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Title: Sexual partnership concurrency and age disparities associated with sexually transmitted infection (STI) and risk behavior in rural communities in Kenya and Uganda

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Sexual partnership concurrency and age disparities associated with sexually transmitted infection (STI) and risk behavior in rural communities in Kenya and Uganda

ABSTRACT

Objectives

We examined sex-specific associations between partner age-disparity and relationship concurrency on *Neisseria gonorrhoeae* and/or *Chlamydia trachomatis* (NG/CT) infection, higher-risk relationships, and condom use as proxies for HIV risk.

Methods

Data were collected in 2016 from 2179 adults in 12 communities in Uganda and Kenya. Logistic regression models examined associations of age-disparity and relationship concurrency on NG/CT, condom use, and higher-risk (commercial sex and other higher-risk) relationships, in past 6-months, controlling for covariates.

Results

Partner age and relationship concurrency were associated with NG/CT in women, but not men: relative to women in age-disparate relationships, women in age-disparate and homogeneous relationships had higher odds of NG/CT (aOR=3.82, 95%CI:1.46-9.98). Among men and women, partnership concurrency was associated with higher-risk partnerships. Additionally, relative to those with a single age-homogenous partner, those with concurrent age-homogenous partners had higher odds of condom use (men: aOR=2.85, 95%CI=1.89-4.31; women: aOR=2.99, 95%CI=1.52-5.89). Concurrent age-disparate partnerships were associated with condom use among men only (aOR=4.02, 95%CI: 2.54-6.37).

Conclusions

Findings underscore the importance of targeted HIV prevention efforts for couples in age-disparate and concurrent relationships.

Keywords: Age-disparity, sexual risk, HIV acquisition, STIs, *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, concurrency, population mobility, sub-Saharan Africa

BACKGOUND

While global trends in HIV infection point to declining HIV incidence in many world regions, incident HIV infection persists in sub-Saharan Africa (SSA). A disproportionate burden of HIV among key populations exist including among women and girls, who account for 59% of all new HIV infections and a high proportion of people living with HIV in eastern and southern Africa (12.3 million women 15+ years compared to 7.3 million men 15+ years) (Karim and Baxter, 2019; Scully, 2018; Sia et al., 2020; UNAIDS, 2020). Sex-specific factors for this disparate outcome include not only biological (Liebenberg et al., 2019) but social-behavioral drivers for young women, including early age of sexual debut, unprotected sex, and limited agency and relational decision-making (Kidman and Kohler, 2019; Maughan-Brown et al., 2019; Mwinnyaa et al., 2018). Further, sexually transmitted infections (STIs), which often have a higher prevalence in women than in men (Buvé et al., 2007), have been shown to increase HIV acquisition risk and transmission (Dubbink et al., 2018; Jongen et al., 2021; Kharsany et al., 2020) and can serve as a bio-marker for unprotected sexual intercourse (Osinde et al., 2012).

Equally as important and less researched, is the role of age-disparate relationships—having at least a 5-year gap in the age of partners—on HIV-acquisition and transmission (Leclerc-Madlala, 2008; UNAIDS, 2015). While HIV incidence among young women is partly attributed to being in sexual relationships with older men (Maughan-Brown et al., 2019; Mwinnyaa et al., 2018), research examining the interplay between age-disparity and HIV has produced mixed results. Studies suggest that prior to widespread ART usage, young women in age-disparate relationships were at an elevated risk for HIV due to their older partner's burden of HIV, STIs, and the occurrence of riskier sexual behavior such as transactional and condomless sex and concurrent relationships (Evan et al., 2016; Maughan-Brown et al., 2016; McKinnon and Karim, 2016; Mwinnyaa et al., 2018). In these relationships, younger women often lack the agency to negotiate safer sex due to power differentials and the transactional nature that define them (Maughan-Brown et al., 2014). Conversely, associations between age-disparate relationships for young women and a decreased risk of HIV acquisition from people living with HIV exist (Maughan-Brown et al., 2018; Street et al., 2016). This research posits that HIV testing is positively correlated with age, and therefore, in the context of U=U (Undetectable = Untransmittable/uninfectious) older men are more likely to be diagnosed, linked to HIV care, virally suppressed, and unlikely to pose additional risk of infection for young women in comparison to their younger counterparts (Akinyi et al., 2017; Govender et al., 2019; Houle et al., 2018; Maughan-Brown et al., 2018; Youssef et al., 2018). A study in KwaZulu Natal found that age-disparate relationships protected young women from increased risk of HIV acquisition (Harling et al., 2014). Thus, whether a male partners' older age is protective or presents potentially higher HIV risk to younger women may depend on levels of HIV care engagement and viral suppression among men living with HIV in a population.

Furthermore, relationship concurrency—any temporal overlap of one or more sexual relationships—has the potential to compound HIV risk, especially among women in age-disparate relationships where their partners have multiple other partners (Steffenson et al., 2011; Tanser et al., 2011; Wilson Chialepeh and Sathiyasusuman, 2015). The number of partners in a network increases the cumulative odds of one or more partners having HIV and a detectable viral load, increasing the risk for HIV acquisition (McKinnon and Karim, 2016). However, if older male partners are virally suppressed and connected to care, they may not spread HIV within concurrent relationships. While there may be synergistic effects between age-disparate relationships and concurrency that may boost the scale of the HIV epidemic, the literature is inconclusive.

The complex dynamic of age-disparity and sexual and behavioral risks, further complicated by the dynamics of mobility, which shapes and interacts with the sexual behaviors of women and men, geographically links centers of infection, incentivizes riskier sexual behavior, and disrupts ongoing HIV care (Camlin et al., 2019; Camlin and Charlebois, 2019; Deane et al., 2010; Isdory et al., 2015; Kreniske et al., 2019; Schuyler et al., 2017; Vissers et al., 2008). Mobility can therefore negate some of the benefits that might otherwise be achieved from HIV care engagement.

Therefore, among a highly mobile population in Uganda and Kenya, we sought to measure associations between partner age-mixing (i.e., sex with people outside of one's age group) and partnership concurrency on the outcome of higher-risk sexual behaviors (measured three ways: 1. active *Chlamydia trachomatis* (CT) and/or *Neisseria gonorrhoeae* (NG) infection), 2. higher-risk partnerships (defined as relationships that were reported as casual sex, one-night stands, commercial sex worker/client, or inherited partner) and, 3. condom use), as proxies for HIV exposure risk. In this way, we hoped to shed light on whether age-disparate relationships are protective for women because their older partners are virally suppressed or whether in this population, age-disparate relationships and concurrency are continuing to place women at increased HIV risk.

METHODS (627 words)

Study design and setting

This study leveraged the Sustainable East Africa Research in Community Health (SEARCH) trial (NCT# 01864603), a 6-year cluster-randomized trial in 32 communities in three regions in Kenya and Uganda, to test the effectiveness of a universal testing and treatment approach for reducing community HIV incidence (Havlir et al., 2019). This study was embedded within 12 of the 32 SEARCH communities, and measured the mobility of individuals in these communities and the impact on HIV incidence and the HIV care cascade.

A multi-level stratified random sampling design based on SEARCH study arm (intervention or control), HIV status (positive or negative), and mobility (non-mobile or mobile) was used to select the sample from the adult population of each of the 12 SEARCH communities. The 12 communities were selected purposively to reflect underlying heterogeneity in forms of mobility across SEARCH communities and were composed of three communities each from two regions of Uganda and three inland and three Lake Victoria shoreline communities in Kenya. Mobile and HIV-positive individuals were oversampled to achieve the desired sample size in each stratum.

Ethical approvals were granted by the Ethical Review Committee of the Kenya Medical Research Institute (KEMRI/SERU/CMR/3052), Makerere University School of Medicine Research and Ethics Committee (2015-040), the Uganda National Council for Science and Technology (HS 1834), and the University of California San Francisco Committee on Human Research (14-15058). All participants provided written informed consent to participate in this study.

Eligibility criteria

Study inclusion was restricted to individuals in the 12 selected SEARCH communities who were aged 16 and older, and for whom baseline HIV sero-status and mobility status was available. HIV status was ascertained using rapid, finger-prick blood based HIV antibody testing and counseling following Ministry of Health guidelines.

Data collection

Mobility and sexual risk behaviors survey data as well as urine samples to screen for *C. trachomatis* (CT) and *N. gonorrhoeae* (NG) were collected during a baseline visit between February and November 2016. Of 2750 possible study participants, 2601 agreed to provide urine samples. Data were collected within rural communities with varying levels of geographic mobility and at the participant's preferred location; research assistants visited participants to collect survey data and biological specimens. Survey data were collected using custom-designed Microsoft Windows forms and an Access database on programmed tablets, and took about one and a half hours to complete. The study used a novel survey instrument, described in detail elsewhere (Camlin et al., 2018; Camlin et al., 2019), that was developed to measure the complex forms of movement that are emergent in low and middle income country settings such as eastern Africa, including women's mobility. Participants were asked about their histories of migration over their lifetimes and mobility in the past six months by purpose, location, and frequency. The study also developed a Relationship History Calendar survey (Camlin et al., 2018), adapted from an instrument previously used in the region and shown to reduce social desirability bias to improve the reporting of sexual relationships and behavior (Luke et al., 2011), to collect information about sexual behavior and partnerships in the past five years; data were collected month-by-month on the type of relationships, and sexual behaviors with each partner, including condom use. Prior to data collection, the customized electronic questionnaire was piloted and pre-tested. For participants who provided urine samples, 7mls of urine were pipetted and transferred into manufacturer provided transport reagent tubes containing a buffer solution/preservative and tightened securely. Urine samples were stored in refrigerated (at 2-8^{o}C) boxes while in the field and transported to a regional laboratory (Mbita in Kenya, Mbarara in Uganda) twice a week. Samples were kept in laboratory fridge at 2-8^{o}C for up to 45 days as per guidelines on manufacturer provided urine transport tube. Most samples were processed within one to two weeks of receipt at the lab and screened for CT/NG using the GeneXpert® CT/NG RT-PCR assay (Cepheid, Sunnyvale, CA, USA) (Tabrizi et al., 2013).

Data Analysis

Independent variables: The primary independent exposure variables of interest were 1) age-disparate relationships in the past six months, based on the UNAIDS definition of relationships with a 5-year or greater age-disparity between the partners' age (UNAIDS, 2015), and 2) partnership concurrency in the past six months. We generated seven different variables that are described in Table 1.

Dependent variables: Three outcome measures of sexual risk behaviors were assessed: (1) active *Chlamydia Trachomatis* (CT) and/or *Neisseria Gonorrhoeae* (NG) infection at the time of sample collection, (2) higher-risk sexual relationship (defined as relationships that were reported as casual sex, one-night stands, commercial sex worker/client, or inherited partner; excluding concurrent partnerships) in the past six months, and (3) any condom use in the past six-months.

Statistical analyses were performed using Stata version 16.1 (StataCorp, College Station, TX, USA). Characteristics of the study populations were summarized by sex. Bivariate comparisons that accounted for clustering of individuals within communities (Rao-Scott F-tests) were used to characterize the relationship between characteristics of interest and sex. Sex-stratified logistic regression models with robust standard errors were used to ascertain associations between age-disparity classifications and sexual risk, controlling for age, occupation, household wealth index, HIV status, mobility in the past six months and adjusting for community clustering. All variables that were significant at the bivariate level and the main exposures were included in model building. The best model was selected based on the Akaike Information criterion (AIC) (since it is less likely to miss potentially important variables). Measures of association are expressed as adjusted odds ratios (aORs) and p-values (two-sided) with <0.05 considered statistically significant. All observations were used in models, but some models have lower sample sizes because the model has dropped those observations which predict the outcome perfectly. As a sensitivity analysis, due to small numbers of positive responses for some variables in models involving the higher-risk sexual relationship variable, we refitted penalized maximum likelihood estimation methods (Heinze, 2006). Confidence intervals were generated via cluster bootstrapping based on 5,000 bootstrap samples.

RESULTS

Demographic and relationship characteristics

Demographics. Of the 2750 participants enrolled in the study, 2179 (79.2 %) had complete survey and relationship calendar history data, including partner age, had a relationship within the past six months, and were thus included in our analyses. In addition, of those who had complete relationship calendar history data, 2082 had provided a urine sample to screen for CT/NG. Women comprised 51.2% of the sample. The age composition of the sample reflected the underlying population structure with somewhat higher proportions of women (34.5%) than men (24.6%) aged 25-34, and of men (28.5%) than women (26.3%) aged 35-44. A large proportion of participants (81.3%) were exclusively in relatively low-risk HIV acquisition occupations such as farming and shop keeping, while 18.7% were in informal higher HIV acquisition risk occupations such as trucking and fishing. Most men and women (76.7% and 86.1%, respectively) were engaged in lower-risk employment as compared to those in informal higher-risk employment (23.3% and 13.9% respectively, $p<0.001$). Most women (81.2%) and men (72.1%) completed primary level education, while 18.8% of women and 27.9% of men completed a secondary level education. Some men (15.3%) and women (14.0%) had household wealth indices in the lowest quintile (Table 2).

Mobility and travel. Overall, 53.9% reported travel in the past six months (Table 2). Overall, more women (56.6%) than men (33.7%) travelled for non-work related reasons, while more men (23.1%) than women (2.7%) travelled for work-related reasons. There was a significant difference in travel in the past six months by sex, with more women (58.0%) than men (49.9%) reporting travel for either work or non-work related reasons ($p<0.001$) (Table 2).

Distribution of age-disparate relationships. Overall, 57.6% of participants reported one sexual relationship, while 21.6% reported having more than one sexual relationship in the past six months (data not shown). The majority of the relationships were only age-disparate (46.2%), as compared to both age-disparate and homogeneous (37.4%), and only age-homogeneous (16.4%). There were significant sex differences in the patterns of relationship age-disparity reported in the last six months. More men (51.1%) than women (41.0%) reported age-disparate relationships ($p<0.001$) (Fig 1). Among women, a greater proportion reported age-disparate (41.0%) compared to both age-disparate and homogeneous (36.7%) or age-homogeneous (22.3%) relationships ($p<0.001$). Reflecting the age-sex mixing pattern in the population, a similar pattern was observed among men, with a greater proportion reporting age-disparate relationship compared to those reporting both age-disparate and homogeneous and age-homogeneous relationships (all $p<0.001$) (Fig 1).

Distribution of concurrent sexual relationships. Among the participants with sexual relationships in the last six months, 15.1% had at least one concurrent relationship; more men (24.2%) than women (5.6%) reported concurrency ($p=0.001$). Figure 2 shows the distribution of age-difference classifications with concurrency by sex. As shown, larger proportions of men than women reported concurrent partnerships of all types in the past 6 months. Specifically, 23.4% of men vs. 4.5% of women reported concurrent age-disparate partners; 14.8% men vs. 4.3% women age-homogenous concurrent partners, and 19.0% men vs. 3.2% women concurrent cross-generational partners (all $p<0.001$) (Table 2).

Higher-risk sexual partnerships, CT/NG, and condom use

Overall, 3.4% of the participants had a positive test for CT (51.4%), NG (44.3%), or both (4.3%) (Table 3). Almost 10% reported having at least one higher-risk relationship in the past six months (casual sex partner, one-night stand, commercial sex, or other higher-risk partner), with more men (24.3%) than women (5.5%) reporting these types of partners ($p<0.001$). Overall, 32.5% of participants reported using a condom in the past six months, with more men (27.5%) than women (19.7 %) reporting condom use ($p<0.001$).

Effect of age-disparity on sexual risk behaviors, by sex

Table 4 shows results of sex-specific multiple logistic regression models examining associations between age-disparate relationship classifications with outcomes of CT/NG (5 models), higher-risk sexual partnerships (5 models), and condom use in past six months (5 models), respectively. As shown, there were pronounced independent associations of partner age and partnership concurrency on active CT/NG in women, but not in men. Relative to women in age-disparate relationships, women in age-homogeneous relationships had nearly three-fold higher odds of active CT/NG (aOR=2.87, 95%CI: 1.18-6.98), and women reporting both age-disparate and age-homogeneous relationships had almost four-fold higher odds of CT/NG (aOR=3.82, 95%CI: 1.46-9.98). Independently, relative to women with only one age-homogeneous relationship in the past six months, women in concurrent cross-generational relationships had more than six-fold higher odds of CT/NG (aOR=6.18, 95%CI: 1.54-24.83) (Table 4). Fig 3a presents the effect sizes of mutually classified variables of concurrent age-disparity on CT/NG occurrence, by sex. The observed effect sizes varied by sex; with greater effects among women as compared to men.

In contrast, among both men and women, sexual partnership concurrency was very highly associated with having also had a higher-risk sex partner in past six months. Relative to those in non-concurrent age-homogenous relationships, associations between concurrent age-disparate partnerships and higher-risk partnerships were significant in men (aOR=13.02, 95%CI: 5.06-33.46) and concurrent cross-generational relationships with higher-risk partnerships in men (aOR=17.77, 95%CI: 7.00-45.19) and women (aOR=16.55, 95%CI: 5.99-45.70) (Table 4). Relative to their counterparts with a single age-homogenous partner in the past six months, those with concurrent partners of all types had higher odds of at least one of those partners having been a higher-risk partner. Sensitivity analysis results (data not shown), aligned closely with the main results presented above and yielded identical substantive conclusions, lending additional confidence to the main results shown in Table 4. Fig 3b presents the effect size of mutually classified variables of concurrent age-disparity on higher-risk partnerships, by sex. The observed effect sizes are fairly evenly distributed by sex with the exception of age-homogeneous relationships where a greater effect was observed in men compared to women.

Similarly, relative to women in age-disparate relationships, women in age-homogeneous relationships had higher odds of reporting any condom use in the last six months (aOR=1.55, 95%CI: 1.03-2.33). Associations between concurrent age-disparate partnerships and any condom use in the past six months were only significant among men (aOR=4.02, 95%CI: 2.54-6.37). Relative to their counterparts with a single age-homogenous partner in the past six months, those with concurrent age-homogenous partners had higher odds of reporting condom use among both men (aOR=2.85, 95%CI: 1.89-4.31), and women (aOR=2.99, 95%CI: 1.52-5.89). A similar pattern was observed among those with a single age cross-generational partner in the past six months, those with concurrent partners of all types had higher odds of reporting condom use among both men and women (Table 4).

Discussion

This study reveals how age-mixing patterns and concurrency in sexual partnerships are associated with higher-risk sexual behaviors (such as CT/NG infection, having a higher-risk sexual partner, and lack of condom use) that can be used as proxies for HIV acquisition risk among adults in rural Eastern African communities. Importantly, these associations differed by sex and reveal highly gendered patterns of partner selection and sexual behavior.

Men were much more likely than women to report concurrent partnerships, while women were more likely to report just one partner in the past six months. Larger proportions of men than women were in both non-concurrent and concurrent cross-generational partnerships (i.e. most often, male partner ten or more years older than female partner), while larger proportions of women than men were in non-concurrent partnerships, including both age-homogenous and age-disparate partners (most often, male partner five or more years older than female partner). Tiny proportions of both men and women had concurrent partners who were age-mates.

In this study, women in relationships with both older and same-age partners had significantly greater odds of having active CT/NG in the past 6 months, a finding consistent with prior South African research (Beauclair et al., 2012; Street et al., 2016). Additionally, women had greater odds of having active CT/NG if they were in a concurrent age-homogeneous, age-disparate, or cross-generational relationships, suggesting that in this setting irrespective of whether one has a relationship with a peer, the risk for STIs as a result of any relationship concurrency is high, and may increase risk of HIV acquisition or onward transmission. Prior research has shown individual-level associations between concurrent relationships and HIV infection risk (Kenyon et al., 2016), due to the heightened risk of potential exposure via several partners rather than differences in specific sexual behaviors (Stoner et al., 2019). While almost all types of age-disparate or concurrent relationships increase the risk for active CT/NG among women, the same effect was not present for men irrespective of the type of relationship age disparity or concurrency. While young women in particular may be more susceptible to STIs for a host of biological and sociological reasons (Buvé et al., 2007), men may be less susceptible for various reasons (e.g. less efficient female-to-male transmission) (Buvé et al., 2007). Although it is hypothesized that older men who are virologically suppressed might pose less HIV acquisition risk to younger women, if we use CT/NG results as a proxy for unprotected sex, then condomless sex is taking place. Therefore, although women may be at risk for HIV acquisition depending on the level of viral suppression in their partners, they remain at risk for unintended pregnancies and STIs and their associated sequela.

Those with concurrent and age-disparate relationships were also more likely to report having higher-risk partners (such as casual or commercial sex partners), thus increasing their potential exposure to HIV infection or onward transmission of HIV. Although this study did not explore associations with HIV infection directly, evidence suggests age-disparate relationships may increase HIV-infection risk, particularly for young women (Bajunirwe et al., 2020; Maughan-Brown et al., 2019, 2018; Mwinnyaa et al., 2018). Both women and men had greater odds of a higher-risk partner regardless of whether their concurrent relationships were age-homogenous, age-disparate, or cross-generational. However, the odds of having a higher-risk partner were almost always higher for men. It is possible that these risks are linked to population mobility. We have previously reported high levels of population migration and shorter-term mobility in this population (with more work-related travel conducted by men and more non-work related travel reported by women) as well as highly gendered associations of higher-risk sexual behaviors with mobility (Camlin et al., 2018). In particular, we have reported high levels of relationship concurrency in this population, with men reporting more overall concurrency than women (Camlin et al., 2018). It is possible that high-levels of population mobility are contributing to men and women having greater opportunities for concurrent and higher-risk partnerships.

Our findings on condom use also point to the gendered nature of age-disparate relationships. In this study, women had increased odds of using a condom in an age-homogenous relationship and both men and women had about equal odds of condom use within concurrent age-homogenous relationships, suggesting, as one might expect, that women have more agency to ask for and use condoms when they are in relationships with their age mates. Men however had greater odds of condom use in age disparate relationships while there was no significant effect for women, suggesting that men have more control over condom use in these relationships while women may lack the power to negotiate safer sex due to power differentials (Maughan-Brown et al., 2014). Interestingly, both men and women had about equal odds of using condoms in cross-generational relationships. One might expect that these relationships would be the least equal in terms of social power or be the most transactional in nature, but it may also be that both men and women are aware of the higher risk for STIs, HIV, and unintended pregnancy in these relationships and are therefore using condoms to protect themselves and their partners from these risks.

Our findings, particularly those on CT/NG infection and higher-risk partnerships support the notion that age-disparate relationships involve unprotected sex, which may fuel HIV transmission. Although our findings present evidence of an association between age-disparate relationships, concurrent relationships, and higher-risk sexual behavior, the precise mechanisms that underlie potential causation have not been definitively explored in this study.

This study had many strengths but also some limitations. First, there was potential of misreporting relationship types and possible error in reporting of partner's age. Data were collected from the index-participant suggesting the information provided may be susceptible to recall bias, but, to keep recall bias at a minimum, we opted to only ascertain a participant's partner history for the past 6 months. In addition, although HIV incidence is an essential outcome of clinical importance, this study in a sample of residents in 12 communities was not powered to detect differences in HIV incidence; the larger intervention trial in 32 communities in which this study was embedded found that cumulative HIV incidence was low and declined by 32% over a three-year period to 0.77% in the intervention and 0.81% in the control (Havlir et al., 2019). Finally, the sampling design of this study reflected its purpose to ascertain the relationship of high-resolution measures of mobility with outcomes of interest including measures of sexual risk behavior; the study did not aim to develop generalizable population estimates of levels of mobility or of risk behavior.

Conclusion

Relationship age-disparity and relationship concurrency have important gendered associations with NG/CT infection, higher-risk sexual partnerships, and condom use. These findings have policy implications and highlight the relevancy of gender targeted and inclusive interventions to reduce sexual risk behaviors among communities in East Africa. These interventions should also be multidimensional given the complex collection of motives that prompt men and women to engage in age-disparate relationships (Leclerc-Madlala, 2008). Our findings underscore the importance of targeted HIV prevention efforts for couples in age-disparate and concurrent relationships, with a focus on mobile populations especially warranted.

Author contributions

Conceptualization: JO, MG, CSC; Funding acquisition: CSC; Methodology: CSC, JO, EC; Investigation: CSC, EC, CC, EB, MG, TBN, SS. Data curation: JO, SAG; Formal analysis: JO, MG; Writing – original draft: JO, MG, CSC; Writing – review & editing: JO, JL, MG, SL, SAG, EC, CSC. All authors participated in review and approval of the final manuscript.

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Availability of data and material

The datasets used for this study are available from the corresponding author on reasonable request.

Declaration of interests

We declare no competing interests.

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Figure legends

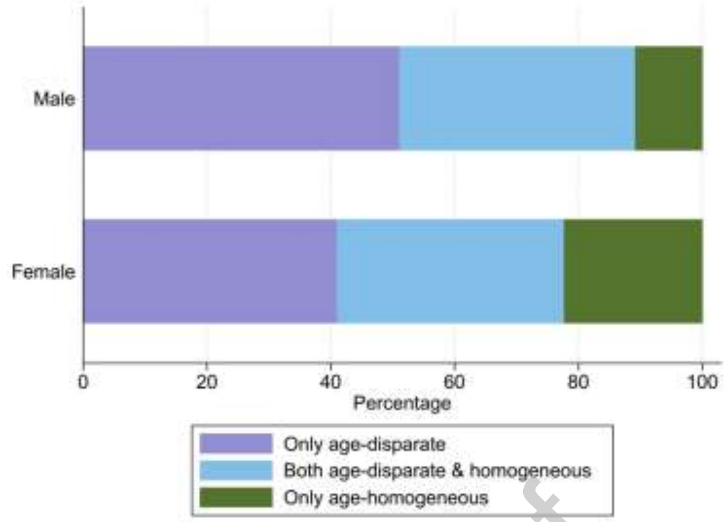

Figure 1: The distribution of partner age-difference classifications, by sex; x-axis (proportions), y-axis (sex)

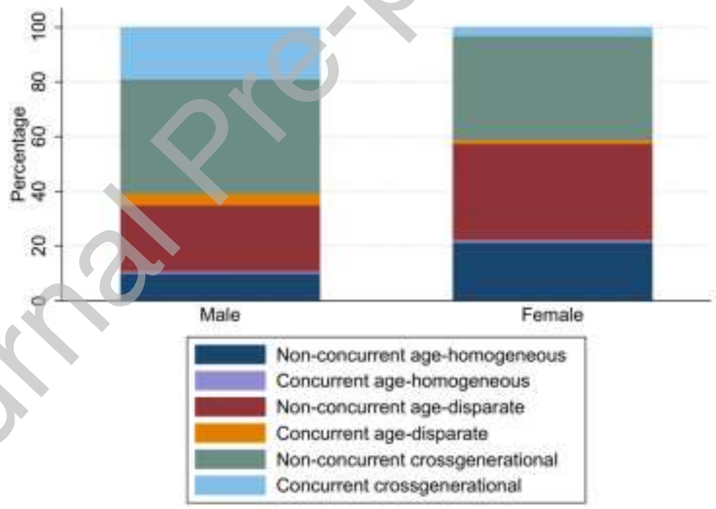

Figure 2: The distribution of partner age-difference classifications with relationship concurrency, by sex; x-axis (sex), y-axis (proportions)

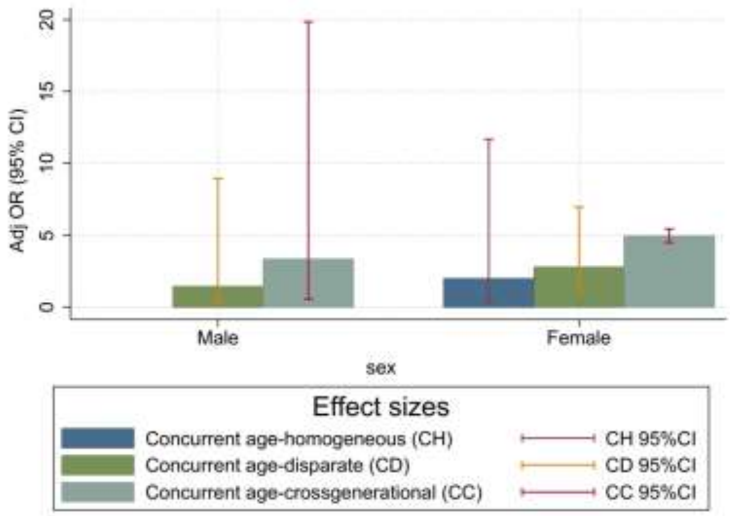

Figure 3a: Effect size of mutually classified variables of concurrent and age-disparate relationships on STI occurrence, by sex.

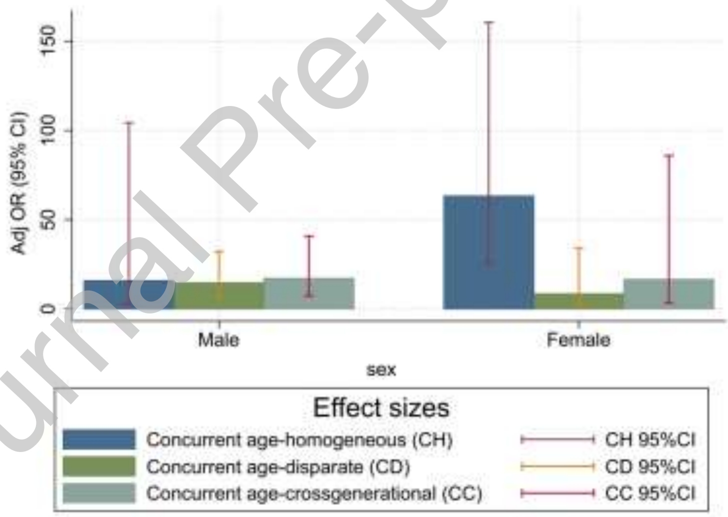

Figure 3b: Effect size of mutually classified variables of concurrent and age-disparate relationships on high risk relationships, by sex.

Table 1: Independent variables of interest looking at age-disparity in relationships.

	Variable	Variable definition	Variable levels
1	Any age-homogeneous relationships	Defined as those with an age-difference of less than 5 years	Any/None
2	Any age-disparate relationships	Defined as those with an age-difference of greater than 5 years	Any/None
3	Age-disparity with three levels		Age-homogeneous, only age-disparate, and both age-disparate and homogeneous
4	Any concurrent age-homogeneous relationship	Defined as those with a concurrent relationship with an age-difference of less than 5 years	Any/None
5	Any concurrent age-disparate relationship	Defined as those with a concurrent relationship with an age-difference of greater than 5 years	Any/None
6	Any concurrent cross-generational relationship	Defined as those with a current relationship with an age-difference of greater than 10 years	Any/None
7	Mutually exclusive variable composed of six levels		Non-concurrent age-homogeneous, concurrent age-homogeneous, concurrent age-disparate, non-concurrent age-disparate, concurrent cross-generational, and non-concurrent cross-generational.

Table 2: Demographic, mobility, and sexual behavior characteristics of index participants with at least one relationship in the past 6 months, by sex and adjusted for community clustering

Characteristic	Category	Total (n, %)	Male (%) (N=1116)	Female (%) (N=1063)	p
Demographics					
Age group	15-24	277 (12.7)	101 (9.1)	176 (16.6)	*<0.001*
	25-34	642 (29.5)	275 (24.6)	367 (34.5)	
	35-44	597 (27.4)	318 (28.5)	279 (26.3)	
	45-54	360 (16.5)	212 (19.0)	148 (13.9)	
	55 and older	303 (13.9)	210 (18.8)	93 (8.7)	
Employment risk level	Low risk	1771 (81.3)	856 (76.7)	915 (86.1)	*<0.001*
	Informal higher-risk	408 (18.7)	260 (23.3)	148 (13.9)	
Educational attainment	At most primary	1668 (76.6)	805 (72.1)	863 (81.2)	*0.001*
	Secondary & above	511 (23.4)	311 (27.9)	200 (18.8)	
Wealth Index	All other wealth quintiles	1859 (85.3)	945 (84.7)	914 (86.0)	0.389
	Poorest wealth quintile	320 (14.7)	171 (15.3)	149 (14.0)	
Regional distribution	Kenya	1222 (56.1)	629 (56.4)	593 (55.8)	0.581
	Uganda East	399 (18.3)	288 (25.8)	270 (25.4)	
	Uganda South-west	558 (25.6)	199 (17.8)	200 (18.8)	
HIV-status	Negative	1309 (60.1)	650 (58.2)	659 (62.0)	0.008
	Positive	870 (39.9)	466 (41.8)	404 (38.0)	
Polygamy status	Yes	383 (17.6)	175 (15.7)	208 (19.6)	0.017
Age-disparity of participants					
Any age-disparate relationship (>=5 years)	Yes	1821 (83.6)	995 (89.2)	826 (77.7)	*<0.001*
Any cross-generational relationship (>=10 years)	Yes	1116 (51.2)	677 (60.7)	439 (41.3)	*<0.001*
Age-disparity of reported relationships	Age-disparate (>=5 yrs)	1006 (46.2)	570 (51.1)	436 (41.0)	*<0.001*

	Both homogeneous & disparate	815 (37.4)	425 (38.1)	390 (36.7)	
	Age homogeneous (0-4 yrs)	358 (16.4)	121 (10.8)	237 (22.3)	
Concurrent age-disparate relationships in the past six months	Yes	309 (14.2)	261 (23.4)	48 (4.5)	*<0.001*
Concurrent age homogeneous relationships in the past six months	Yes	211 (9.7)	165 (14.8)	46 (4.3)	*<0.001*
Concurrent age cross-generational in the past six months	Yes	246 (11.3)	212 (19.0)	34 (3.2)	*<0.001*
Mobility of participants					
Any work or non-work travel in the past 6 months	Yes	1174 (53.9)	557 (49.9)	617 (58.0)	*<0.001*
Any work-related travel in the past 6 months	Yes	287 (13.2)	258 (23.1)	29 (2.7)	*<0.001*
Any non-work-related travel in the past 6 months	Yes	978 (44.9)	376 (33.7)	602 (56.6)	<0.001
Travel type in the past 6 months	No travel	1005 (46.1)	559 (50.1)	446 (42.0)	<0.001
	Work-related	196 (9.0)	181 (16.2)	15 (1.4)	
	Non-work-related	887 (40.7)	299 (26.8)	588 (55.3)	
	Both work and non-work-related	912 (4.2)	77 (6.9)	14 (1.3)	

Age homogeneous defined as a difference of 0-4 years in age, while age-disparate is defined as a difference of more than 5 years in age
cross- generational relationship any relationship with age difference of 10 years and more
Work related travel is for earning money or looking for work while non-work-related travel is travel for any other reasons such as care-giving, attending funeral, and social functions
Among the men in polygamous marriages (15.7%), 68.6% (120/175) reported a concurrent relationship, while among the women, 5.3% (11/208) reported a concurrent relationship (defined as having had two or more sexual partners within any month of the preceding six months).

Table 3: Sexual risk behaviors and STI among index participants, by sex and adjusted for community clustering

Characteristic	Category	Total (%)	Male (%) (N=1116)	Female (%) (N=1063)	p
Active STI (CT/NG)* (n=2,082)	Negative	2012 (96.6)	1033 (97.3)	979 (96.0)	0.086
	Positive	70 (3.4)	29 (2.7)	41 (4.0)	
Any higher-risk sex partner in past 6-months**	No	1966 (90.2)	945 (75.7)	1004 (94.5)	0.051
	Yes	213 (9.8)	271 (24.3)	59 (5.5)	
Any reported condom use in past 6-months	No	1302 (67.5)	809 (72.5)	854 (80.3)	0.001
	Yes	626 (32.5)	307 (27.5)	209 (19.7)	

*STI: active Chlamydia Trachomatis (CT) and/or Neisseria Gonorrhoeae (NG) infection at the time of data collection, as determined by the *Gene Xpert CT/NG©* assay using urine samples
** Casual sex partner, one night stand, commercial sex worker/client, or inherited partner

Table 4: Associations between age-disparate relationship classifications with sexual health risk behaviors in rural Uganda and Kenya, by sex*

Characteristic	Category	aOR (95% CI)	p	aOR (95% CI)	p
STI Infection (N=860)					
		Male (N=860)		**Female (N=930)**	
Age-disparity of reported relationships	Age-disparate (>=5)	1	-	1	-
	Both (disparate & homogeneous)	0.54 (0.28-1.02)	0.057	3.82 (1.46-9.98)	0.006
	Age-homogeneous (0-4)	0.36 (0.09-1.50)	0.161	2.87 (1.18-6.98)	0.020

Concurrent age-disparate relationships in past six months vs. None	Yes	1.46 (0.61-3.51)	0.397	5.37 (1.91-15.08)	0.001
Concurrent age homogeneous relationships in past six months vs. None	Yes	0.81 (0.23-2.82)	0.736	4.64 (2.15-9.98)	<0.001
Concurrent age cross-generational relationships in past six months vs. None	Yes	1.79 (0.65-4.91)	0.258	6.18 (1.54-24.83)	0.010
Mutually exclusive current age-disparity classifications	Non-concurrent age-homogeneous	1		1	
	Concurrent age-homogeneous	-	-	1.99 (0.23-17.40)	0.533
	Concurrent age-disparate	1.43 (0.16-13.04)	0.749	2.79 (0.64-12.27)	0.174
	Concurrent age cross-generational	3.31 (0.46-23.66)	0.233	4.95 (1.35-18.19)	0.016
Higher-risk relationship					
		Male (N=1,116)		**Female (N=1,063)**	
Age-disparity of reported relationships	Age-disparate (>=5)	1	-	1	-
	Both (disparate & homogeneous)	1.57 (1.00-2.48)	0.052	1.24 (0.75-2.03)	0.406
	Age-homogeneous (0-4)	0.85 (0.51-1.40)	0.529	1.39 (0.72-2.67)	0.322
Concurrent age-disparate relationships in past six months vs. None	Yes	18.51 (10.68-32.07)	<0.001	13.19 (4.96-35.05)	<0.001
Concurrent age homogeneous relationships in past six months vs. None	Yes	7.64 (4.74-12.32)	<0.001	15.35 (7.17-32.85)	<0.001
Concurrent cross-generational relationships in past six months vs. None	Yes	14.90 (10.16-21.84)	<0.001	15.10 (6.64-34.34)	<0.001
Mutually exclusive concurrent age-disparity classifications	Non-concurrent age-homogeneous	1		1	
	Concurrent age-homogeneous	19.25 (3.12-118.74)	0.001	64.95 (14.06-300.05)	<0.001
	Concurrent age-disparate	13.02 (5.06-33.46)	<0.001	8.42 (1.04-68.23)	0.046
	Concurrent age cross-generational	17.77 (7.00-45.19)	<0.001	16.55 (5.99-45.70)	<0.001
Any condom use in the last six months					
		Male (N=1,033)		**Female (N=895)**	
Age-disparity of reported relationships	Age-disparate (>=5)	1	-	1	-
	Both (disparate & homogeneous)	1.04 (0.67-1.62)	0.854	1.27 (1.00-1.61)	0.054
	Age-homogeneous (0-4)	0.69 (0.47-1.00)	0.050	1.55 (1.03-2.33)	0.035
Concurrent age-disparate relationships in past six months vs. None	Yes	4.02 (2.54-6.37)	<0.001	2.57 (0.87-7.55)	0.086
Concurrent age homogeneous relationships in past six months vs. None	Yes	2.85 (1.89-4.31)	<0.001	2.99 (1.52-5.89)	0.002
Concurrent age cross-generational relationships in past six months vs. None	Yes	3.67 (2.50-5.39)	<0.001	3.23 (1.16-9.04)	0.025
Mutually exclusive current age-disparity classifications	Non-concurrent age-homogeneous	1	-	1	-
	Concurrent age-homogeneous	2.37 (0.54-10.38)	0.252	12.26 (1.90-79.07)	0.008
	Concurrent age-disparate	4.69 (2.44-9.00)	<0.001	1.32 (0.18-9.58)	0.785

Concurrent age cross-generational	4.21 (2.25-7.86)	<0.001	2.72 (0.95-7.84)	0.063

***** *Individual models for the listed independent variable are adjusted for age, occupation, wealth index, HIV status, any mobility in the past six-month, region, and community clustering.*