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"Social Networks, HIV/AIDS and Risk Perceptions"

by

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Abstract

Understanding the determinants of individuals' perceptions of their risk of becoming infected with HIV and their perceptions of acceptable strategies of prevention is an essential step towards curtailing the spread of this disease. We focus in this paper on learning and decision-making about AIDS in the context of high uncertainty about the disease and appropriate behavioral responses, and we argue that social interaction is an important determinant of risk perceptions and the acceptability of behavioral change. Using longitudinal survey data from rural Kenya and Malawi, we test this hypothesis. We investigate whether social interactions—and especially the extent to which social network partners perceive themselves to be at risk –exert causal influences on respondents' risk perceptions and on one approach to prevention, spousal communication about the threat of AIDS to the couple and their children. The study explicitly allows for the possibility that important characteristics, such as unobserved preferences or community characteristics, determine not only the outcomes of interest but also the size and composition of networks. The most important empirical result is that social networks have significant and substantial effects on risk perception and the adoption of new behaviors even after controlling for unobserved factors.

1 Introduction

Africans represent 70 percent of the world's population living with HIV, and 75 percent of the AIDS-related deaths since the early 1980s have occurred in Africa (United Nations 2000). In Malawi, for instance, the median prevalence of HIV among women attending antenatal facilities outside major urban areas in 2001 was 16%, with a range across rural surveillance sites from 4.5% to 36%, placing it eighth on a list of most infected countries headed by Botswana with a median prevalence of 35% (UNAIDS/WHO 2002). The Government of Malawi and World Bank (1998, p. vi) assess these levels of HIV infections with substantial concern: "The HIV/AIDS epidemic in Malawi has reached crisis proportions. [...] The evidence that HIV prevalence continues to be high among young adults means prevention activities must be intensified. The expected doubling of AIDS cases and deaths over the next decade means the coping mechanisms of individuals, families, and communities must be fortified."

The key behavioral options of individuals to respond to increased HIV/AIDS risks in rural Malawi—as well as in many other developing countries with high HIV/AIDS prevalence—include

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greater marital fidelity, the use of condoms in sexual relations outside of marriage, or within marriage when one spouse is potentially infected, and adjustments in the timing of first sexual intercourse and marriage. While AIDS is clearly a crisis, it is evident that the vast majority of rural adults—for example, 85% in Malawi and 65% in Botswana—have escaped infection, in part by adopting the above prevention strategies. Moreover, despite the pessimism of most writing on HIV/AIDS in sub-Saharan Africa, there are indications that behavioral changes are an important strategy for preventing infection. Recent surveys (e.g., the Demographic and Health Surveys, DHS) in areas where HIV/AIDS is particularly high show that almost everyone has the abstract knowledge to prevent HIV/AIDS: they know that HIV is primarily transmitted sexually, and that it can be prevented by abstinence before marriage and fidelity after. A few studies have gone further, showing that rural men and women know that AIDS is fatal and that they are deeply worried about contracting HIV and the implications for their children should they become infected and, in the absence of treatment, invariably die (Foster n.d.; Green n.d.; Rutenberg et al. 2000; Smith 2002; Zulu and Chepngego 2002). It is thus reasonable to expect that individuals and couples adjust their behaviors with respect to sexual and marital relations in order to respond to the threat of AIDS. Some studies also claim that intervention programs that focus on such behavioral changes are substantially—by a factor of up to 28—more cost-effective in terms of reducing HIV/AIDS mortality than highly active antiretroviral therapy (HAART) (Marseille et al. 2002). Moreover, this effectiveness of behavioral strategies to prevent HIV/AIDS may be further enhanced because attitudinal and behavioral change, once begun, is likely to be rapid and pervasive, much as fertility declines, once begun, have been rapid and widespread (Bongaarts and Watkins 1996).

The timing, pace and extent of behavioral responses by individuals and couples to HIV/AIDS risk is importantly related to (a) individuals' subjective perceptions of their infection risks and (b) their knowledge about and the availability of acceptable and effective strategies to reduce this risk. Risk-perceptions—in addition to information about and access to prevention strategies—have therefore been a central aspect in many theories of AIDS-related behavior changes such as the "Health Believe Model", the "AIDS Risk Reduction Model" or the "Theory of Reasoned Action" (UNAIDS 1999). Despite this emphasis on risk perceptions, however, very little research has focused on the determinants of subjective risk assessments. In particular, although behavior change occurs at the level of individuals, empirical studies and recent economic theories suggest the hypothesis that individuals engage in social learning and form their assessment of risk about AIDS infections—or of other health hazards—in interaction with others (e.g., see Kohler 1997; Manski 2000; UNAIDS 1999). Social interaction, for instance, can provide information about the level of HIV/AIDS in the local community, the infection status of (potential) sexual or marital partners, the availability, acceptability and effectiveness of preventive strategies, and other determinants of HIV/AIDS risk.

At least two sources of empirical evidence support this hypothesis. First, experimental and empirical studies have revealed strong influences of peers on risk assessments, expectations and subjective beliefs (Fiske and Taylor 1991; Nisbett and Ross 1980; Rabin 1998). Second, a growing literature on the diffusion of family planning in developing countries suggests that social interactions are an important determinant of the adoption of new demographic behaviors. In particular, where clinic methods of family planning or small family models constituted an innovation, as in many developing countries in the past few decades, there has been considerable uncertainty—similar to that associated with AIDS-related behavior changes—about the risks associated with new behaviors to limit fertility. Several studies have documented that individuals have turned to others to help to evaluate these risks. For example, qualitative data from Thailand and Kenya provide evidence that women chat with each other about family planning and family size (Entwisle et al. 1996; Rutenberg and Watkins 1997; Watkins 2000) and AIDS (Watkins and Schatz 2001). Related studies on the determinants of contraceptive use in high-fertility areas have estimated and found strong influences of social interactions on demographic attitudes and behavior (e.g., Entwisle et al. 1996; Kohler et al. 2001; Montgomery and Chung 1998; Munshi and Myaux 2000). Though qualifications are needed in many cases because the studies do not all control for the endogenous choices of social network partners, on the whole these studies suggest that social networks play an important role in shaping the diffusion of innovations in developing countries. Behrman et al. (2002), for instance, conclude that social networks have significant and substantial effects on contraceptive use even after controlling for unobserved factors that may determine the nature of the social networks (for a related literature on learning about agricultural innovations, see for instance Foster and Rosenzweig 1995).

In summary, the above studies suggest that social interactions may exert important influences on individuals' and couples' responses to increased HIV/AIDS risks. Nevertheless, these effects are not well documented or understood. In this paper we therefore investigate the relevance of social interactions for perceptions of the risk of infection with HIV and for the adoption of a potentially important preventive strategy, spousal communication about the threat of AIDS. Our study is based on longitudinal household surveys conducted in Kenya in 1994–2000 and in Malawi in 1998–2001. These surveys have two features that make them exceptional in the research on HIV/AIDS in developing countries: (*a*) the surveys elicited information about the social network partners with whom the respondents have talked about AIDS, and (*b*) the panel-design of these data provide multiple observations about risk perceptions and spousal communication that allow us to control for unobserved heterogeneity using fixed-effect and GMM-IV fixed-effect estimation. Our analyses yield three main findings: First, the endogeneity of social networks may substantially distort the usual cross-sectional estimates of network influences. Second, social networks have significant and substantial effects even after controlling for unobserved factors. Third, these network effects generally are nonlinear and asymmetric. They are particularly large for individuals who have at least one network partner with strong concerns about AIDS, and network partners with strong concerns about AIDS exert stronger effects on individual's risk perception than network partners with no or only modest concerns.

2 Background

The determinants of behavioral responses to HIV/AIDS—such as increased marital fidelity, condom use and changes in the timing of extra-marital and marital relations—include a broad range of social, economic and personal aspects, including for instance:

- individual characteristics, including age, education, marital status, health status, preferences for social interactions, preferences for a variety of sexual partners, susceptibility to HIV infection due to other sexually transmitted diseases, etc.;

- knowledge about HIV/AIDS, its symptoms and pathways of transmission;
- knowledge about exposure to HIV/AIDS, including knowledge about own risk behaviors, behaviors of the spouse that can lead to HIV infection, prevalence of HIV/AIDS in the population that constitutes the most important source of direct and indirect sexual contact with infected individuals;
- perceptions of the risk of contracting HIV/AIDS based on one's own behavior and that of one's sexual partner(s);
- knowledge about the social acceptability of behavioral changes such as the use of condoms within marriage;
- the outcomes of household bargaining processes within couples who face a joint risk about those behavioral responses that require the consent or involvement of both partners; and
- current and future expected prices of information, condoms, antiretroviral therapy, and other items relevant for preventing or treating HIV/AIDS.

Our analyses in this paper focus on the fourth aspect—individuals' risk perceptions and the intra-household communication about these risks—and we particularly investigate the relevance of social interactions for assessing this risk and discussing it with spouses. An important innovation that distinguishes this study from earlier investigations is that our analyses explicitly recognize that many of the above determinants of AIDS/HIV risk assessments are unobserved and simultaneously affect risk perceptions as well as the size, composition and selection of individual's network partners. This is in contrast to most of the existing literature on social interactions and demographic behaviors, which has assumed, usually implicitly, that it is acceptable to treat networks as if they were formed randomly.

There are at least two reasons to expect that this assumption may often be violated: First, a theoretical consideration of learning under uncertainty suggests that social interactions about HIV/AIDS are determined by the following factors: (*i*) the costs and benefits of social learning about AIDS and AIDS-related issues; (*ii*) the various social constraints imposed on the ability to engage in interactions about HIV/AIDS due to the availability of suitable network partners and the social acceptability of communications about risks and prevention strategies within households and within the community; and (*iii*) the ability to reduce uncertainty about AIDS risks or about prevention strategies through interaction with others, which depends in part on network partners' knowledge, their possibly strategic communication of this knowledge, and the ability of individuals to interpret correctly the information they obtain from others. Within such a model, optimal learning and decision-making at some time t is subject to budget and information constraints. This leads to reduced-form relations of the perceived AIDS risk and the propensity to adopt AIDS-related behavioral changes at time t that include on the right-side all of the variables that are predetermined from the point of view of individuals at the time of the current period's decisions: all preferences, all household and community characteristics, all current and expected prices, information collected prior to time t, etc. Because the perceived AIDS risk, the adoption of AIDS-related behavioral change and social networks all are dynamic, these relations need to be updated for assets that are carried over time.[1] Second, Watkins and Warriner (2000) show on the basis of survey and qualitative data collected in rural Kenya that the networks with whom respondents discuss issues of family planning and AIDS are relatively homogeneous compared to networks in more economically and socially stratified countries: for example, the respondent and his or her network partners tend to be similar in terms of their age, education, and economic status. This homogeneity of networks is undoubtedly due in part to the constraints imposed by the context of rural Kenya and Malawi (or similar contexts in other African countries), where relatively homogeneous populations live in small communities with poor transport and communication facilities. This homogeneity is qualified once additional qualitative data are considered. In particular, semistructured interviews with 40 women show that a primary criterion for the choice of network partners appeared to be a preference for talking with others "like me", i.e. homophily. The qualitative data also show that in addition to network selection on the basis of homophily, there is some strategic selection of network partners because they are believed to use family planning and thus may have relevant information. From these studies, and consistent with the above theoretical considerations, the process of network selection therefore appears to be structured by a combination of homophily and strategic selection of network partners who have relevant knowledge or experience.

3 Empirical Model

Based on the above considerations, we posit that prior social networks are not likely to be random in the sense of being independent of disturbance terms in relations for the estimation of risk perceptions and AIDS-related behaviors at time t. Therefore we use an empirical specification of the relation determining risk perceptions and AIDS-related behaviors in which there is explicit recognition that, in addition to observed right-side variables (including social networks prior to time t), there are unobserved factors. A first-order linear approximation to the model for the perceived risk of AIDS is:[2]

$$Y_{it} = a \cdot N_{it-} + b \cdot X_{it-} + f_i + e_{it}, \tag{1}$$

where

Y_{it} is perceived AIDS risk of individual i at time t, varying in the Kenya data from 1 = no perceived AIDS risk to 4 = high perceived AIDS risk and in the Malawi data from 1 = no perceived AIDS risk to 3 = high perceived AIDS risk;

N_{it-} is the social network for individual i prior to time t (we use the subscript "$t-$" to emphasize that the variable N refers to the time prior to t; we use this notation also for other predetermined variables);

X_{it-} is a vector of other state variables for individual i determined prior to time t (e.g., age, marital status, women's schooling, wealth indicators);

f_i is a vector of unobserved fixed factors that are assumed to determine risk perceptions and AIDS-related behaviors by individual i (e.g., the persistent part of preferences, unobserved

[1]For instance, there may be changes in the size and composition of the groups in which such social interactions occur, in the prevalence of HIV in the local population, or in the marital fidelity of a spouse.

[2]The corresponding model for the adoption of AIDS-related behavioral change, and in particular communication about AIDS/HIV risk with the spouse, is analogous.

current community characteristics, expectations regarding future prices and interfamilial and community resources on which the individual can draw); and

e_{it} is an i.i.d. disturbance term that affects the perceived AIDS risk of individual i at time t due to, for example, new information about AIDS prevalence provided by, say, the death of a family/community member due to AIDS, new information about the behavior or the spouse, or price shocks that are deviations from the long-run secular price trends.[3]

The basic estimation problem is that the representation of social networks prior to time t is likely to be correlated with the unobserved fixed factors that determine current risk perceptions and AIDS-related behaviors. In particular, social networks prior to time t, N_{it-}, are likely to have been partially determined by variables that appear also in the equation for risk perception (1), including the individual characteristics, X_{it-}, and the unobserved fixed factors, f_i. In addition, social networks are likely to depend on individual and context variables, Z_{it-}, that do not affect risk perception as well as on other unobserved factors, u_i, that are uncorrelated with X_{it-} and e_{it}. A first order approximation to this process of network formation is:

$$N_{it-} = g \cdot X_{it-} + h \cdot Z_{it-} + k \cdot f_i + u_{it-}. \quad (2)$$

As a result of this specification, the ordinary least squares (OLS) estimate of the coefficient of social networks, a, in the determination of current risk perceptions and AIDS-related behaviors in equation (1) includes not only the effect of social networks, but also the correlated effect of the unobserved factors, f_i, that affect both networks N_{it-} and risk perceptions Y_{it-}. In particular, in the simplest case in which there is no X_{it-} in equation (1), the estimate of a equals the true value of a plus the effect of f_i times the correlation between f_i and N_{it-}.

To obtain consistent estimates of the coefficient a, which measures the impact of social networks on risk perceptions and AIDS-related behaviors, it is necessary to break the correlation between the term representing social networks and the compound disturbance term including both fixed and random elements. For this purpose we combine in our estimation-strategy both fixed effect and instrumental variable estimation, and we follow an approach that is motivated by recent progress in estimation techniques for dynamic panel models (e.g., Arellano and Honoré 2001). As an illustration of our estimation strategy, consider a pure fixed effects estimation using a longitudinal dataset with two survey waves, that is, a dataset that corresponds to the household panel available for our analyses. In this model, the fixed-effect estimates are obtained from the OLS estimation of the differenced version of equation (1) as

$$\Delta Y_{it} = a \cdot \Delta N_{it-} + b \cdot \Delta X_{it-} + \Delta e_{it}, \quad (3)$$

where Δ denotes the difference in variables between the the survey waves at time t and $t + 1$.

Although the fixed effect estimation of equation (1) is likely to improve upon standard OLS analyses, it is nevertheless not fully satisfactory. In particular, the fixed-effect estimation relies on the important assumption that the social network prior to time t, N_{it-}, does not depend on the

[3]The assumption that the disturbance terms e_{it} is i.i.d., which also excludes autocorrelation, is not severe in the application to short panels with two waves since the persistence of any unobserved influences are captured by the individual fixed effect.

lagged disturbance terms $e_{i(t-1)}$ (or higher order lags). That is, fixed effect estimation does not yield consistent estimates of the network effects on risk perception if the network is determined as

$$N_{it-} = g \cdot X_{it-} + h \cdot Z_{it-} + k \cdot f_i + l \cdot e_{i(t-1)} + u_i. \tag{4}$$

This specification differs from the earlier relation in Eq. (2) because the lagged disturbance term of the relation for AIDS risk perception, $e_{i(t-1)}$, affects individuals' social network composition prior to time N_{it-}. While it renders fixed effect estimation inconsistent, such feedback from lagged disturbances affecting perception to network composition is particularly likely if individuals adapt their social networks, or their efforts devoted to social interactions about AIDS, in response to earlier information about AIDS risks or changes in AIDS risk perceptions. For instance, individuals who experienced an AIDS-related death of a friend or relative in the past may have an increased awareness about AIDS that leads them to increased social interactions about this topic.

By combining fixed effect and instrumental variable estimation, our estimation can allow for such feedback from lagged disturbances affecting AIDS risk perceptions on the current social network size and composition. In particular, since the differenced relation (3) does not include the individual fixed-effect, f_i, variables that are correlated with the fixed-effect, but uncorrelated with Δe_{it}, can be used as instruments. Of particular relevance for us are variables that describe the opportunities and constraints for social interactions about AIDS. Two aspects of these opportunities and constraints are observed in our data. First, our data include measures such as the number of funerals attended in the last year and the number of births in a village in the last year. Since funerals and—to a lesser extent—births provide opportunities for social interaction about AIDS, the village-average number of funerals and births constitute measures (albeit imperfect) of the local opportunities for social interactions. Second, an additional important indicator of the constraints and opportunities for social interactions is related to the composition of a respondent's social networks at the beginning of the panel. This composition differs among individuals because respondents had differential opportunities or incentives to interact about AIDS with others in the past. This differential "stock" of network partners at time t is likely to be correlated with the fixed effects f_i in relation (1). This differential stock of past interactions leads to different opportunities for new interactions during the period between surveys. For instance, in Section 5.1 we present evidence that the increase in network partners (or those who are very worried about AIDS among them) is inversely related to the initial number of network partners, which is plausible because the probability of a chance conversation with a new individual in the course of daily life (for example, while fetching water or going to the grain mill) *ceteris paribus* would seem to be greater over a given time interval the fewer network partners one has had in the past. Similarly, we find evidence that the change in the number of network partners between panels is positively related to events that plausibly increase opportunities to increase interaction (e.g., funerals, and other events that lead to social gatherings).

If the stock of social network partners in the network at the beginning of the panel is correlated only with the individual fixed-effect, but not with the random term in the differenced relation (3), Δe_{it}, then the stock of social network partners at the beginning of the panel can be used as an instrument for the change in the social network composition between the survey waves, ΔN_{it-}. For instance, networks generated according to equation (4) in combination with the formation of risk perceptions in equation (1) satisfy this condition. Hence, in this model the "stock" of network partners can therefore be used as an instrument for ΔN_{it-} in Eq. (3). Moreover, the instruments can also include other "stock variables" at the beginning of the panel that are correlated to individual fixed effects but not Δe_{it}, such as age, education, marital status, and indicators of household wealth.

In order to demonstrate empirically the relevance of considering the endogeneity of social networks in inferences of social interaction effects, we will implement the following four estimation techniques in our subsequent analyses:

- standard OLS analyses of equation (1);
- fixed-effect estimation of equation (1), which in our case is equivalent to OLS applied to the differenced relation (3);
- IV fixed-effect estimation of relation (3) that instruments for the change in the social network measures, ΔN_{it-};
- GMM-IV fixed effect-estimation, which uses a more efficient weighting of the moment conditions implied by the IV fixed-effect estimation.

4 Data and Context

Our analyses are based on data from the Kenyan Diffusion and Ideational Change Project (KDICP) and the Malawi Diffusion and Ideational Change Project (MDICP). In both cases, the data consist of a longitudinal household survey, and a set of semi-structured interviews and focus groups that we collected in rural areas during 1994–2000 (Kenya) and 1997–2001 (Malawi). In Kenya, the first wave of the longitudinal household survey (KDICP 1) was conducted in December 1994 and January 1995 in S. Nyanza District, with a sample of 923 women and 744 husbands. Two years later the second wave (KDICP 2) of the survey re-interviewed these women and men, followed by a third wave in January and February 2000 (KDICP 3). Only the second and third wave of the survey addressed aspects related to HIV/AIDS; thus the survey provides a panel with two waves of AIDS related perceptions and behaviors. In total, 545 women (408 men) participated in these last two rounds of the data collection.[4] In Malawi, the project interviewed in 1998 1541 ever-married women of childbearing age (15-49) and 1065 men (husbands of the currently married women) on topics related to AIDS and family planning (MDICP 1) in the Rumphi (North), Mchinji (Center), and Balaka (South) regions.[5] A follow-up survey (MDICP 2) was conducted in 2001. Details of data collection are available at http://www.pop.upenn.edu/networks. Summary statistics for the respondents participating in both surveys are reported in Table 1 for Kenya and Table 2 for Malawi.

There are both similarities and differences between our sites in Kenya and Malawi. In both Kenya and Malawi, the regions covered by the survey are primarily characterized by subsistence agriculture. Education is valued as a route out of poverty. Although most men and women have attended school, few in our samples had studied beyond the primary grades: those with more

[4]A comparison of these data for South Nyanza District, where our study was conducted, in the first two rounds of our survey with the corresponding variables collected by the 1993 Kenya Demographic and Health Survey (KDHS 1994) in rural Nyanza Province, shows that our data are representative of the Province

[5]Although the sample was designed to be representative for the selected rural regions, and not the national population of Malawi, responses to MDICP questions show close correspondence with comparable questions asked by the Malawi Demographic and Health Survey.

education seek work in the cities. Cash necessary for such expenses as school fees and clothing is obtained from remittances, wage labor, or, especially for women, small scale retailing (e.g., buying bananas in a larger market and reselling them locally). Despite a broad similarity in the overall socioeconomic contexts, there is marked variation across survey sites in the level of market activity and proximity to major transport routes. Moreover, variation in marriage patterns between our sites in Kenya and Malawi, suggest the possibility of different network dynamics. In the Kenya site, and in one of the three sites in Malawi, residence is patrilocal. Thus, men who are *de jure* residents of a village are related to each other through a common ancestor. Women, however, must form new networks at marriage, although they do retain links with their natal families in other parts of the region. The other two sites in Malawi, however, are predominantly matrilocal, such that it is the men rather than the women who form new networks at marriage.

Our survey data on sexual behavior is more extensive for Malawi than for Kenya, since in Malawi we added partnership and marital histories to the questionnaire (for more detail, see Bracher et al. 2002). However, the qualitative data for Kenya suggests that sexual patterns are similar. In all three study sites in Malawi, girls become sexually active earlier than boys and also marry earlier. Their first sexual partner tends to be older than they are themselves, and their first husband to be even older. Men are more likely to report premarital sex on the survey than women, but qualitative data show that premarital sex is common for both; we suspect that both men and women, but particularly women, underreport premarital and extramarital sex on surveys. Men are also more likely than women to report that during their first sexual relationship they had concurrent sexual relations with someone other than their regular partner although the proportions are not particularly high. Both men and women, however, evidenced a considerable lack of trust in the sexual faithfulness of their first sexual partner. The first sexual partnership tended to be short, and condom use was negligible. Fewer men than women reported marrying their first sexual partner (albeit women may be more likely to omit early relations that did not lead to marriage), and once sexually active, men were slower than women to marry. Although some reported no premarital or extramarital partners, widespread premarital and extramarital experience suggests that in this context strict abstinence and fidelity can be considered innovative behaviors.

UNAIDS/WHO (2002) estimate that between 1992 and 2001 the median prevalence of HIV among women attending antenatal facilities outside major urban areas increased from six per cent (range 2-14%, 10 sites) to 16 per cent (range 4-36%, 16 sites). HIV prevalence peaks among antenatal women at ages 25–29. These general trends are similar for Kenya. During 1988-99 the median HIV prevalence among attendees of antenatal clinics outside urban areas increased from less than 1% to 23%, and HIV prevalence ranged from 6% to 41% among 20 rural surveillance sites in 1999. As expected, HIV prevalence is higher among specially selected groups, such as commercial sex workers. Indeed, 70% of sex workers tested in Lilongwe/Malawi in 1994 and 55% of sex workers tested in Mombassa/Kenya in 1993–95 were HIV positive.

Not surprisingly concerns about the risk of AIDS infection are widespread in both rural Kenya and Malawi (Tables 1–2). Between 36 percent and 40 percent of women in Kenya responded in the 1996/97 and 2000 surveys that they perceived themselves to have a moderate or high risk of becoming infected with AIDS (for Malawi, 61 and 47 percent perceived a high risk of AIDS in

1998 and 2001).[6] In addition, more than 85 percent (Kenya) and 87 percent (Malawi) of women knew of at least one recent death which they suspected was caused by AIDS, and more than 30 percent (Kenya) and 16 percent (Malawi) know about more than five such cases (virtually no one is tested, but the symptoms of AIDS are well-known). Respondents are generally also aware of several mechanisms by which HIV/AIDS is transmitted and several ways of protection. For instance, in 1996/97, more than 90 percent of women in Kenya knew that AIDS can be transmitted by sex and 48 percent knew about possible transmission by injections. Similarly high levels of knowledge prevail in Malawi. Qualitative data collected in the Malawi study sites also showed that there is a great deal of uncertainty about the desirability or even the possibility of reducing pre-marital and extramarital sex, as well as about condom use in extramarital relations—and condom use within marriage is not yet even a topic of discussion (Kaler 2002; Schatz 2002; Tawfik 2001; Zulu and Chepngego 2002).

Due to the high perceived infection risks and the widespread knowledge of AIDS-related deaths, AIDS has also become a frequent topic in interactions in social networks and within couples. The networks are highly gendered: men talk with men, women with women (Watkins and Warriner 2000; Zulu et al. 2002). Our qualitative data also suggest that these discussions are often provoked by observing or hearing about an illness or death. Although virtually no one has a clinical diagnosis of AIDS, the common symptoms (loss of weight, diarrhea, failure to respond to treatment for opportunistic infections) are well known (Chimwaza and Watkins 2002). Discussions often link these symptoms to local knowledge of the sexual behavior of the patient or the deceased. Most importantly, in discussions about AIDS there is often an attempt formulate locally acceptable strategies of prevention that adapt the prevention advice promulgated by international agencies and the government to local circumstances: for example, men may chat about the advisability of using a condom with a particular partner or a particular type of partner, and women may consult each other about strategies for persuading a husband to be faithful (Smith and Watkins 2003; Watkins 2003; Watkins and Schatz 2001). Conversations with spouses are focused on the threat of AIDS to the couple's children. Typically, both husband and wife acknowledge their joint fates that the behavior of each affects the survival of both; they consider the implications of their possible deaths for their children should they be orphaned; and encourage mutual fidelity (Zulu and Chepngego 2002).

Although unusual for data on HIV/AIDS, our quantitative data also include detailed accounts about women and men's interactions about HIV/AIDS with social network partners besides their spouse that allow us to investigate the role and importance of these interactions. In particular, the data include information on egocentric networks, i.e., networks that contain the respondent and network partners with whom the respondent had chatted about AIDS, with detailed information on up to four network partners. The term chat was used to indicate informal conversations rather than the lectures on HIV/AIDS given at clinics. The network data were collected by first asking the

[6] The question eliciting the respondents perceived AIDS risk was phrased as "How worried are you that you might catch AIDS?," with responses ranging from "not worried at all" to "worried a lot". This question is also frequently used in public health research on AIDS to assess risk perceptions, and responses to this question are positively correlated at .46 with a question—only asked in the 2001 Malawi survey—about the subjective likelihood that the respondent will become infected with HIV in the future.

respondents with how many network partners they had chatted about AIDS.[7] After the respondents listed all network partners with whom they had conversations about AIDS, they were asked a series of questions about a maximum of four of these network partners. The questions asked of the respondent about her/his network partners included relationship (co-wife, sister-in-law, sister, etc.), the degree of closeness (confidant, friend, acquaintance), the network partner's age, sex and wealth, and the perception of the network partner about the risk of becoming infected with HIV/AIDS.[8] Over three-quarters of the women have talked with at least one person about AIDS, and over two-fifths of the women have talked with at least one person who feels at a moderate or great risk of becoming infected with AIDS. On average, women report that they have talked with on average with 3.9–4.8 network partners about AIDS, and men report a slightly more interactions ranging from close to 4 to about 7 network partners. Detailed information about interactions is available for about 2.4–3.6 network partners. In general, the respondents report more interactions with network partners that perceive a high AIDS risk as compared to network partners that assess their risk as low. In addition to talking with network partners about AIDS, husbands and wives also discuss their risks and how they can prevent infection.

We represent social networks by the extent to which each respondent's network partners are reported to be worried about AIDS.[9] Since the questions were asked slightly differently in Kenya and Malawi, we represent the perception of risk slightly differently. In particular, perception of risk is a categorical variable with four options in Kenya (categories are: none (1), some (2), moderate (3) and great (4)) and with three options in Malawi (categories are: none (1), moderate (2) and great (3)). In our regression analyses for Kenya, we therefore combine the number of network partners who perceive either no or only a small risk of AIDS infection, and we also combine the number of network partners who perceive moderate or great risks of getting AIDS. In Malawi, we include the number of network partners in three categories of risk perception: no risk, moderate risk and high risks of getting AIDS. The essential variable representing social interactions about HIV/AIDS is therefore the number of network partners with whom the respondent has interacted about HIV/AIDS classified by the network partners' reported risk perception (for Kenya the categories are: no or only a small risk and moderate or great risks; for Malawi the categories are: no risk, moderate risk and high risks).[10]

[7] The question about the number of conversations did not have an explicit time reference. A related question in the Kenyan survey about the time of the last conversation about AIDS shows that many conversations were relatively recent: the last conversation with the network partner occurred within one year prior to the survey in more than 80% of all cases. We expect that this pattern is similar in Malawi.

[8] The specific question regarding the risk perception of the network partners was "How worried is *name of network partner* about getting AIDS?" with the same response categories as for the respondent.

[9] Although in what follows we will refer to the network partners perceptions of risk, this perception is reported by the respondent; see footnote 8.

[10] A possible problem regarding our representation of network partners is that it may incorporate random or systematic measurement error. Random measurement error in a right-side variable, as is well-known, biases estimated coefficients towards zero and is exacerbated in fixed effects estimates because such measurement error is larger relative to the deviations from averages on which fixed effects depend than it is relative to the level of the same variables. We are not able to control for random measurement error. So to the extent that when we ask a respondent how many network partners she has and she responds with the true number plus or minus a random term, we underestimate the effect of networks. Systematic measurement error would occur if, for example, respondents systematically under-report their number of network partners because they simply do not recall them all or they over-report AIDS worries of their network partners because they perceive the research team to favor such responses and

they wish the team to learn that their friends are concerned about the increased infection risks. Systematic

Our primary dependent variable is the respondent's own risk perception. For our regression analyses, we construct a continuous index for a respondent's risk perception from the categorical values by scoring each response with the values indicated in parentheses for the corresponding levels of subjective risk: none (1), some (2), moderate (3) and great (4) for Kenya; and none (1), moderate (2) and great (3) for Malawi. We adjust for the potential heteroscedasticity in these regression analyses by using White's (1980) heteroscedasticity-consistent covariance matrix estimator.[11] A further dependent variable is available for the Kenyan data where the household survey also provides longitudinal data on the husband-wife communications about HIV/AIDS (Table 1).[12] This spousal communication has markedly increased during the period of the panel in Kenya, and this change is often seen as an important step towards adopting risk-prevention strategies within marriage.

Our empirical representation of these dependent variables and their relation to social networks is given in equation (1). In addition to social networks, the variables X_{it-} on the right-hand-side of equation (1) include in our empirical model the respondent's age, age^2 and education. These variables are not time-varying and therefore vanish in the fixed effect and FE-IV estimation. In addition we include several time-varying variables that appear also in the differenced relation (3) that underlies the fixed-effect and GMM-IV fixed effect models. Children ever born is included because our qualitative data revealed an important concern about children becoming orphans due to AIDS. This concern is presumably greater the greater the number of children. We also include variables that indicate whether a household has a radio and metal roof because these indicators provide a measure of wealth that we have found to be correlated with other measures of economic status such as usual and actual income. In our analyses, we instrument in the FE-IV estimations for the variables representing the size and composition of social networks and for the number of children ever born because these variables are closely related to the formation of risk perceptions and respondents' preventive strategies (e.g., condom use or changes in intercourse frequencies). We treat a household's possession of a radio and metal roof as exogenous once fixed effects are removed.

measurement error can bias the estimates in either direction, depending on its nature. If respondents systematically understate their number of network partners and do so more the larger is the true number of their network partners, for example, the result is likely to be an upward bias in the estimated impact of the number of network partners in OLS estimates. (Intuitively, the variable that is used in the estimates is smaller than the true number but it represents the effect of the larger number by attributing greater than true effects to the reported number.) If respondents systematically overstate the proportion of their network partners who are worried about AIDS, the result is likely to be a downward bias in the estimated influence of network partner's AIDS concern on the respondents risk perception. To the extent that individual respondents always misreport their number of network partners by the same amount (though this amount may differ across respondents), our individual fixed effects control perfectly for systematic measurement error.

[11] An alternative approach would be the use of categorical models, such as ordered probit. However, because of the nonlinearity in the function relating the latent score to the observed variable these categorical models cannot be combined with fixed effect and FE-IV models. Using linear regression applied to the continuous index described above avoids this problem, while maintaining asymptotically consistent estimators of the coefficients of interest and their standard errors. For further discussion, see Arellano and Honoré (2001) or Honoré and Kyriazidou (2000).

[12] The question was asked as "Have you ever talked to your husband about the chances that you or he might get infected with AIDS?"

5 Results

5.1 Determinants of social network changes

In Table 3 we report regressions for women of change in the number of network partners between the survey waves on the initial number of network partners, individual characteristics and indicators of opportunities for social interaction. The pattern that emerges from these regressions is that a smaller initial number of network partners in each risk-category is strongly associated with larger changes in the number of network partners in both Malawi and Kenya. There are no strong influences across network partners with different risk assessments, which suggests that women do not try to replace network partners who have one category of specific risk perception with partners who have other risk perceptions; on the contrary, women seem to desire a fairly balanced representation of different AIDS risk perceptions in their social networks. In addition, there are very few systematic influences of individual characteristics on the change in social networks over time. One exception is that in Malawi secondary education seems to have a slightly positive and a modest negative effect on the change in the number of network partners with moderate and low risk perception, respectively. In addition, and potentially surprisingly, the indicators of opportunities for social interaction as represented by the average number of funerals attended in a village or the total number of births in a village, do not have strong effects on the change in the network representation. Although we do not report the results here, the pattern of network changes between waves is very similar also for males.

The above changes in the number of network partners between survey periods are consistent with our theoretical discussion in Section 3 about the determinants of network change. Moreover, the dependence of the changes in the size of respondents' networks on the initial size and composition of the network and fixed individual characteristics such as age and higher education is likely to be due to individual fixed effects f_i. These effects, however, are removed in our fixed effect estimations that are based on the differenced relation in equation (3). In our analyses we therefore assume that the variables used to predict the change the number of network partners in the analyses in Table 3 are uncorrelated with the residual in Eq. (3) and therefore can be used as instruments for ΔN_{it-} in this relation.

5.2 Social network influences on individual's risk perception

We have used three different estimation techniques to estimate the AIDS risk perception relation in equation (1): GMM-IV fixed-effect estimation, fixed effect estimation and OLS. Since the results of IV fixed-effect and GMM-IV fixed-effect analyses are very similar, we report only the latter results. The dependent variable in Tables 4–5 is the respondents' risk perception about getting AIDS, which ranges from 1 to 4 in Kenya and 1 to 3 in Malawi (see Section 4). A consequence of this differential variable coding is that the estimated coefficients for Kenya and Malawi are not directly comparable.

The GMM-IV fixed-effect estimates are ex ante our preferred estimates because the estimation controls both for time-invariant and time-varying characteristics that may affect the extent to which individuals are worried about AIDS (Section 3). We also suggested that three sets of variables in our data can potentially serve as instruments in the (GMM-)IV fixed-effect estimations: (1) variables that measure the opportunities and constraints for social interactions about AIDS; (2) variables that measure the "stock" of social network partners at the beginning of the periods studied; and (3) variables describing time-invariant characteristics of respondents and their social environment. In our GMM-IV fixed-effect analyses we therefore instrumented the right-hand-side variables pertaining to the respondents' social networks, and additionally we instrument the change in the children-ever-born since this variable is endogenous to many AIDS-related behavioral changes such as condom use. The instruments used in these analyses include at least one network partner with moderate/high risk perception in the initial data round, remaining number with moderate/high risk perception in the initial data round, at least one network partner with no/low risk perception in the initial data round, remaining network partners with modest/low risk perception in the initial data round, village average number of funerals attended (an indicator of the possibility for social interactions about AIDS during funerals) between data rounds, village number of newborn babies (an indicator of the possibility for social interactions about AIDS during social activities associated with childbirth between data rounds.[13] In addition, we include among the instruments the respondent characteristics age and age^2, at least primary education, children ever born at the time of the initial data collection, marital status, having radio and having a hut with a metal roof. In our OLS analyses we also include the respondent characteristics age, age^2, at least primary education, at least secondary education in addition to the network measures and the time-varying variables describing children ever born, marital status, having radio and having a hut with a metal roof.

Our initial analyses in Table 4 include the number of network partners with different risk perceptions. Most importantly, the GMM-IV fixed-effect analyses show that social interactions affect individuals' worry getting AIDS. In particular, each additional network partner with high risk perception *increases* the respondent's risk perception by .23 (Kenya) and .11 (Malawi). Network partners with moderate or low risk perception, on the other hand, *decrease* the respondents own risk assessment. In Kenya, the effect is equal to -.07 and weakly significant, and in Malawi the effect is -.13 (network partners with moderate risk perception) and -.23 (network partners with low risk perception).

In addition to these coefficient estimates obtained from our preferred GMM-IV fixed-effects estimation, the comparison of the different estimated effects across the different models in Table 4 is interesting. In Kenya, fixed effect estimation yields estimates of .17 and .04 for the number of network partners with high and low risk perception, and OLS respectively yields .16 and -.07. Compared to our preferred model, OLS and fixed effect estimation therefore underestimate the effect of social interactions with network partners who worry a lot about the chances of getting AIDS. In addition, the comparison of the results obtained from GMM-IV fixed-effect and fixed-effect estimation suggests that the residual in the differenced relation in equation 3 is negatively correlated with the change in the network over time. For instance, this can occur if respondents whose disturbance term in the AIDS perception equation (equation 1) is towards increased worries about AIDS then increase their efforts devoted to social interaction and increase their social networks

[13]This variable is included only in analyses for females because some village identifiers are ambiguous for men in the Kenyan data.

(and particularly, network partners with high risk perception).[14]

The pattern of coefficients across the different estimation methods is somewhat different in Malawi. Compared to our preferred model, the fixed effect and OLS estimation *overestimate* the effect on respondents' risk perception of the number of network partners with high concerns about AIDS, and these models also *underestimate* the reducing effect of network partners with only moderate and low risk perceptions. Regarding the dynamic adjustment of respondents' social networks over time, the comparison of IV fixed-effect and fixed-effect estimates suggests a positive correlation between the residual $\Delta\varepsilon_{it}$ of the differenced risk perception equation (equation 3) and the differenced network characteristics ΔX_{it-}. Therefore, respondents whose past disturbance term shifted them towards high risk perceptions tend to have smaller changes in the social network between Malawi 1 and 2, while respondents who were less worried in the past have faster increases in the number of network partners.[15]

In Table 5 we further analyze the network effects on AIDS risk perceptions and investigate potentially nonlinear network effects. In contrast to our analyses above, which imply constant marginal effects of additional network partners with either high or low risk perception, we also investigate whether the marginal impact of having one network partner with a given behavior or characteristics (e.g., having high perceived AIDS risk) is different from those of having more network partners with such characteristics. For this purpose we separate the number of network partners with low, moderate or high risk perception into a dummy variable indicating 'at least one network partner with low/moderate/high risk perception' and 'the remaining number of network partners with this risk perception'.

The GMM-IV fixed-effect analyses in Table 5 reveal that having at least one network partner

[14] Strictly speaking, the above interpretation is not fully correct since the estimates obtained from fixed-effect estimation yields

$$\text{plim } \hat{b} = b + \text{plim } \left(\frac{1}{n}(\Delta X_{t-})'(\Delta X_{t-})'\right)^{-1} \text{plim } \left(\frac{1}{n}(\Delta X_{t-})'(\Delta\varepsilon_{t-})'\right),$$

where ΔX_{t-} and $\Delta\varepsilon_{t-}$ are the matrices/vectors of stacked individual characteristics ΔX_{it-} disturbances $\Delta\varepsilon_{ti-}$. If the off-diagonal elements of the probability limits in the above relation are large enough, the above argument stated in terms of correlation may not hold.

[15] Our data includes risk perceptions and other detailed information on up to four network partners with whom the respondent has talked about HIV/AIDS. This information for up to four network partners is used for the analyses in Table 4 and also for the following analyses in Tables 5–8. However, 35–55% of respondents in Kenya and 28–49% of respondents in Malawi report in the survey state that they have interacted with more than four network partners (Tables 1 and 2). In order to assess the implications of this censoring of detailed information about network partners, and specifically about the network partners' risk perceptions, we also investigate three different assumptions about risk perceptions of network partners for whom detailed information is not available. In particular, we assume that all network partners beyond the first four have (a) high perceived AIDS risk, (b) low perceived AIDS risk, or (c) are distributed among the different risk categories in a proportion that is equal to that observed for the first network partners. In Table A.1 we re-estimate the GMM FE-IV estimates of Table 4 using the assumptions (a–c) for the risk perceptions of network partners beyond the first four. Our intuition is that assumption (b) is likely to be much closer to reality than assumptions (a) and (c) given that (i) the usage rates reported by the respondents themselves in the sample and (ii) a probable tendency to mention first those network partners who are very concerned about HIV/AIDS (even though there was no instruction to do so) because conversations with such network partners may have seemed more relevant in a context where outsiders have come to ask questions about this topic (for a related discussion, see Miller et al. 2001). The estimates in Table A.1, particularly for assumptions (b) and (c), are basically consistent with those in Table 4 in terms of the pattern of network influences on respondents' risk perception as well as the size and significance of the estimated coefficients. The main implications of the different assumptions is that the estimated coefficients become smaller, and sometimes insignificant, for the risk category to which the 4+ network partners are assigned. This effect is expected the increase in the mean and variance of the variable with this adjustment.

with high worries about AIDS increases the respondents' risk perception by .54 (Kenya) and .18 (Malawi), while additional network partners have a substantially smaller effect of .055 (Kenya) and .076 (Malawi). For network partners with low or no perceived AIDS risk the pattern is less clear and statistically insignificant in Kenya. In Malawi, on the other hand, the above nonlinearity also persists and is significant for all categories of network partners' perceived risk. The first network partner with moderate AIDS worries reduces respondents' risk perception by .25, and the reduction is equal to .36 for the first network partner with no risk perception. Additional network partners beyond the first one in any category of AIDS risk concerns have a substantially smaller effect on respondents' risk perception.[16]

OLS analyses and pure fixed-effect analyses yield a slightly distorted picture compared to GMM-IV fixed-effect estimates. In particular, in Kenya OLS and fixed-effects underestimate the effect of the first network partner with high risk, and overestimate the marginal effect of additional network partners. In Malawi, the distortions are somewhat different; OLS and fixed effects overestimate the effect of network partners with high risk perceptions and underestimate the reducing effect of network partners with only moderate or low AIDS concerns.

In summary, the estimates in Tables 4–5 suggest: (*i*) having social network partners exerts significant and substantial effects on respondents' risk perception about AIDS even with controls for unobserved factors that may affect both the propensities to worry about AIDS and social networks. (*ii*) OLS estimates based on the assumption that social networks are random result in biases in the estimates for these network effects, and the direction of the bias differs in Kenya and Malawi. For Kenya, the network effects obtained from GMM-IV fixed-effect regressions are between 35 and 70 percent *larger* than those obtained from standard OLS analyses, while for Malawi the GMM IV fixed-effect estimates tend to be smaller in magnitude than the corresponding OLS estimates; (*iii*) the social network effects are asymmetric and nonlinear, and they are particularly relevant for network partners with moderate/high concerns about AIDS and for individuals who have at least one network partner who is perceived to have this characteristic.

Despite the very gendered nature of social networks in Malawi and Kenya, the estimates of social network influences on worry about AIDS are remarkably similar for males. In Table 6, for instance, the same key findings prevail to males as for females. The GMM-IV estimates reveal significant and relevant social network influences for men, with the strongest influences exerted by the first network partner in any specific category (an exception is for moderate risk perception in Malawi, where the overall influence is not significant). In addition, the network influences are asymmetric where social interactions with individuals expressing high concerns increase, and social interactions with partners expressing low concerns decrease the respondents' risk perceptions. Moreover, the distortions of fixed-effect and OLS estimates as compared to our preferred GMM-IV fixed-effect estimates are very similar for males and females.

[16]This result is similar to estimates obtained for social network effects on family planning use; see Behrman et al. (2002) and Montgomery et al. (2001).

5.3 Social network influences on spousal communication about AIDS risk

Although we can document similar network influences on risk perception for both men and women, husband and wife can nevertheless reach quite different conclusions about their exposure to AIDS risk and the appropriate preventive behavior. Differences in assessments about AIDS risk can in part be due to asymmetric information or knowledge (for instance, about the extent of extra-marital sexual relations) or due to different patterns of social interaction. This suggests that strategies of prevention might be very different for women and men. Although the survey data show that both men and women discuss AIDS in their social networks, the qualitative data show that the resulting strategies differ. Men primarily discuss the possibilities of remaining faithful or how to select partners who are not infected. Although women also have extramarital relations, their discussions with their network partners appear to focus on how to persuade their husbands to be faithful. For both, however, divorce is a threat: divorce is very common (about 50% of first marriages in Malawi end in divorce), and qualitative data show that it is instigated by both women and men, with remarriage typically following rapidly.

Spousal communication about preventing AIDS thus emerges as a further important determinant of prevention. In addition, our qualitative and earlier quantitative analyses suggest that social networks are likely to be an important determinant of the propensity to discuss the risk of AIDS with one's spouse. On one hand, the previous section has demonstrated network effects on risk perceptions and these perceptions constitute an important motivation for adopting preventive behavior within marriage. On the other hand, social interactions are likely to shape the perceptions about appropriate marital behavior

We are able to perform analyses of social network influences on spousal communication in Kenya (in Malawi, unfortunately, the question was not consistently asked over time). Tables 7 and 8 report our analyses of whether women and men have discussed the chances of getting AIDS with their spouses. In the analyses for females the dependent variable is the wives' response to the question about spousal communication, while it is the husbands' response in the analyses for males.[17] We estimate linear probability models, and the specification of the right-side variables is analogous to the analysis in our earlier sections. We use a linear probability model because the role of fixed effects and its combination with instrumental variable estimation is more transparent in this linear approximation to binary choice models. But for dichotomous dependent variables the assumptions of normality and homoscedasticity of the disturbance term are violated. We adjust for these violations of the classical OLS model in our IV fixed effect estimates by using robust standard errors (White 1980), and with this modification the linear probability model in equation (1), with Y_{it} representing the binary indicator about spousal communication, provides consistent estimates of the parameters and their standard errors.

In Table 7 we focus on the results obtained from considering the number of network partners with different risk perceptions. The GMM-IV fixed-effect estimation indicates that network partners have a relevant and significant effect on spousal communication about AIDS. Moreover, in contrast

[17] The responses do not always overlap within households. Miller et al. (2001), for instance, have found a systematic gender component to reporting: For many of the survey questions considered, when spouses disagree, husbands are more likely to say "yes" and wives "no." The findings are interpreted in terms of gendered strategies in the interview process.

to the early asymmetrical effects of network partners with different risk perceptions, the effect is in the same direction for spousal communication: independent of the network partner's concern about AIDS, each additional network partner has a positive effect of approximately .04 (females) and .05–.06 (males) on the probability of talking with the spouse about the chance of getting AIDS, and this effect is remarkably similar across genders. Contrary to the pattern in our analysis of risk perceptions, standard OLS analyses would overestimate this network effect by up to 80%. If we allow for nonlinear network effects in Table 8, the overall significance of our results is reduced due to the additional parameters. Nevertheless, there remains an indication in the GMM-IV fixed-effect estimates that the effect of network partners is nonlinear with the largest effect exerted by the first network partner, but the result is less clear-cut than in our earlier analyses of risk perceptions (for instance, it is also absent for very concerned network partners for females, while it prevails for the other coefficients).

In summary, our analyses suggest that social networks not only influence the perception of AIDS risks, but also important household decision processes in the adoption of preventive behavior. In particular, social interaction with network partners increases the probability of spousal communication about AIDS, and this effect does not seem to depend on the specific risk perception of the network partner.

6 Conclusions

Epidemiological and social science research on HIV transmission and prevention in Africa has recognized the importance of changes in sexual behavior. That individuals know in the abstract how HIV is transmitted and how it can be prevented has been well documented by many surveys, including the ones used here. Individuals in affected communities remain unclear, however, about the advisability and effectiveness of the changes in sexual behavior that are recommended by experts. Our understanding of responses to the epidemic also remains incomplete without an understanding of how men and women living in the rural areas of sub-Saharan Africa come to perceive their risk of HIV infection and how they come to formulate what they consider to be acceptable and effective strategies of prevention.

In this study we argue that social interactions are mechanisms for reducing this uncertainty and we hypothesize that interactions in social network have important effects on individuals' risk perceptions and their consideration of new behaviors. Our empirical analyses test this hypothesis and provide new estimates based on longitudinal data that we collected in rural Kenya and Malawi on AIDS and AIDS-related social interactions. Our major findings are as follows. First, and foremost, our analysis shows that social networks have significant and substantial effects on individuals' AIDS risk perceptions even when we control for unobserved factors that also may determine the nature of the social networks. Thus, to understand the dynamics and diffusion of behavioral change in response to AIDS it may be essential to incorporate the impact of social networks. The failure to do so may lead to misunderstanding the dynamics of behavioral change. Second, this effect of social networks extends to the area of spousal communication about AIDS risk, and interactions with network partners—independent of network partners' risk assessment—tend to increase the probability of husband-wife communication about the disease. Third, the effects of social networks that we found contribute to a better understanding of diffusion. These effects are generally nonlinear and asymmetric. They are particularly large for having at least one network partner who is perceived to have a great deal of concern about AIDS. The inclusion of additional network partners with the same characteristic or with the opposite characteristic generally has much smaller or insignificant effects. An exception to this asymmetry occurs in the network effects on spousal communication, where network partners, independent of their risk perception, have strong and significant effects.

These findings are of central importance for understanding and curtailing the spread of HIV/AIDS because they document that social interactions constitute a—potentially important—determinant of how individuals and couples develop strategies for coping with AIDS. In particular, this study shows that social networks exert systematic and strong influences on risk perceptions and the probability of spousal communication about AIDS risks in rural areas, and that these influences are in addition to potential other factors such as program interventions focusing on the spread of knowledge about the disease, access to condoms and changes in sexual behaviors within and outside marriage. Social interactions thus are likely to have a substantial impact on the course of the epidemic and the magnitude of its consequences, and these should be taken into consideration in devising program interventions with respect to the AIDS epidemic.

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Table 1: Summary statistics for the Kenya data

	Females		Males	
	Kenya 2	Kenya 3	Kenya 2	Kenya 3
N	701	882	523	599
Individual Characteristics at $t-$				
Age	32.77		43.40	
	(8.39)		(12.92)	
Not currently married	0.07	0.13	0.03	0.04
Children ever born	5.44	5.34	7.44	7.46
	(3.09)	(3.17)	(6.73)	(5.37)
Has radio	0.60	0.63	0.65	0.73
Has metal roof	0.26	0.41	0.27	0.41
Has at least primary schooling	0.79	0.82	0.90	0.92
Has secondary or higher schooling	0.14	0.14	0.28	0.33
Perceived AIDS risk, respondent				
Proportion perceiving no risk	0.25	0.20	0.28	0.21
Proportion perceiving small risk	0.35	0.44	0.38	0.53
Proportion perceiving moderate risk	0.26	0.27	0.23	0.22
Proportion perceiving great risk	0.14	0.09	0.11	0.04
AIDS network				
Prop. with at least one nwp in AIDS network	0.76	0.88	0.83	0.91
Uncensored size of AIDS network	4.88	6.20	6.54	9.43
	(5.88)	(6.96)	(7.80)	(10.7)
Censored size of AIDS network	2.38	2.91	2.70	3.26
	(1.61)	(1.42)	(1.52)	(1.27)
Proportion with more than 4 network partners	0.35	0.53	0.43	0.55
Proportion with at least one nwp who perceives moderate or great AIDS risk	0.42	0.43	0.48	0.48
Number of nwp who perceive moderate or great AIDS risk	0.91	1.06	1.09	0.93
	(1.28)	(1.24)	(1.37)	(1.19)
Proportion with at least one nwp who perceives no or small AIDS risk	0.47	0.70	0.55	0.77
Number of nwp who perceive no or small AIDS risk	0.98	1.61	1.19	2.07
	(1.27)	(1.40)	(1.36)	(1.47)
Communication with spouse about AIDS risk				
Proportion having talked to spouse	0.56	0.71	0.73	0.83

Table 2: Summary statistics for the Malawi data

	Females		**Males**	
	Malawi 1	Malawi 2	Malawi 1	Malawi 2
N	1179	1159	806	799
Individual Characteristics at $t-$				
Age	31.08	34.26	37.05	40.36
	(9.26)	(9.39)	(10.43)	(10.96)
Not currently married	0.11	0.11	0.01	0.03
Children ever born	4.38	5.11	5.28	6.17
	(3.05)	(2.89)	(4.20)	(3.98)
Has radio	0.57	0.64	0.67	0.73
Has metal roof	0.07	0.10	0.08	0.11
Has at least primary schooling	0.64	0.67	0.79	0.83
Has secondary or higher schooling	0.05	0.06	0.14	0.15
Perceived AIDS risk, respondent				
Proportion perceiving no risk	0.17	0.29	0.27	0.42
Proportion perceiving moderate risk	0.21	0.23	0.19	0.21
Proportion perceiving great risk	0.61	0.47	0.53	0.37
AIDS network				
Prop. with at least one nwp in AIDS network	0.83	0.95	0.92	0.97
Uncensored size of AIDS network	4.33	5.84	6.24	7.04
	(5.14)	(5.57)	(6.46)	(6.92)
Censored size of AIDS network	2.53	3.42	3.08	3.56
	(1.50)	(1.09)	(1.26)	(0.95)
Proportion with more than 4 network partners	0.28	0.42	0.43	0.49
Prop. with at least one nwp who perceives great AIDS risk	0.61	0.52	0.67	0.47
Number of nwp who perceive great risk	1.46	1.06	1.77	1.05
	(1.49)	(1.28)	(1.59)	(1.35)
Prop. with at least one nwp who perceives moderate AIDS risk	0.31	0.45	0.32	0.43
Number of nwp who perceive moderate AIDS risk	0.50	0.71	0.54	0.71
	(0.87)	(0.95)	(0.94)	(1.03)
Proportion with at least one nwp who perceives no AIDS risk	0.26	0.57	0.30	0.58
Number of nwp who perceive no or small AIDS risk	0.48	1.12	0.68	1.24
	(0.94)	(1.23)	(1.20)	(1.32)

Table 3: Females: regression of changes between survey waves in the number of network partners with different risk perceptions on the initial number of network patterns and personal characteristics

	Kenya		**Malawi**		
	Change between K2 and K3 in the number of nw-partners with		Change between M1 and M2 in the number of nw-partners with		
	high risk perception	low risk perception	high risk perception	moderate risk perception	low risk perception
at least one nwp with high perceived risk, time $t-$	-0.8965	-0.0532	-1.0101	0.0689	-0.1062
	(0.1476)**	(0.1802)	(0.0909)**	(0.0768)	(0.0943)
# of remaining nwps with high perceived risk, time $t-$	-0.8729	0.0654	-0.8558	-0.0187	-0.0199
	(0.0853)**	(0.0939)	(0.0436)**	(0.0330)	(0.0435)
at least one nwp with moderate perceived risk, time $t-$			-0.1698	-0.8928	0.1207
			(0.0959)$^{+}$	(0.0804)**	(0.0982)
# of remaining nwps with moderate perceived risk, time $t-$			0.0448	-0.9736	0.0513
			(0.0799)	(0.0697)**	(0.0844)
at least one nwp with no or low perceived risk, time $t-$	0.0995	-0.6591	-0.0425	-0.1621	-0.8985
	(0.1343)	(0.1646)**	(0.1041)	(0.0782)*	(0.1080)**
# of remaining nwps with no or low perceived risk, time $t-$	0.0718	-0.9699	0.0812	0.0778	-0.9830
	(0.0777)	(0.0858)**	(0.0802)	(0.0528)	(0.0758)**
children ever born	0.0129	0.0091	-0.0402	0.0199	0.0163
	(0.0249)	(0.0278)	(0.0205)*	(0.0142)	(0.0172)
dummy for not married, time t	-0.1871	-0.0737	-0.2436	0.0510	0.2854
	(0.2118)	(0.2763)	(0.1163)*	(0.0905)	(0.1267)*
Respondent has radio, time t	0.1363	-0.0689	0.0850	-0.0726	0.1820
	(0.1123)	(0.1342)	(0.0798)	(0.0607)	(0.0763)*
Respondent has metal roof, time t	-0.0073	0.1576	-0.0335	-0.0682	-0.1310
	(0.1341)	(0.1470)	(0.1521)	(0.1175)	(0.1458)
Respondent has at least primary education	0.1018	0.3319	0.0418	0.0298	-0.0049
	(0.1419)	(0.1697)*	(0.0851)	(0.0645)	(0.0809)
Respondent has secondary education	0.2712	0.1492	-0.2539	-0.2700	0.5556
	(0.1695)	(0.1889)	(0.1713)	(0.1188)*	(0.1942)**
age	-0.0539	0.0078	0.0276	-0.0127	-0.0456
	(0.0515)	(0.0570)	(0.0264)	(0.0177)	(0.0265)$^{+}$
(age/10) squared	0.0675	-0.0201	-0.0180	0.0063	0.0502
	(0.0684)	(0.0764)	(0.0348)	(0.0226)	(0.0369)
Village-average number of funerals attended	0.1131	-0.1033	-0.0640	-0.0027	0.0476
	(0.0652)$^{+}$	(0.0651)	(0.0284)*	(0.0238)	(0.0282)$^{+}$
Village total number of births between waves	0.0082	0.0124			
	(0.0081)	(0.0095)			
Constant	1.1252	1.3573	0.7191	0.9619	1.5955
	(0.9673)	(1.0462)	(0.4470)	(0.3124)**	(0.4456)**
N	545	545	1138	1138	1138

Notes: Standard errors in parentheses. *p-values:* $^{+}$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$. Changes in the network partners are measures as the number partners in Kenya 3 (or Malawi 2) minus the number of network partners in the corresponding category in Kenya 2 (or Malawi 1).

Table 4: Females: regression of respondent's risk perceptions on the number of social network partners with high, moderate and low risk perception and personal characteristics

	Kenya			Malawi		
	GMM FE-IV	Fixed Effect	OLS	GMM FE-IV	Fixed Effect	OLS
# of nwp with high risk perception	0.2199	0.1742	0.1618	0.1052	0.1184	0.1554
	(0.0440)**	(0.0318)**	(0.0237)**	(0.0244)**	(0.0189)**	(0.0131)**
# of nwp with moderate risk perception				-0.1349	-0.0676	-0.0519
				(0.0371)**	(0.0247)**	(0.0184)**
# of nwp with low risk perception	-0.0744	-0.0448	-0.0737	-0.2307	-0.1715	-0.1814
	(0.0429)$^+$	(0.0286)	(0.0212)**	(0.0367)**	(0.0229)**	(0.0183)**
children ever born	-0.0907	-0.0111	0.0115	0.0701	-0.0007	-0.0052
	(0.0902)	(0.0412)	(0.0146)	(0.0489)	(0.0204)	(0.0082)
dummy for not married, time t	0.1913	0.1725	0.1894	-0.2189	-0.1834	-0.0906
	(0.1903)	(0.1814)	(0.0976)$^+$	(0.0980)*	(0.0985)$^+$	(0.0544)$^+$
Respondent has radio, time t	-0.1456	-0.1164	-0.0881	0.0451	0.0308	0.0325
	(0.1005)	(0.1027)	(0.0632)	(0.0540)	(0.0541)	(0.0344)
Respondent has metal roof, time t	0.0025	-0.0020	0.0430	0.0971	0.0875	0.0401
	(0.1240)	(0.1276)	(0.0670)	(0.0967)	(0.0936)	(0.0586)
Respondent has at least primary education			0.1417			0.0914
			(0.0784)$^+$			(0.0368)*
Respondent has secondary education			-0.1180			0.0759
			(0.0876)			(0.0686)
age			0.0216			0.0133
			(0.0274)			(0.0104)
(age/10) squared			-0.0475			-0.0155
			(0.0373)			(0.0132)
Dummy for survey wave Kenya 3 or Malawi 2			-0.0206			-0.0718
			(0.0528)			(0.0324)*
Constant	0.0363	-0.0190	1.9248	-0.0778	-0.0815	2.0157
	(0.0791)	(0.0617)	(0.4756)**	(0.0507)	(0.0361)*	(0.1786)**
N	545	545	545	1138	1138	1138

Notes: Standard errors in parentheses. *p-values:* $^+$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.

Table 5: Females: regression of respondent's risk perceptions on the number of social network partners with high, moderate and low risk perception and personal characteristics, allowing for nonlinear network effects

	Kenya			Malawi		
	GMM FE-IV	Fixed Effect	OLS	GMM FE-IV	Fixed Effect	OLS
at least one nwp with high	0.5383	0.4213	0.3336	0.1779	0.2502	0.3232
perceived risk, time $t-$	(0.1293)**	(0.0960)**	(0.0752)**	(0.0818)*	(0.0551)**	(0.0426)**
# of remaining nwps with high	0.0547	0.0641	0.0812	0.0757	0.0644	0.0873
perceived risk, time $t-$	(0.0740)	(0.0535)	(0.0401)*	(0.0363)*	(0.0276)*	(0.0185)**
at least one nwp with moderate				-0.2541	-0.1215	-0.1049
perceived risk, time $t-$				(0.0909)**	(0.0557)*	(0.0410)*
# of remaining nwps with moderate				-0.0266	-0.0386	-0.0081
perceived risk, time $t-$				(0.0646)	(0.0418)	(0.0298)
at least one nwp with no or low	-0.0796	-0.1825	-0.1237	-0.3628	-0.1693	-0.2690
perceived risk, time $t-$	(0.1239)	$(0.0988)^{+}$	(0.0801)	(0.0952)**	(0.0576)**	(0.0441)**
# of remaining nwps with no or low	-0.1031	-0.0079	-0.0646	-0.1257	-0.1643	-0.1213
perceived risk, time $t-$	(0.0684)	(0.0467)	$(0.0356)^{+}$	(0.0606)*	(0.0349)**	(0.0289)**
children ever born	-0.0949	-0.0135	0.0109	0.0692	-0.0002	-0.0057
	(0.0898)	(0.0417)	(0.0146)	(0.0494)	(0.0205)	(0.0082)
dummy for not married, time t	0.1156	0.1737	0.1952	-0.1998	-0.1827	-0.0871
	(0.1871)	(0.1814)	(0.0975)*	(0.0989)*	$(0.0990)^{+}$	(0.0540)
Respondent has radio, time t	-0.1006	-0.1031	-0.0858	0.0541	0.0346	0.0327
	(0.0997)	(0.1017)	(0.0630)	(0.0546)	(0.0542)	(0.0343)
Respondent has metal roof, time t	-0.0303	-0.0159	0.0392	0.0786	0.0829	0.0359
	(0.1234)	(0.1261)	(0.0669)	(0.0980)	(0.0934)	(0.0577)
Respondent has at least primary education			0.1406			0.0863
			$(0.0777)^{+}$			(0.0365)*
Respondent has secondary education			-0.1213			0.0662
			(0.0882)			(0.0680)
age			0.0234			0.0153
			(0.0275)			(0.0104)
(age/10) squared			-0.0503			-0.0180
			(0.0374)			(0.0132)
Dummy for survey wave Kenya 3 or Malawi 2			-0.0312			-0.0642
			(0.0528)			(0.0325)*
Constant	0.0274	-0.0282	1.8864	-0.0616	-0.0829	1.9618
	(0.0787)	(0.0618)	(0.4778)**	(0.0514)	(0.0364)*	(0.1793)**
N	545	545	545	1138	1138	1138

Notes: Standard errors in parentheses. *p-values:* $^{+}$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.

Table 6: Males: regression of respondent's risk perceptions on the number of social network partners with high, moderate and low risk perception and personal characteristics, allowing for nonlinear network effects

	Kenya			Malawi		
	GMM FE-IV	Fixed Effect	OLS	GMM FE-IV	Fixed Effect	OLS
at least one nwp with high	0.3313	0.1637	0.2823	0.1959	0.2256	0.2746
perceived risk, time $t-$	(0.1526)*	(0.1083)	(0.0795)**	(0.1105)$^+$	(0.0755)**	(0.0571)**
# of remaining nwps with high	0.1506	0.1336	0.1772	0.0916	0.1267	0.1545
perceived risk, time $t-$	(0.0900)$^+$	(0.0648)*	(0.0451)**	(0.0436)*	(0.0338)**	(0.0231)**
at least one nwp with moderate				0.0125	0.0232	-0.0398
perceived risk, time $t-$				(0.0924)	(0.0627)	(0.0508)
# of remaining nwps with moderate				-0.0681	-0.0735	-0.0558
perceived risk, time $t-$				(0.0626)	(0.0458)	(0.0345)
at least one nwp with no or low	-0.1098	-0.1583	-0.1904	-0.6089	-0.2922	-0.3316
perceived risk, time $t-$	(0.1553)	(0.1312)	(0.0885)*	(0.1254)**	(0.0817)**	(0.0627)**
# of remaining nwps with no or low	-0.0858	-0.0286	-0.0003	-0.0840	-0.1477	-0.1716
perceived risk, time $t-$	(0.0679)	(0.0492)	(0.0331)	(0.0612)	(0.0385)**	(0.0296)**
children ever born	-0.0096	-0.0119	0.0120	0.0135	-0.0032	-0.0044
	(0.0130)	(0.0090)	(0.0057)*	(0.0381)	(0.0162)	(0.0061)
dummy for not married, time t	0.0162	0.1450	0.4716	-0.0821	-0.0745	-0.0542
	(0.2862)	(0.3118)	(0.2238)*	(0.1747)	(0.1933)	(0.1048)
Respondent has radio, time t	0.0993	0.0816	-0.0098	-0.0022	0.0177	0.0191
	(0.1129)	(0.1168)	(0.0625)	(0.0642)	(0.0648)	(0.0407)
Respondent has metal roof, time t	-0.0230	-0.0032	0.0079	0.1862	0.2289	0.0775
	(0.1245)	(0.1249)	(0.0652)	(0.1414)	(0.1377)$^+$	(0.0712)
Respondent has at least primary education	-0.0662	-0.0953	-0.1171			-0.0389
	(0.0707)	(0.0687)	(0.1142)			(0.0483)
Respondent has secondary education			-0.1269			-0.0282
			(0.0630)*			(0.0555)
age			-0.0047			0.0137
			(0.0150)			(0.0122)
(age/10) squared			-0.0045			-0.0123
			(0.0154)			(0.0142)
Dummy for survey wave Kenya 3 or Malawi 2			-0.1179			-0.0397
			(0.0618)$^+$			(0.0372)
Constant			2.4157	-0.0594	-0.0825	1.8105
			(0.3568)**	(0.0513)	(0.0407)*	(0.2530)**
N	407	407	407	790	790	790

Notes: Standard errors in parentheses. *p-values:* $^+$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.

Table 7: Kenya: linear probability model for having talked with spouse about the risk of getting AIDS

	Females			**Males**		
	GMM FE-IV	Fixed Effect	OLS	GMM FE-IV	Fixed Effect	OLS
# of nwp with high risk perception	0.0470	0.0595	0.0805	0.0615	0.0408	0.0618
	(0.0231)*	(0.0164)**	(0.0124)**	(0.0203)**	(0.0153)**	(0.0122)**
# of nwp with low risk perception	0.0438	0.0438	0.0771	0.0573	0.0385	0.0718
	(0.0219)*	(0.0136)**	(0.0111)**	(0.0190)**	(0.0140)**	(0.0110)**
children ever born	0.0173	0.0075	-0.0078	-0.0009	-0.0009	0.0048
	(0.0420)	(0.0185)	(0.0069)	(0.0049)	(0.0039)	(0.0024)*
Respondent has radio, time t	0.0345	0.0383	0.1374	-0.0341	-0.0447	0.0506
	(0.0510)	(0.0523)	(0.0342)**	(0.0509)	(0.0520)	(0.0355)
Respondent has metal roof, time t	0.0750	0.0718	0.0101	-0.0289	-0.0118	0.0417
	(0.0583)	(0.0591)	(0.0363)	(0.0546)	(0.0586)	(0.0314)
Respondent has at least primary education			0.0695			0.1055
			(0.0440)			(0.0589)+
Respondent has secondary education			0.0826			0.0450
			(0.0423)*			(0.0308)
age			0.0166			0.0098
			(0.0137)			(0.0075)
(age/10) squared			-0.0252			-0.0124
			(0.0188)			(0.0074)+
Dummy for survey wave Kenya 3 or Malawi 2			0.1079			0.0198
			(0.0268)**			(0.0248)
Constant	0.1056	0.1198	0.0534	0.0436	0.0639	0.2338
	(0.0382)**	(0.0292)**	(0.2370)	(0.0265)+	(0.0260)*	(0.1929)
N	481	481	481	408	408	408

Notes: Standard errors in parentheses. *p-values:* + $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.

Table 8: Kenya: linear probability model for having talked with spouse about the risk of getting AIDS, allowing for nonlinear network effects

	Females			**Males**		
	GMM FE-IV	Fixed Effect	OLS	GMM FE-IV	Fixed Effect	OLS
at least one nwp with high	0.0364	0.0933	0.0962	0.1091	0.0758	0.0831
perceived risk, time $t-$	(0.0632)	(0.0465)*	(0.0386)*	(0.0656)$^+$	(0.0469)	(0.0361)*
# of remaining nwps with high	0.0422	0.0380	0.0648	0.0255	0.0173	0.0452
perceived risk, time $t-$	(0.0399)	(0.0256)	(0.0187)**	(0.0346)	(0.0242)	(0.0205)*
at least one nwp with no or low	0.1156	0.0667	0.1478	0.1551	0.1101	0.1427
perceived risk, time $t-$	(0.0622)$^+$	(0.0456)	(0.0390)**	(0.0571)**	(0.0435)*	(0.0382)**
# of remaining nwps with no or low	0.0108	0.0309	0.0463	0.0116	0.0097	0.0452
perceived risk, time $t-$	(0.0333)	(0.0216)	(0.0175)**	(0.0286)	(0.0215)	(0.0157)**
children ever born	0.0170	0.0073	-0.0076	0.0001	-0.0013	0.0047
	(0.0420)	(0.0184)	(0.0069)	(0.0051)	(0.0039)	(0.0024)*
Respondent has radio, time t	0.0343	0.0403	0.1375	-0.0306	-0.0384	0.0512
	(0.0516)	(0.0525)	(0.0340)**	(0.0503)	(0.0518)	(0.0352)
Respondent has metal roof, time t	0.0645	0.0640	0.0082	-0.0358	-0.0096	0.0426
	(0.0594)	(0.0591)	(0.0362)	(0.0547)	(0.0589)	(0.0314)
Respondent has at least primary education			0.0705			0.1021
			(0.0439)			(0.0586)$^+$
Respondent has secondary education			0.0867			0.0499
			(0.0424)*			(0.0314)
age			0.0185			0.0102
			(0.0136)			(0.0074)
(age/10) squared			-0.0284			-0.0125
			(0.0187)			(0.0074)$^+$
Dummy for survey wave Kenya 3 or Malawi 2			0.1047			0.0193
			(0.0271)**			(0.0247)
Constant	0.1083	0.1184	0.0101	0.0475	0.0637	0.1992
	(0.0385)**	(0.0294)**	(0.2355)	(0.0263)$^+$	(0.0260)*	(0.1925)
N	481	481	481	408	408	408

Notes: Standard errors in parentheses. *p-values:* $^+$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.

Table A.1: Females: re-estimation of the GMM IV-FE models in Table 4 assuming that network parterns beyond the first four have (*a*) high perceived AIDS risk, (*b*) low perceived AIDS risk, or (*c*) are distributed among the different risk categories in a proportion that is equal to that observed for the first four network partners.

	Kenya			**Malawi**		
Assumption about risk perceptions of network partners beyond the first four	(a)	(b)	(c)	(a)	(b)	(c)
# of nwp with high risk perception	0.0062	0.2377	0.0523	0.0078	0.1637	0.0320
	(0.0093)	(0.0419)**	(0.0168)**	(0.0066)	(0.0240)**	(0.0086)**
# of nwp with moderate risk perception				-0.1807	-0.1124	-0.0416
				(0.0365)**	(0.0387)**	(0.0216)$^{+}$
# of nwp with low risk perception	-0.1376	-0.0124	-0.0631	-0.2862	-0.0163	-0.0571
	(0.0403)**	(0.0100)	(0.0158)**	(0.0347)**	(0.0068)*	(0.0143)**
children ever born	-0.0688	-0.0864	0.0218	0.0510	0.0821	0.0429
	(0.0883)	(0.0893)	(0.0889)	(0.0482)	(0.0503)	(0.0501)
dummy for not married, time t	0.1817	0.1947	0.2734	-0.2170	-0.1639	-0.1745
	(0.1842)	(0.1865)	(0.1886)	(0.0979)*	(0.1018)	(0.1032)$^{+}$
Respondent has radio, time t	-0.0868	-0.1382	-0.1492	0.0485	0.0437	0.0499
	(0.1012)	(0.1020)	(0.0992)	(0.0546)	(0.0560)	(0.0561)
Respondent has metal roof, time t	-0.0194	0.0218	-0.0806	0.1235	0.0738	0.1376
	(0.1259)	(0.1258)	(0.1266)	(0.0978)	(0.1016)	(0.1095)
Constant	0.1023	-0.0038	0.0226	-0.0695	-0.1900	-0.1886
	(0.0775)	(0.0713)	(0.0715)	(0.0514)	(0.0480)**	(0.0486)**
N	545	545	545	1138	1138	1138

Notes: Standard errors in parentheses. *p-values:* $^{+}$ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.