of HIV acquisition in AGYW, efforts to prevent HIV should not focus singularly on partner age, as certain types of peer-aged partners posed substantial risk as well. Finally, we found that condomless and transactional sex were present across partner types with variable observed HIV acquisition risk, indicating that these behaviors should be examined within the broader context of a partnership. Collectively, these findings suggest that interventions that account for contextual differences between sexual partner types and that address the specific prevention needs and risks posed by different partners may be important for preventing HIV infection in this vulnerable population.

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