Marriageable Mates: Patterns in Partnership Formation and Sero-Sorting in Rural Uganda

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Abstract:

HIV risk is shaped as much by the partners we choose as by the sex we have. In the absence of widespread uptake of couples testing, most partnerships lack information about the prospective partners' sero-status. This paper seeks to determine how effective individuals are at managing this uncertainty. Previous research suggests that individuals use selective partnership formation to select against risky attributes, such as age, mobility, and widowhood. What remains unclear, however, is how accurate people are at selecting sero-negative partners. This paper examines trends in marital partnership formation and sero-sorting over 13 years using census data from a sero-surveillance site in Southwestern Uganda. Taking into account population composition changes over time, this paper finds evidence of intra-group preference among both sero-positives and sero-negatives. This paper provides the first quantitative analysis of sero-sorting and the effectiveness of partnership selection as an HIV prevention strategy.

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As the HIV epidemic has matured in Sub-Saharan Africa, individuals have become more aware of the causes and consequences of HIV, as well as of ways to prevent infection. HIV prevention policy has centered on behavior change, such as condom use and fidelity, while HIV research has uncovered alternative prevention strategies that are locally developed and adapted. One such strategy is partnership selection, in which individuals select for partners they think will minimize their risk of HIV infection. Qualitative studies have shown that individuals use partner characteristics (Kaler 2004) and sexual partners' biographies gathered from community gossip (Watkins 2004) to identify and select partners deemed to be of lower HIV-risk. Quantitative studies have shown that remarriage rates of widows declined substantially as the HIV epidemic matured and AIDS-related mortality started increasing (Reniers 2008). It is unclear, however, whether partnership selection is an effective HIV prevention strategy, that is, whether people are accurately selecting partners of the same sero-status.

Sero-sorting, a form of homophily, is the preference for partners of the same sero-status. The formation of sero-concordant partnerships, where both partners are of the same sero-status, is an under-explored and potentially important avenue for HIV prevention. Considering only transmissions from marital partners, marriages where both partners are sero-negative are risk-free without the introduction of HIV from outside of the marital partnership. Marriages where both partners are sero-positive do not run the risk of infection from their marital partner for the first time. Unprotected sex among sero-positives is not risk-free, however. If partners carry different strains of the virus, they may be at risk of super-infection (Poudel et al. 2007).[1] Sero-discordant unions, on the other hand, are higher-risk partnerships where from the start of union

[1] Since this study concerns itself with the prevention of HIV – and not all risks associated with HIV – I will ignore super-infections for the purposes of this study. It is important to note, nonetheless, that sero-concordant unions do not mean that partners no longer need to use condoms; condoms are still an important protection among sero-concordant positive unions to prevent re-infection and super-infection.

formation the sero-negative partner faces a risk of HIV transmission from the sero-positive partner.

To determine if sero-sorting is an effective HIV prevention strategy, the first step is analyzing the extent to which individuals already express a homophily preference. To answer this question, this paper measures how effective individuals are at selecting partners of the same sero-status. It analyzes trends in marital partnership formation and sero-sorting over thirteen years using data from a sero-surveillance site in Southwestern Uganda. This paper provides the first evaluation of how effective partnership selection is in containing the epidemic at the population level. It assesses whether individuals are effective at selecting partners of the same sero-status, compared to selection occurring independent of HIV status. A population-level analysis also removes the problem of inter-dependence of partnership selection (Reniers and Helleringer 2011), as it looks at the population-level marriage outcomes, rather than trying to discern mutually dependent strategies at the individual level. A sero-surveillance site provides the ideal setting to measure sero-sorting and partnership selection, as the survey's census is able to provide a more comprehensive account of the pool of potential partners. However, linked partnership data is only available for marital partnerships, not allowing the analysis to extend to sero-sorting in non-marital unions. Since there is a crucial difference between trying to prevent HIV and actually remaining sero-negative, it is essential to determine whether partnership selection is allowing people to effectively manage their HIV risk.

Why would sero-sorting be effective at reducing HIV transmission?

Marriage is an important context for HIV transmission in a generalized epidemic setting: Higher durations of partnerships and lowered rates of condom use make marital partnerships a high-exposure setting. HIV can enter marital partnerships through intra- and extra-marital transmission. Sero-sorting concerns itself with the former. Unions among individuals of the same sero-status remove themselves from the risk of intra-marital transmission without extra-marital transmission first occurring.

Attempts to measure the risk associated with discordant unions have revealed mixed results. Some studies have shown a high risk associated with discordant partnerships: Dunkle et al.(2008) found that 55 - 93% of new infections in urban Rwanda and Zambia occurred among sero-discordant couples. However, other studies have suggested that discordant partnerships play a much smaller role in HIV transmission, with Gray et al. (2011) finding that discordant partnerships in rural Uganda only account for 18% of incidence. The challenge with measuring the risk associated with discordance is two-fold. First, most studies are only able to measure whether the sero-conversion of the negative spouse occurred, but cannot isolate whether it results from intra- or extra-marital transmission. This may lead studies to overstate the risk of discordance. Second, studies investigating discordance capture the sero-status of the couples at two points in time, but not from the point of union formation. Given the high infectiousness following sero-conversion, we may expect to see couples transition from sero-discordant to sero-concordant positive in a short period of time. These transmissions may be lost when couples are not followed from the point of union formation, understating the risk of discordance.

While there is debate on the share of population incidence that discordant couples account for, there is less debate on the fact that discordance is risky at the individual level. For example, using the numbers from Gray et al.'s (2011) study, while sero-discordant couples only accounted for 18% of incidence, 8% of sero-negative partners in discordant relationships sero-converted over the period of observation. This compares to non-married couples that account for

30% of the sero-conversion, but only had an incident rate of 0.7%. Discordance also accounts for the majority of marital partnerships among those who are sero-positives: In one five-country study two-thirds of infected couples were in discordant unions (de Walque 2007).

(Insert Figure 1)

Sero-sorting can be seen as a risk-reducing social process at both the individual and the popualtion level. Figure 1 summarizes these effects. At the individual level, sero-sorting implies that those in sero-sorted partnerships are not exposed to discordance. Two sero-negative individuals in a partnership do not risk intra-marital transmission; the only risk comes from extra-marital transmission. Two sero-positive partners are already positive, and don't run the risk of infecting their partner. There are also network-level benefits to sero-sorting (Reniers and Helleringer 2011). A sero-concordant negative union removes two susceptibles from the marriage market, while a sero-concordant positive union removes two infected from the marriage market. The resulting partnerships have a lower probability of being sero-discordant the stronger the homophily preference.

Previous research has shown that selection into and out of marriage influences the risk in the pool of potential marital partners.[2] We know that sero-positive individuals and individuals suspected of being sero-positive due to infidelity face higher rates of marital dissolution (Reniers 2008; Porter et al. 2004), that HIV prevalence is higher among those widowed or separated compared to those married (de Walque and Kline 2012; Nabaitu, Bachengana, and Seeley 1994), and that widows are less likely to remarry than non-widows (Reniers 2008). All of these factors increase the number of sero-positive individuals in the marriage market. What we do not know,

[2] Throughout this paper I use the terms marriageable pool and marriage market interchangeably to refer to the pool of potential marital partners.

however, is whether sero-sorting also affects the types of unions formed and the risk of the marriageable pool.

The potential impact of sero-sorting may also be changing over time. With increased HIV testing rates and more individuals knowing their sero-status, sero-sorting may become easier (Reniers and Helleringer 2011). With the roll-out of anti-retroviral therapy (ART), sero-positives are also living longer and as a result, their marital ambitions may change. In the absence of homophily on sero-status, the increasing number of marriageable sero-positives may result in a higher number of sero-discordant unions. Homophily on sero-status is therefore not only an important strategy for reducing HIV-risk transmission now, but may become increasingly so over time.

What evidence is there of sero-sorting?

a. Men who have sex with men (MSM) in the United States

The first evidence of sero-sorting emerged in the MSM community in the US (Cox, Beauchemin, and Allard 2004; L. Eaton et al. 2007; L. A. Eaton et al. 2009; Snowden, Raymond, and McFarland 2009; Marks et al. 2010; Snowden, Raymond, and McFarland 2011), identified as one of a range of sero-adaptive behaviors where individual risk management behaviors responded to the sero-status of their partners. Findings that unprotected anal intercourse among MSM in the US was associated with higher STI rates, but not higher HIV rates, was seen as evidence that individuals were selecting partners of the same sero-status to engage in risky behaviors with (Snowden, Raymond, and McFarland 2011). In the same study, Snowden, Raymond and McFarland found that sero-adaptive behaviors such as sero-sorting were more commonly reported than consistent condom use: 27.5% of sero-negative men and 22.2% of sero-positive men reported sero-sorting. If HIV risk is a function of one's own status, the status of one's partner, and the riskiness of the behaviors one engages in, then one can modify only one component of this equation as a risk-reduction strategy. Considering the challenges in adopting consistent condom use to reduce HIV infection, sero-sorting may be an easier risk-reduction strategy if individuals are more willing to change their choice of sexual partners than other behaviors that they engage in. Evidence from the MSM community in the US suggests that individuals may be more willing to modify partnership selection than condom use.

b. Partnership Preference in Sub-Saharan Africa

Evidence of sero-sorting outside of the United States has been limited. The only indication of sero-sorting in Sub-Saharan Africa (SSA) has emerged from qualitative studies on partnership preferences among sero-positive and sero-negative individuals. There are a variety of mechanisms through which sero-sorting may be desirable in SSA:

> *"Through serosorting, HIV negatives can maximize their long-term health outcomes without compromising their reproductive ambitions. HIV positives, on the other hand, may seek seroconcordant partners out of altruistic considerations, or because it removes uncertain consequences (including rejection, divorce and violence…) of disclosing HIV positive status to a partner of unknown or HIV negative status. The companionship of a partner with the shared experience of living with HIV/AIDS is also an important motivation to form seroconcordant HIV positive partnerships." (Reniers and Helleringer 2011; Page 5).*

The Malawi Diffusion and Ideational Change Project (MDICP) first drew attention to partnership selection as an adaptive strategy to prevent HIV infection. Kaler (2004) highlighted partnership selection as an opportunity for agency in responding to HIV risk; behavior and characteristics associated with higher risk influenced men's notions of desirable women. For example, they saw more outgoing women, bar girls, and town girls as "risk groups", and instead preferred women from "good families" or school girls and younger women, who they assumed to have had fewer previous sexual partners (Kaler 2004). Watkins (2004) shows how social norms are changing, as consulting local community knowledge about potential partners' sexual histories is considered a wise decision before partnership formation. The preference for sero-status may also override other considerations in partnership selection: Studying youth in rural Malawi, Clark, Poulin and Kohler (2009) found that HIV-negative status was more important in selecting potential partners than attractiveness or education, and that 80% of respondents indicated they would undergo pre-marital testing.

Using quantitative survey data from the MDICP, Reniers (2008) analyzed selection into and out of marriage and finds that individuals are more likely to divorce partners they suspect of infidelity and less likely to remarry widows, as both infidelity and widowhood are characteristics associated with higher HIV risk. While unable to assess the effectiveness of these selection processes, Reniers provides evidence of a strong association between widowhood and being HIV-positive.

Qualitative research in Uganda, Nigeria and Malawi has shown that sero-positive individuals often desire to form partnerships with other sero-positive partners (Seeley et al. 2009; Rhine et al. 2009; Gombachika 2012). Sero-concordant positive unions were identified as desirable due to the shared experiences and a fear of rejection by sero-negative partners. Respondents also identified ART clinics and support groups as places to look for prospective partners.

c. Discordant/Concordant Studies

With a wealth of evidence on the desirability of partners of the same sero-status, attempts to quantify the occurrence of sero-sorting have been limited to cross-sectional studies of concordant and discordant partnerships. Looking at remarried couples' sero-status in DHS surveys from 13 countries (de Walque and Kline 2012), and all couples' concordance and discordance in DHS surveys from five countries (de Walque 2007), sero-positive individuals were more likely to be in sero-discordant than sero-concordant unions. This does not necessarily indicate that sero-positives are not sero-sorting, however. Limited to cross-sectional analyses, both studies only showed prevalent infection at one point in time. They were not able to discern couples that found sero-discordant unions, versus sero-concordant negative couples where one partner sero-converted due to extra-marital transmission. Determining whether sero-sorting is in fact occurring requires longitudinal data and the status of the couple at union formation, a limitation this paper is able to overcome using a unique open-cohort population survey in rural Uganda.

Setting

Data for this paper come from the Medical Research Council and Uganda Virus Research Institute (MRC/UVRI) study site in rural Southwestern Uganda. The study site comprises approximately 20,000 adult and child respondents from 25 villages. Subsistence agriculture is the primary livelihood source, along with cash crops such as bananas, coffee, and beans, and fish trading. The majority of the population belongs to the Baganda tribe (73%), and a sizeable minority is of Rwandese origin (15%). HIV prevalence among study respondents 15 years and older grew from 6.2% in 2000 to 7.7% in 2005 (Shafer et al. 2008). Marital union formation, through formal and informal marriage, is the predominant life course for study respondents, though there is also a high level of union instability with 10.1% of respondents currently divorced (Nabaitu, Bachengana, and Seeley 1994). In a setting with high HIV prevalence and marriage rates, marriage represents an important context for HIV exposure, making it reasonable to limit the study of partnership selection as an HIV prevention strategy to only marital unions.

Data

The data for this study come from the General Population Cohort (GPC), an annual population census and sero-survey that has been conducted in the area since 1989. Details of the population cohort study and methodology have been described elsewhere (Nunn et al. 1997; Nakibinge et al. 2009; Asiki et al. 2013). This paper draws on annual data from 1999 to 2011. The dataset includes information on individual demographic variables, sexual behavior, marriage histories, and sero-status.

Two datasets were constructed: a longitudinal dataset of all respondents in the marriageable pool each year, and a couple-level dataset of all new unions formed. The marriageable pool contains all those at risk of marriage within a given year, including those previously unmarried, those formerly married, and polygynous men. Men who currently have one wife, but intend to take on additional wives are not identifiable within the dataset, so the pool of polygynous men is biased to include only those with two or more wives. Excluding the polygynous men, who never stop being at risk of marriage, there were 64,044 single person-year observations. Defining a single spell as the period of time from when one is at risk of marriage until one exits the marriage pool due to either marriage or censoring, there were 14,085 single spells, and 2,570 exits for marriage.

Over the 13 years of observation there were 1,251 new marriages and 1,318 remarriages. Of those respondents reporting new marriages, approximately 75% married partners within the study site, leading to 912 linked new marriages and 1,031 linked remarriages, providing a total sample of 1,942 marriages over 13 years.

Methods & Measurement

To determine if individuals are accurately sero-sorting, new unions – including both first marriage and remarriage – are analyzed over 13 years to discern the proportion of individuals selecting into sero-concordant positive or negative unions compared to higher-risk sero-discordant unions. Measuring the occurrence of sero-sorting first requires removing population-composition effects that may obscure actual homophily based on sero-status.

Due to the large difference in group size between sero-negative and sero-positives, intra-group preference or homophliy measurements may be biased by group size. To control for group size, homophily bias (eq 1.) is calculated, where p_a is the observed proportion of intra-group marriages and p_e is the expected proportion of intra-group marriages (McClintock 2010). The denominator removes the effects of group size by normalizing the measure between -1 and 1, where a value greater than 0 indicates intra-group preference. Homophily bias provides an intuitive way to think about the excess cases of each partnerships type.

$$H = \frac{(p_a - p_e)}{(1 - p_e)} \qquad (1)$$

To then measure this same intra-group preference on sero-status in a statistically robust framework, a log-linear model is used to determine the statistical significance of mixing. Covariates for women's HIV status, men's HIV status, and year are included in the complete independence model, and compared to the inclusion of a dummy variable indicating homophily on sero-status. Deviance is examined to determine the fit of the models with and without the homophily parameter.

Timing and Population Composition Effects

In order to determine whether trends over time are the result of changes in sero-sorting or are driven by changes in prevalence, the proportion of sero-concordant negative couples observed are compared to the number that would be observed if mixing occurred at random among a population with the same annual sex-specific prevalence levels. For example, to calculate the probability of selecting a sero-concordant positive couple, I took the probability of selecting a sero-positive woman and the probability of selecting a sero-positive man and, calculated the joint probability assuming independence.

To compare differences in observed and expected values I first construct a ratio of the observed proportion discordant to the expected proportion discordant under random mixing. Pearson standardized residuals are also calculated, and used to measure the Pearson Chi-Square statistic by year.

Homophily bias and a random mixing model both take into account how the number of those positive and negative in each year may be affecting the observed patterns in sero-sorting. However, both approaches make the assumption that those marrying in a given year were those who were at risk of marriage in that year. The more likely case is that individuals select their partners from a much wider pool of potential partners. To take this into account, the random-mixing model and homophily bias measures are recalculated using the marriageable pool as those exposed to the risk of marriage. That is, all those who are never married, formerly married or a polygynous man in time t-1 are used to calculate the expected proportions of discordant and concordant unions at time t, holding constant the number of marriages in a given year.

While this study improves upon previous research by measuring sero-sorting at union formation, it is not able to look at sero-status at first sex within the partnership. Therefore, this research design is not immune to some of the timing-effects that plague cross-sectional studies, as it is possible that couples sero-convert between the time of first sex and marriage. Using a lagged time reference for the pool of marriageable individuals removes some of these problems by taking into account statuses not at the time of union formation, but in the time period prior to marriage. Analyses are also run on the pool of married individuals with sero-status measured the year prior to marriage, but results were similar and therefore not included below. Despite using lagged and non-lagged sero-statuses, if the interval between first sex and marriage is longer, some of the sero-concordant positive unions observed may be the result of sero-discordant unions with sero-conversion prior to marriage. However, since differences were not large between the lagged and non-lagged status for those in the married pool, I assume that this effect is small.

Sero-Status Measurement and Imputation

Measuring sero-sorting using linked partnership data requires a known sero-status for both partners in order to classify the sero-status of the union. While the sero-survey has an approximate participation rate of 83% each year, sero-status for both partners is only known for 54% of new unions formed. To assess whether missing data on sero-status is influencing the results, two different imputations methods were used. Since we know that someone who tests positive will remain positive, and that if someone tests negative they were negative in past years, it is possible to undertake a logical imputation carrying forward positive statuses and backwards negative statuses. This provides complete couples' sero-statuses for 76% of first marriages and 77% of remarriages.

Since analyses of sero-sorting must take into account changes in population composition, it is important to assess how imputation of sero-status may influence population. Since logical imputation can only impute positive statuses forward and negative statuses backward, we would expect it to bias the population composition to include more sero-negatives in earlier years and more sero-positives in later years. To limit the effect of imputation on population composition, a limited logical imputation was used, imputing positive sero-status forward two person-years and negative statuses backward two person-years. This provides full sero-status for both partners in 69% of all new marriages.

(Insert Table 1)

To take into account how results may be influenced by missing data on sero-status, analyses were run using no imputation, logical imputation and limited-logical imputation. The findings were not significantly different, so this paper only includes limited-logical imputation results. Analyses were also run including those with unknown sero-status, leading to six positive concordant/discordant statuses (Table 1), and then again only including those with known sero-status. Sero-unknown status indicates that an individual did not participate in the sero-survey that year and imputation based on previous or future tests was not possible; it does not indicate whether their partner knows their sero-status or not. Results presented below are on the sample of those with known sero-status, unless otherwise indicated.

(Insert Figure 2 & 3)

Results

The raw numbers of partnership types - excluding unknown partnerships - indicate that the majority of unions each year are sero-concordant negative. Sero-discordant unions range from 4 to 15% of marriages, while sero-concordant positive partnerships account for less than 10% of marriages in most years. The marriageable pool shows that the proportions of sero-negative and sero-positive individuals at risk of marriage have not changed much over time, other than a slight increase in sero-positives between 2010 and 2011. Sero-positives account for less than 15% of the pool of marriageable partners within a given year, but the proportion of sero-positive women is higher than the proportion of sero-positive men, a trend that has remained consistent across time. Table 2 provides a breakdown of these numbers for each year, highlighting the differences between the married and marriageable pools, as well as when partnership types are analyzed including or excluding unions with at least one partner with an unknown sero-status. Looking just at proportions of couple types by known sero-status, discordance is always the same or more prevalent than concordant-positive unions, though the degree of difference varies greatly over time.

(Insert Table 2)

To determine how different the observed proportions are from what we would expect to see at random, Table 3 provides the observed and expected frequencies for each partnership type, in addition to the Pearson-standardized residual. It is very clear that over time we consistently see more concordant-positive partnerships than we would expect to see at random, and fewer discordant partnerships. The difference between observed and expected number of partnership types is greatest among sero-concordant positive unions, as indicated by the high magnitude of the Pearson-standardized residuals. While the difference between the observed and expected show that couples are not forming unions independent of HIV status, this does not hold for all years. In 2005, 2008 and 2009 there is no statistically significant difference between the sero-sorting patterns observed and those we would expect to see at random, as indicated by the Pearson Chi-Square statistic.

(Insert Table 3)

The intra-group preference in Table 3 breaks down homophily by sex and sero-status. We can see from the raw numbers that, compared to women, a higher proportion of men are in intra-group marriages. Similarly, a higher proportion of sero-negatives enter concordant unions than sero-positives. Across years, an average of 25% of sero-positive women form a sero-concordant partnership, compared with 37% of men; among sero-negatives, 61% of women and 72% of men enter sero-concordant marriages. The denominator in calculating intra-group preference is all men or women of that sero-status, some of whom will enter marriages with a partner of an unknown sero-status. If 25% of sero-positive women are in a sero-concordant positive union, this does not imply that 75% are in a discordant union; the remaining 75% are in sero-discordant unions or concordant positive unions but I do not know the status of their partner.

Homophily bias, on the other hand, indicates the excess of each type of union compared to what we would expect to see at random, normalized between -1 and 1. Taking into account what we would expect to see under random mixing, as well as the differences in group size between sero-negatives and sero-positives, the trends observed in the raw numbers of intra-group preference no longer hold (Figures 4 & 5). While sero-negative men still exhibit greater homophily than sero-negative women, this gendered difference does not hold among sero-positives. Moreover, homophily is now much stronger among sero-positives than sero-negatives. The only instance of no intra-group preference is among both sero-positive men and women in 2009. However, these values are not very different from 0, and take place in a year in which the differences between observed and expected trends in sero-sorting are not statistically significant.

(Insert Figure 4 & 5)

Thus far all analyses presented have been based on the expected values calculated among the pool of married individuals each year. However, this does not reflect the true population at risk of marriage each year. Figures 6 and 7 show the observed and expected values for sero-concordant and discordant partnerships, respectively, but now include the expected values calculated from the marriageable pool. For sero-concordant positive partnerships the difference between the married and marriageable pools expected values are not large. The observed number of sero-concordant positive partnerships is greater than that expected under random mixing regardless of who is considered at risk of marriage. This is true for all years but 2009. However, it is important to note that the expected values frequently fall within the confidence interval. This is most likely due to the small number of sero-concordant partnerships observed, and the resulting larger standard errors.

(Insert Figure 6 & 7)

For discordant partnerships, on the other hand, the change from the married to the marriageable pool does have a great effect. While the expected number of discordant partnerships from the married pool was consistently greater than that observed, this is no longer the case for the marriageable pool. In almost all years the black line, indicating the expected values, falls within the confidence interval. From 2005 onwards the expected values from the marriageable pool are very similar, the same, or sometimes even less than those observed.

(Insert Figure 8 & 9)

Figures 8 and 9 present the same data, but accentuate the degree of difference between observed and expected values, plotting observed against expected values. The 45 degree red line indicates that there is no difference between observed and expected. For sero-concordant positive partnerships, in Figure 8, almost all points fall below the line, indicating more observed than expected sero-concordant partnerships. Sero-discordant partnerships are less common than expected, but the difference from the 45 degree line is much less in the marriageable pool.

(Insert Figure 10 & 11)

While it is clear that there are more sero-concordant positive partnerships than we would expect, and under some conditions fewer discordant partnerships than we would expect, it is also important to see how this differs from the maximum scenario. The maximum scenario asks if every sero-positive person who could partner with another sero-positive did, what proportion of all unions would be sero-concordant positive? This has important policy implications, as it shows the degree to which sero-sorting could be improved. Figure 10 shows that the maximum number of sero-concordant positive partnerships is higher than what is observed, though the difference between observed and maximum values is highly variable. Figure 11 shows a much greater difference between maximum and observed values for sero-discordant partnerships, with the differences between observed and maximum values following a similar trend over time. An important caveat to consider is that maximum sero-sorting can only be calculated among those who marry in a given year.

(Insert Table 4)

To assess how significant the homophily preference is, the results from the log-linear model are included in Table 4. The first column shows the complete independent model, which with a deviance of 228.62 on 37 degrees of freedom, is a poor fit for the data. Adding a dummy variable for homophily significantly improves the fit of the model, with a reduction in deviance of 145.37. However, the remaining deviance of 83.25 on 36 degrees of freedom shows that even taking into account homophily, the model is still a poor fit for the data.

Discussion

This paper provides the first quantitative analysis of couples' status at union formation in Sub-Saharan Africa. Even after adjusting for population composition, and considering multiple definitions of who is at risk of marriage, there is evidence to suggest that marital sero-sorting is occurring for sero-positives and sero-negatives. While overall there is evidence of sero-sorting, there are no discernible time trends. There are some years where there is no evidence of sero-sorting, but these years are dispersed over time. Part of the lack of trend could be driven by the small number of sero-concordant unions. For example, in 2009 there are no observed or expected sero-concordant positive partnerships as all HIV-positives that did marry married someone with an unknown HIV status and were excluded from the sample. While sero-sorting is not clear in every year, across time there are no general trends. If ART or rising awareness of HIV transmission were affecting sero-sorting, we would expect to see differences over the course of the 13 years of observation. This paper finds no such evidence.

Sero-sorting is not equal among sero-negatives and sero-positives. Measuring homophily bias, I find that sero-positives have a greater excess of intra-group partnerships than sero-negatives. This is an important finding that supports the qualitative research in Sub-Saharan Africa on the desirability of sero-concordant unions among the sero-positive.

Homophily among sero-negatives is stronger among men than among women, but there are no noticeable gender differences among sero-positives. Gender differences in choice are important as men may have more ability to choose their partners than women.

While sero-sorting is important in explaining the mixing patterns observed in rural Uganda, as the results from the log-linear model suggest, there are other factors that need to be taken into account. Below I outline the additional analyses I am currently undertaking to address this.

Limitations and Next Steps

While there clearly are trends in sero-sorting, and in particular a higher homophily preference among sero-positives, this analyses provides no evidence that sero-sorting is a purposeful selection process. It is possible that direct or indirect selection preferences may be driving the observed trends in sero-sorting. Direct selection may be occurring if partners purposefully choose their partners based on their known sero-status, which can occur through either sero-status disclosure or pre-marital testing. Indirect selection may occur if individuals select partners based on attributes that are assumed to be associated with lower risk, or if they choose partners with desirable attributes regardless of HIV but those attributes are in fact correlated with HIV.

Part two of this paper, currently a work-in-progress, employs a sequential explanatory mixed-methods strategy to investigate the social mechanisms that may be driving sero-sorting. The Intimacy and Risk Study's qualitative data provide the main evidence for understanding the process of partnership selection. These interviews come from a stratified random sample of respondents within the GPC study site. I am analyzing narratives of partnership formation focusing on (1) how men and women describe the idea of partnership "choice", (2) what characteristics individuals deem desirable in marital partners, and (3) how they think about risk in the process of partnership selection. With an increase in HIV testing and counseling in Uganda, the qualitative analysis also explores the extent to which individuals use perceived versus confirmed sero-status when selecting for partners. Since partnership selection is a complex process influenced by an array of observable and unobservable factors, it is not possible to claim that a partner who is chosen with certain attributes was selected for those attributes. However, these interviews provide important evidence on how individuals think about HIV when forming unions, and provide indications as to whether sero-sorting is occurring through direct or indirect selection.

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Figure 1: Potential individual and network effects of sero-sorting

Partnership Type	Individual-Level Effects	Network-Level Effects
Sero-Concordant Positive	- Risk of super-infection	+ Removes two infected from marriage market
Sero-Concordant Negative	+ Partners not at risk of intra-marriage infection	+ Removes two susceptibles from marriage market
Sero-Discordant	- Partner at risk of intra-marriage infection	

Table 1: Numbers of unions by couples sero-status, including missing sero-status

Sero-Status of Union	First Marriages	Remarriages
Concordant Negative	642	619
Discordant	36	117
Concordant Positive	10	59
Negative and Unknonwn	201	201
Positive and Unknown	16	29
Both Unknown	7	7

Figure 2: Proportion of concordant and discordant new marriages, 1999 – 2011 (excluding sero-unknown)

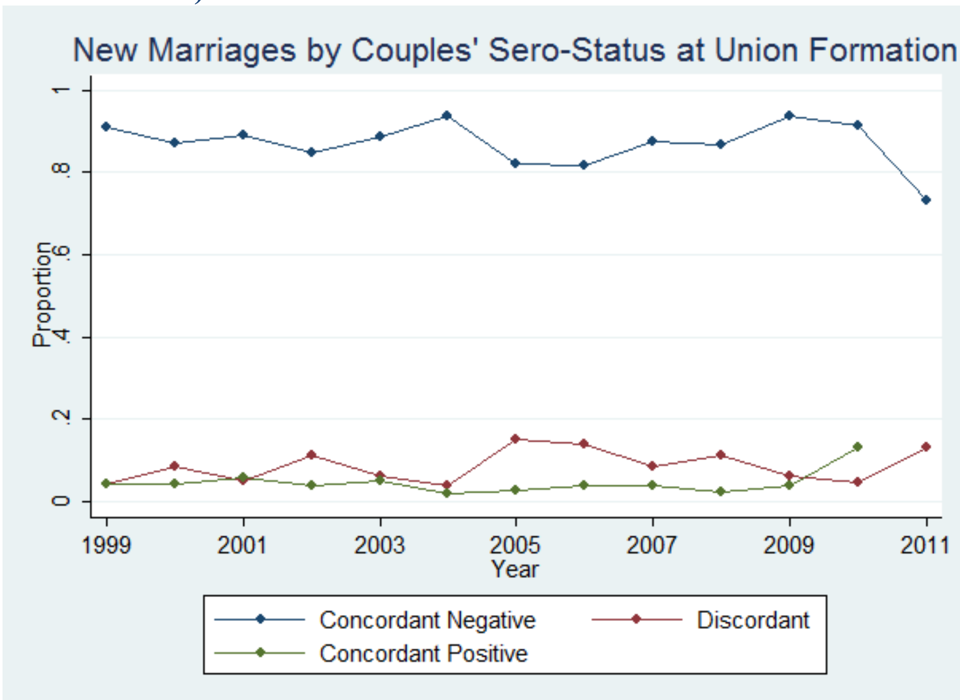

Figure 3: Proportion of sero-positive and sero-negative men and women in the marriageable pool, 1998 – 2011 (excluding sero-unknown)

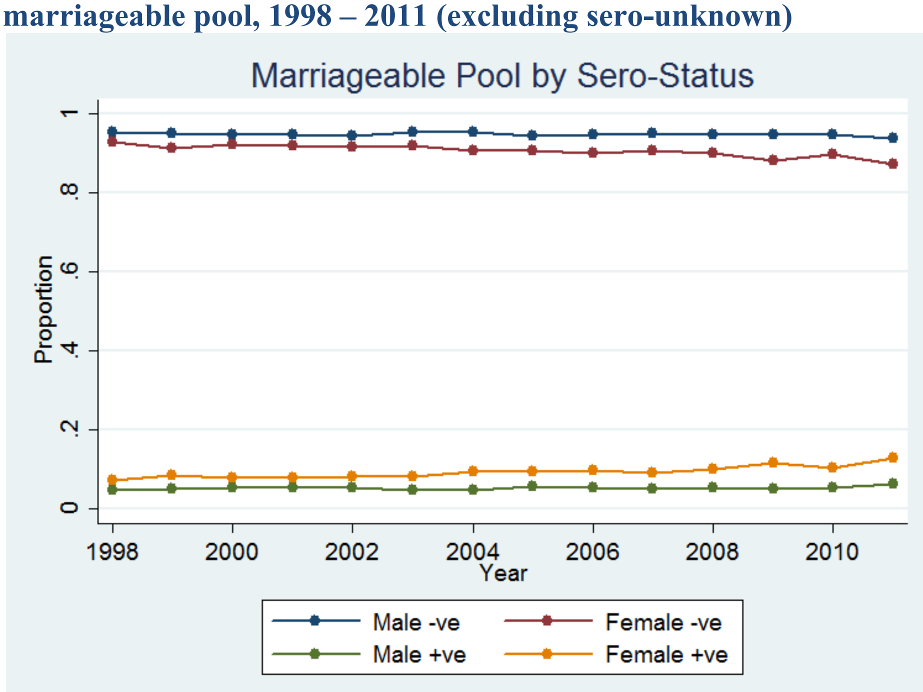

Table 2: Sero-Status of individuals and couples, 1999-2011

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Married Males														
Sero-Negative	51	76	103	203	87	119	135	124	121	101	154	179	138	1591
Sero-Positive	4	5	12	25	6	4	13	18	6	7	7	9	31	147
Unknown Status	16	26	28	122	35	54	72	69	74	65	70	97	110	838
Married Females														
Sero-Negative	54	82	115	244	96	132	162	144	146	133	186	190	169	1853
Sero-Positive	6	10	8	22	13	9	20	18	25	15	10	20	36	212
Unknown Status	11	15	20	84	19	36	38	49	30	25	35	75	74	511
Marriageable Males														
Sero-Negative	1788	2275	2459	2228	2303	2290	2141	2158	2166	2118	2241	2196	1922	28285
Sero-Positive	127	154	161	154	144	135	141	102	103	73	67	76	129	1566
Unknown Status	270	428	585	896	896	930	1037	972	969	1051	904	820	1160	10918
Marriageable Females														
Sero-Negative	1054	1634	1807	1662	1778	1802	1734	1727	1754	1747	1602	1859	1705	21865
Sero-Positive	101	140	150	152	155	188	180	156	133	116	104	114	220	1909
Unknown Status	170	295	479	642	656	704	709	721	734	792	710	635	883	8130
Marriages (All)														
N	71	107	143	350	128	177	220	211	201	173	231	285	279	2576
Discordant	3%	6%	3%	5%	4%	2%	8%	7%	4%	6%	3%	2%	5%	5%
Concordant Positive	3%	3%	4%	2%	3%	1%	1%	2%	2%	1%	0%	2%	5%	2%
Concordant Negative	94%	92%	92%	93%	93%	97%	91%	91%	94%	93%	97%	96%	91%	93%
Marriages (Known Status)														
N	45	70	99	159	79	97	113	99	104	90	130	128	97	1310
Discordant	4%	9%	5%	11%	6%	4%	15%	14%	9%	11%	6%	5%	13%	9%
Concordant Positive	4%	4%	6%	4%	5%	2%	3%	4%	4%	2%	0%	4%	13%	4%
Concordant Negative	91%	87%	89%	85%	89%	94%	82%	82%	88%	87%	94%	91%	73%	87%

Table 3: Observed and Expected Number of Discordant and Concordant Marriages, and Homophily Bias

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Discordant													
Observed	2	6	5	18	5	4	17	14	9	10	8	6	13
Expected	7	11	15	28	13	9	20	21	19	14	12	17	29
Pearson Residual	3.68	2.27	7.05	3.40	5.18	2.73	0.50	2.20	5.02	1.03	1.17	7.25	8.49
Concordant Positive													
Observed	2	3	6	6	4	2	3	4	4	2	0	5	13
Expected	0	0	1	1	1	0	1	1	1	1	0	1	3
Pearson Residual	8.55	13.63	42.25	14.41	18.93	16.07	3.34	4.87	14.99	3.36	0.29	33.42	31.21
Concordant Negative													
Observed	41	61	88	135	70	91	93	81	91	78	122	117	71
Expected	38	59	83	130	65	88	92	77	85	76	118	110	65
Pearson Residual	0.32	0.10	0.31	0.20	0.37	0.11	0.02	0.22	0.48	0.07	0.14	0.41	0.50
Pearson Chi-Square	12.55 *	16.00 **	49.61 ***	18.01 **	24.48 ***	18.91 ***	3.85	7.30	20.49 ***	4.46	1.60	41.08 ***	40.20 ***
Intra-Group Preference													
Sero-Negatve Women	0.76	0.74	0.77	0.55	0.73	0.69	0.57	0.56	0.62	0.59	0.66	0.62	0.42
Sero-Negative Men	0.80	0.80	0.85	0.67	0.80	0.76	0.69	0.65	0.75	0.77	0.79	0.65	0.51
Sero-Positive Women	0.33	0.30	0.75	0.27	0.31	0.22	0.15	0.22	0.16	0.13	0.00	0.25	0.36
Sero-Positive Men	0.50	0.60	0.50	0.24	0.67	0.50	0.23	0.22	0.67	0.29	0.00	0.56	0.42
Homophily Bias													
Sero-Negatve Women	0.21	0.10	0.16	0.05	0.16	0.07	0.02	0.06	0.10	0.04	0.06	0.08	0.05
Sero-Negative Men	0.26	0.14	0.25	0.07	0.22	0.10	0.03	0.09	0.18	0.09	0.11	0.10	0.08
Sero-Positive Women	0.29	0.27	0.73	0.22	0.27	0.20	0.10	0.16	0.14	0.10	-0.03	0.23	0.30
Sero-Positive Men	0.46	0.56	0.47	0.19	0.63	0.47	0.16	0.16	0.62	0.22	-0.04	0.52	0.35

Note: Excluding those with unknown sero-status, using only the pool of married individuals

* p< 0.05 ** p<0.01 ***p<0.001

Figure 4: Proportion of sero-negative men and women with concordant marriages (H(m) and H(f)) and the homophily bias for sero-negative men and women (H(m)Bias) and H(f) Bias)

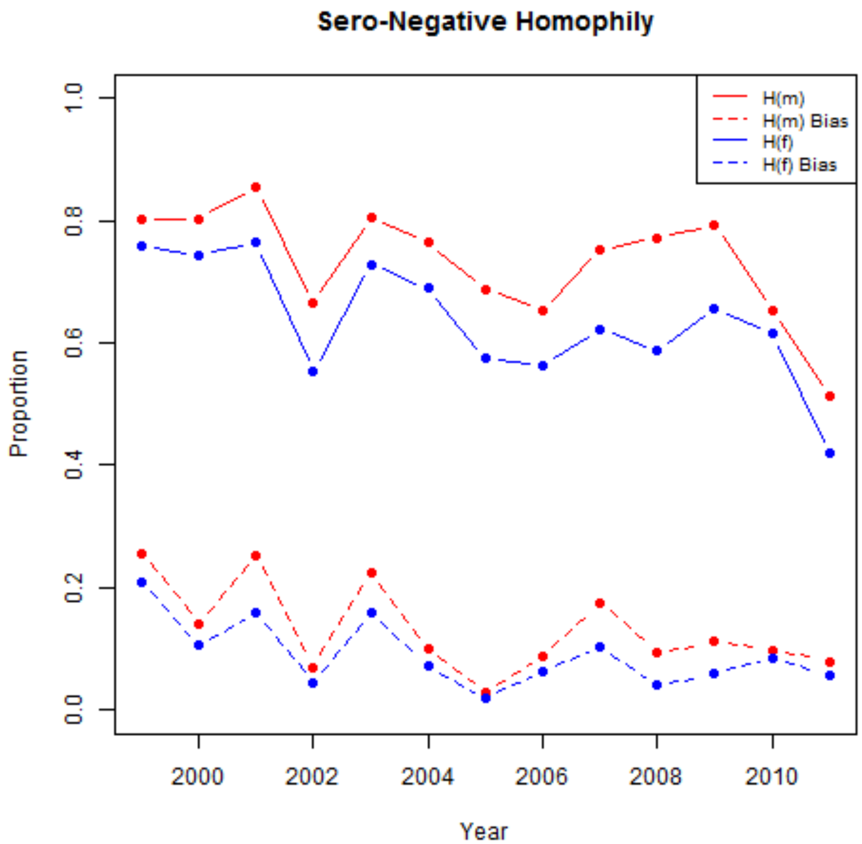

Figure 5: Proportion of sero-positive men and women with concordant marriages (H(m) and H(f)) and the homophily bias for sero-positive men and women (H(m)Bias) and H(f) Bias)

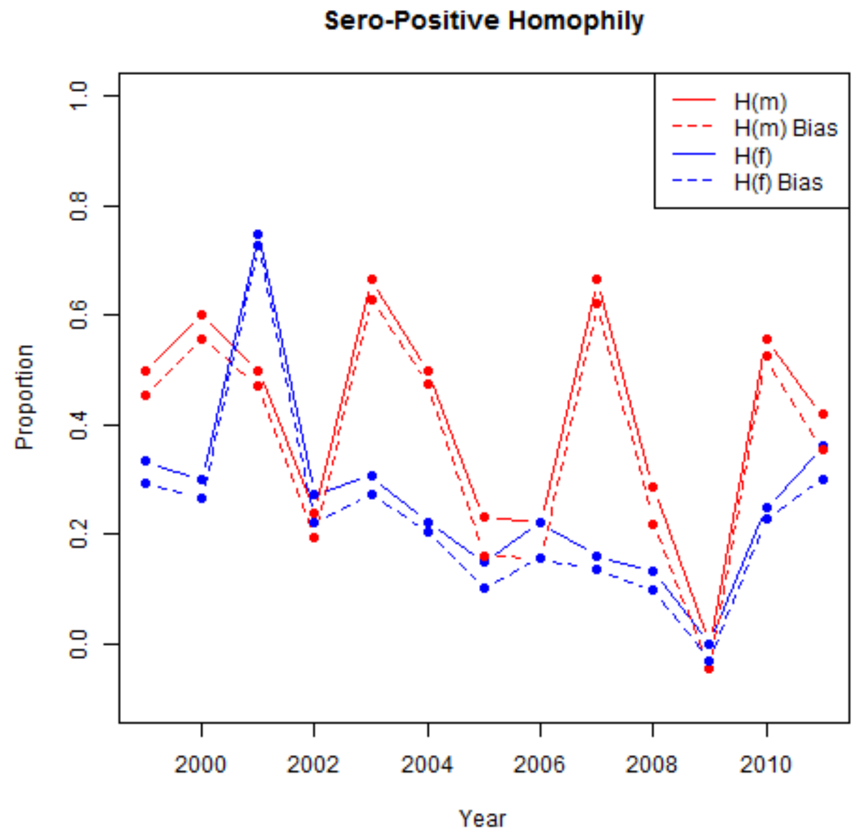

Figure 6: Observed and Expected Proportion of Sero-Concordant positive marriages

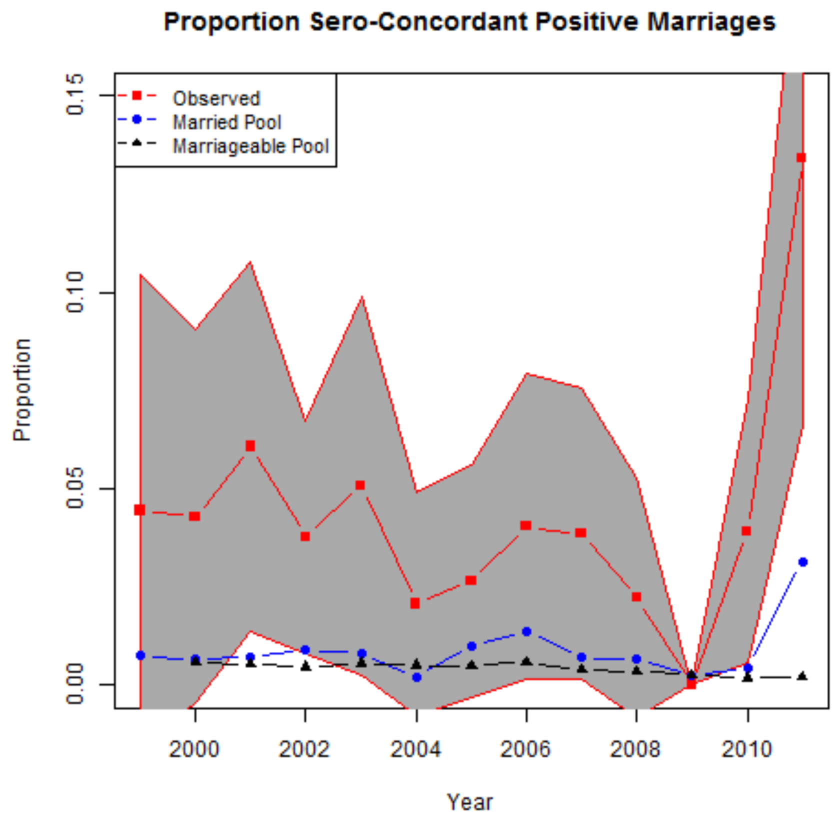

Figure 7: Observed and Expected Proportion of Sero-Discordant marriages

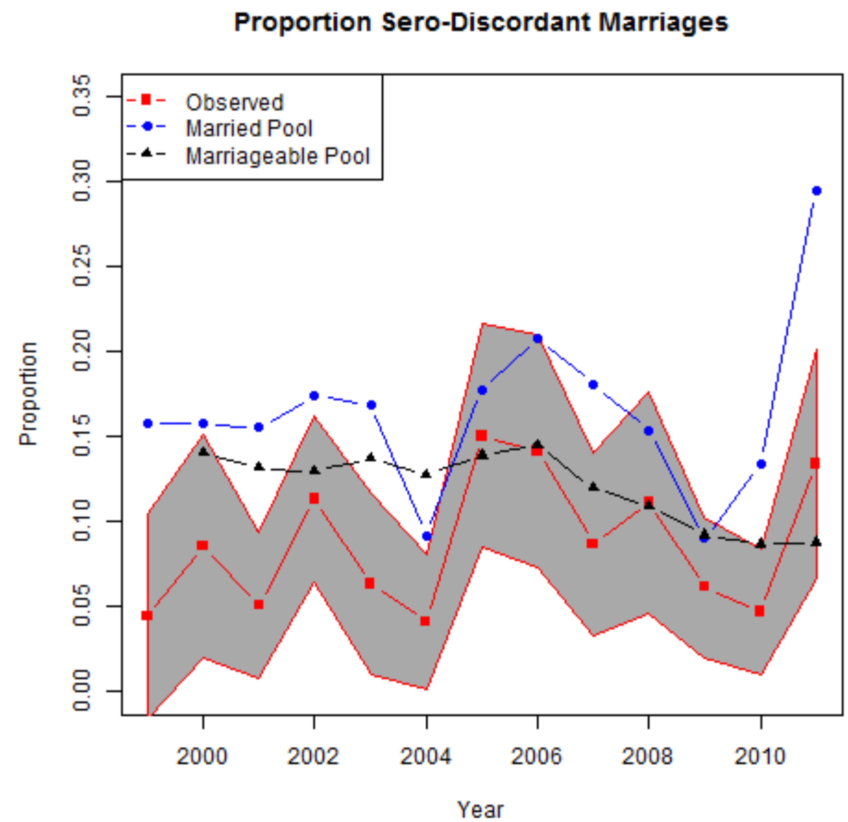

Figure 8: Ratio of observed to expected sero-concordant positive marriages

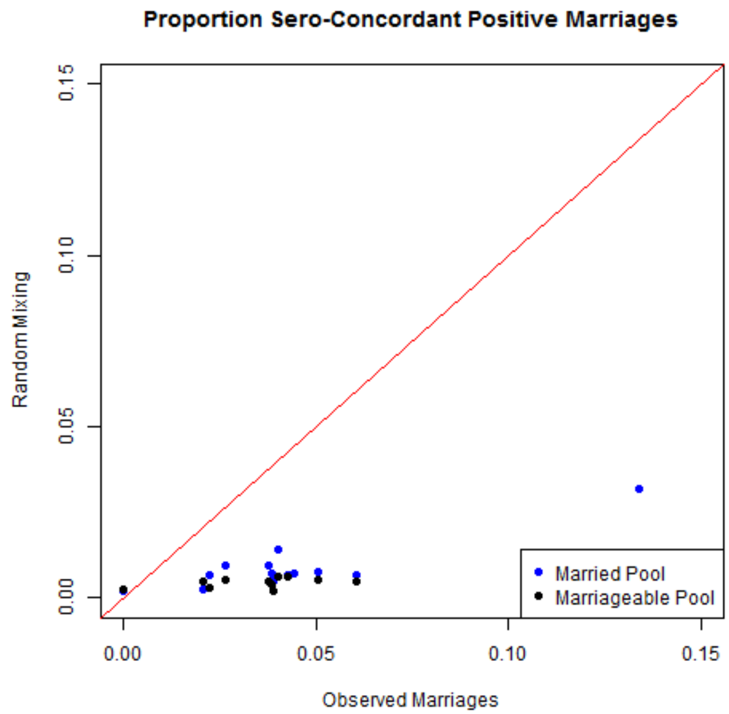

Figure 9: Ratio of observed to expected sero-discordant marriages

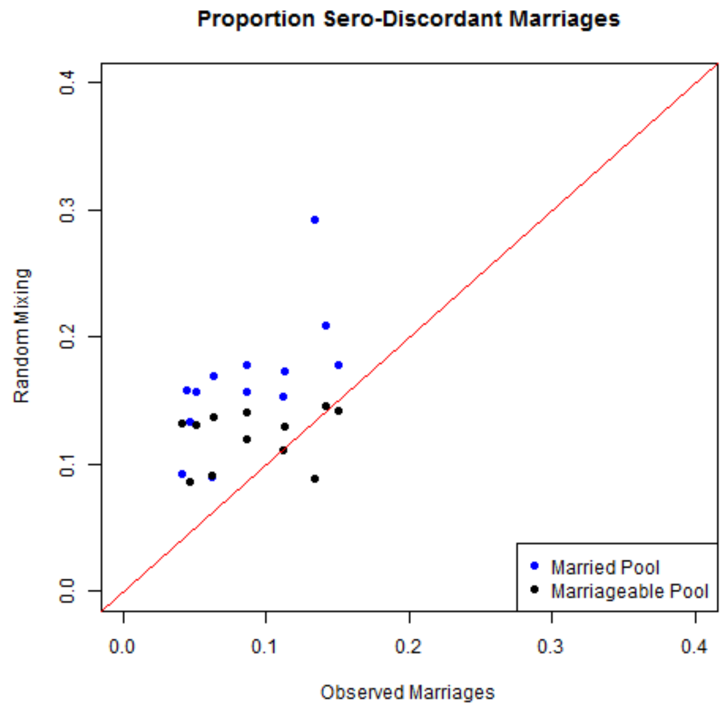

Figure 10: Maximum proportion of sero-concordant positive marriages, conditional on the married pool

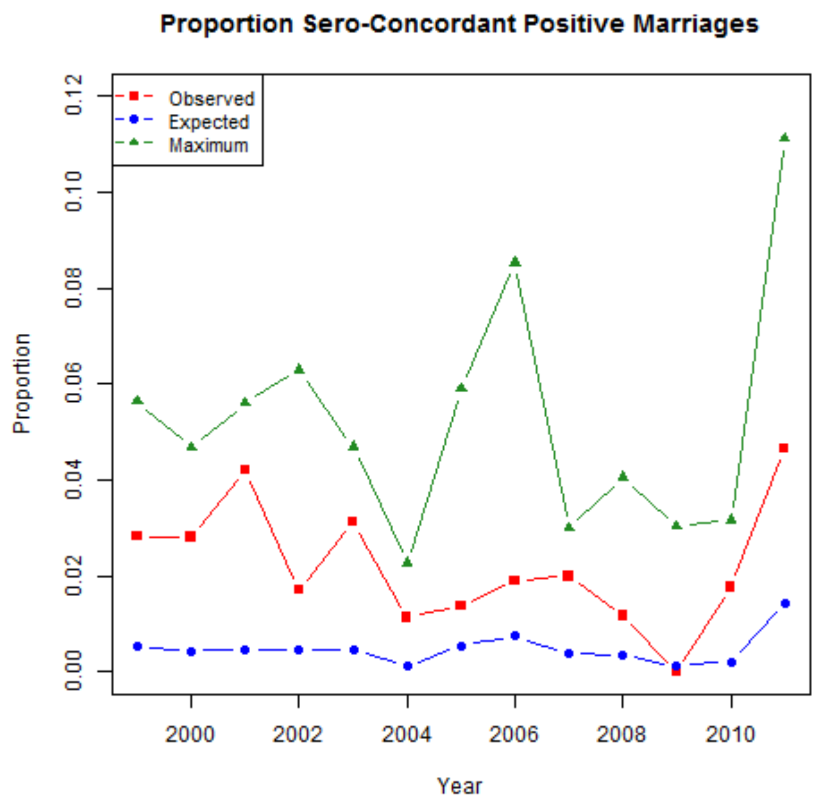

Figure 11: Maximum proportion of sero-discordant marriages, conditional on the married pool

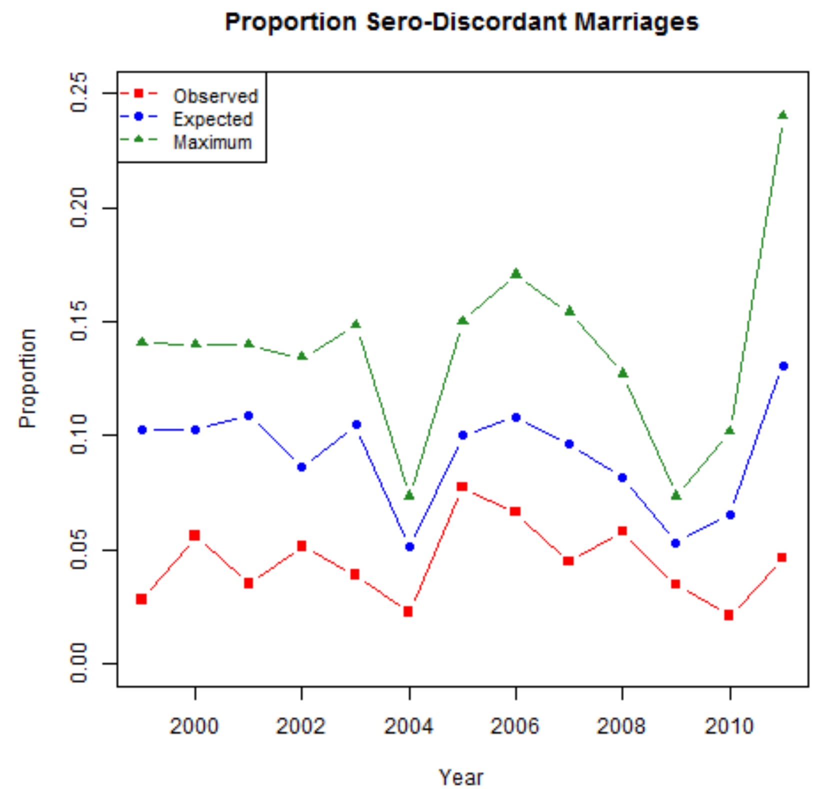

Table 4: Log-Linear Model

	(1)	(2)
Female Positive	0.102***	0.252***
	(0.0844 - 0.123)	(0.201 - 0.317)
Male Positive	0.0862***	0.188***
	(0.0706 - 0.105)	(0.150 - 0.236)
Homophily		4.285***
		(3.410 - 5.384)
Constant	81.05***	19.68***
	(66.33 - 99.03)	(14.61 - 26.52)
Deviance	228.619	83.252
dof	37	36
P-value	0.000	0.000

*** p<0.001, ** p<0.01, * p<0.05

Note: Year coefficients were excluded from the table, however not all years were significant, only 1999, 2000, 2002, 2009, and 2010 were significantly different from 2011