Population Studies, Vol. 59, No. 3, 2005, pp. 265–282

Routledge
Taylor & Francis Group

Social networks, perceptions of risk, and changing attitudes towards HIV/AIDS: New evidence from a longitudinal study using fixed-effects analysis

Stéphane Helleringer and Hans-Peter Kohler
University of Pennsylvania

The study presented here is an investigation of the importance of social interactions to perceptions of the risk of AIDS, and explores spousal communication about the AIDS epidemic in rural Malawi. A fixed-effects analysis based on longitudinal data collected in 1998 and 2001 shows that social interactions on the subject of HIV/AIDS have significant and substantial effects on respondents' perceptions of the risk of HIV/AIDS, even after controlling for unobserved factors that affect the selection of social networks. These effects are more complex than previously thought. The dominant mechanisms—social learning and social influence—are found to vary by sex and by region, because of regional variations in the marriage pattern and the resulting implications for the formation of local social networks. The conclusion of the study is that rather than fostering denial and inaction, social interactions are an important vector of change in the face of the HIV/AIDS epidemic.

Keywords: HIV/AIDS; social interactions; risk perceptions; Malawi; unobserved heterogeneity; longitudinal studies

[Submitted June 2004; Final version accepted April 2005]

It is well known that AIDS is a major cause of adult mortality in sub-Saharan Africa. Initially, researchers attributed the spread of HIV primarily to a lack of correct information, or to myths and rumours disseminated informally (Bond and Dover 1997). Now, however, the conventional view is that the severity of the AIDS epidemic in Africa is due to social and cultural 'barriers' that inhibit behavioural change in spite of widespread knowledge about the fatal consequences of the disease and about recommended methods of prevention. Such barriers are thought to include the following: a political economy that stimulates labour migration, which in turn separates spouses (Setel 1999); patterns of breastfeeding and postnatal abstinence that make women unavailable for sexual relations with their husbands for extended periods of time (Caldwell et al. 1989; Caldwell et al. 1992); and other beliefs that are said to inhibit change—for example, that 'males are biologically programmed to require sex with more than one woman', that sexual intercourse with a condom is not 'sweet', or that it is necessary to preserve risky circumcision rituals (Barnett and Blaikie 1992; Orubuloye et al. 1997). Moreover, fatalism and a lack of perceived self-efficacy also appear as important elements in the failure to control the AIDS epidemic (Campbell 2003). The belief that 'death comes when it is due' is said to be widespread. Caldwell (2000, p. 124) argues that men involved in high-risk practices tend to justify their behaviour in terms of competing risks: 'if the latency period for AIDS is a decade, then they are not worried because they are likely to die of something else in such a long time'.

According to Caldwell (2000), such beliefs and judgements are actively maintained by varied forms of social interaction, and individuals may experience pressure from peers to engage in risky behaviour. Much has also been said about mechanisms of taboo, stigma, and denial that generate an 'extraordinary silence around the causes of the disease' and prevent open discussion of AIDS (Nzioka 1996; Caldwell 2000). However, the view that social interactions constrain the adoption of new and safer behaviour in response to the epidemic in Africa has recently been questioned. Low-Beer and Stoneburner (2004) argue

ISSN 0032-4728 print/ISSN 1477-4747 online/05/030265-18
DOI: 10.1080/00324720500212230

that in Uganda, the only country in sub-Saharan Africa that has experienced a dramatic decline in HIV prevalence, social interactions have facilitated the adoption of new behaviour. In particular, more survey respondents in Uganda than in neighbouring countries reported personal channels of communication about AIDS and more reported knowing someone with AIDS or who had died of AIDS. The authors suggest that communication may have provided greater personal exposure to the fear-evoking consequences of the epidemic, and thus catalysed the process of behaviour change. Others have reached similar conclusions using qualitative data. Setel (1999, p. 185), drawing on participant observation in Tanzania to trace the construction of local knowledge about HIV, finds that the process 'required nothing other than an ability to engage in collective creative thought about a disease that remained a chimerical presence for most, long after scientific authorities had announced its epidemiologic arrival'. Watkins (2004) has used data from observational field journals to predict that the epidemic in Malawi—and possibly also other sub-Saharan African countries—is at a turning point. The journals indicate that social interactions have played an essential role in forming individuals' perceptions of their risk of HIV/AIDS and their evaluation of the benefits (and costs) of behavioural changes such as the adoption of condom use, increased marital fidelity, or more careful selection of sexual partners.

The present study makes use of a unique longitudinal set of data collected in rural Malawi since 1998 to investigate the effects of social interactions on perceptions of risk and on the attitudes of individuals towards AIDS. In particular we ask whether social interactions play an active role in maintaining beliefs that sustain high-risk practices, or whether they foster and encourage attitudes conducive to behavioural change.

Background

A growing literature on the diffusion of family planning in less developed countries provides evidence that social interactions are an important determinant of the adoption of new demographic behaviour (Bongaarts and Watkins 1996; Casterline 2001; Kohler 2000, 2001; Watkins et al. 2003). The key theoretical idea driving these empirical investigations is that the global promotion of fertility control has provoked considerable uncertainty about the risks of adopting the small-family model and new methods of family planning, and that, in response to this uncertainty, individuals have turned to others for help in evaluating the risks and benefits associated with the 'new' practices. For example, analyses of both qualitative and aggregate data from Thailand and Kenya show that women have informal discussions among themselves about family planning and family size (Montgomery and Casterline 1993; Entwisle et al. 1996; Rutenberg and Watkins 1997; Watkins 2000), and that these informal conversations have influenced attitudes and behaviour relating to fertility (e.g., Entwisle et al. 1996; Montgomery and Chung 1998; Kohler et al. 2001; Munshi and Myaux 2002). Even in countries like Italy where fertility is very low, social interactions appear to be influential (Bernardi 2003).

While there is less evidence for the role of social interactions in shaping responses to heightened mortality from AIDS than there is for the new methods of fertility control, it seems reasonable to expect social interactions to be at least as important in shaping responses in this arena, and perhaps more so. Again, there is great uncertainty surrounding HIV/AIDS, since the ability of individuals to learn directly from the deaths of friends, relatives, and neighbours is constrained by several factors. First, the long latency period of the disease makes it almost impossible to link symptoms and eventual death to particular sexual encounters or to risky behaviour that took place as long as a decade, or even more, before death. Second, it is likely that many infections occur during the migration of men beyond their villages, and during premarital or extramarital relationships that the participants attempt to keep secret. Nonetheless, men brag about their affairs, women confide in friends (Tawfik 2003), and those infected with a sexually transmitted disease seek treatment advice from others. Thus, as Watkins (2004, p. 673) has shown, when someone in a village dies, members of social networks contribute to the diagnosis of the cause of death by contributing fragments of local knowledge. In the same networks, men and women are 'collectively navigating AIDS': they 'evaluate the sources of risk and varieties of sexual pleasure, debate global and national prescriptions and formulate local and sometimes innovative strategies of prevention' following conversations with relatives, friends, neighbours, acquaintances, and even strangers.

Despite the presumption that social interactions influence perceptions of the risk of AIDS and the adoption of prevention strategies, it is difficult to make convincing causal inferences from either qualitative or survey data (e.g., Manski 1995; Behrman et al. 2002). First, individuals' engagement in

social interactions is often determined by their own attitudes and preferences. Social-network partners are therefore not chosen randomly from the population, but are selected systematically according to observed and unobserved characteristics, a process often resulting in homophily (social interactions among persons sharing common characteristics). Research designs that do not address this selection issue are likely to misrepresent the role and relevance of social interactions. Second, hardly any studies have tried to identify the underlying mechanisms that link social interactions and individual behaviour in the context of HIV/AIDS (the few that have done so include Behrman et al. 2004).

Theories of social interaction and demographic change usually distinguish between two processes through which the social environment exerts an influence on individuals' behaviour or attitudes: *social learning* and *social influence* (Montgomery and Casterline 1996; see also Axinn and Yabiku 2001; Kohler et al. 2001; Behrman et al. 2002; Kravdal 2002; Moursund and Kravdal 2003). We use the term 'social influence' to refer to the processes by which preferences for sexual behaviour, gender relations, or other behaviour relevant to AIDS are potentially affected by the opinions and attitudes that prevail in an individual's social environment. These processes may lead individuals to change their preferences in response to normative pressures after interactions with others about the threat of AIDS—for example, if network partners express their disapproval of a man having sexual intercourse with sex workers on the ground that it exposes himself and his spouse to the risk of HIV infection. On the other hand, 'social learning' is seen in individuals' use of social interactions to gather information that helps them cope with the uncertainties brought about by changing environments, such as those arising from a new epidemic like HIV/AIDS. Thus network partners may be sources of information about, for example, modes of transmission of the disease, adequate prevention strategies, or the relevant characteristics and partnership histories of potential sexual partners.

The empirical distinction between the two mechanisms—social learning and social influence—is relevant to the present study for several reasons. First, because the existence of social interaction may modify the evaluation of the impact of AIDS-related policy interventions, understanding the mechanisms of social interaction could facilitate the optimal design and use of such policy interventions. Second, the distinction between social learning and social influence allows us to test Caldwell's hypothesis about the role of social interactions in the African AIDS epidemic and their importance in maintaining cultural 'barriers' that prevent behavioural change. For example, whereas sexual intercourse outside marriage is widely practised in sub-Saharan Africa because of long durations of postnatal abstinence and high levels of polygyny, Caldwell (2000, p. 127) argues that 'wives are not supposed to recognize their husbands' extramarital activities and the pretence is well maintained'. According to this point of view, the risk perceptions of women, or the possibility of spousal communication about AIDS-related matters, are constrained by the actions and judgements of relatives and other relevant reference groups. Evidence for social learning about risk perceptions or attitudes towards prevention strategies would thus conflict with this characterization of the social environment and its consequences for individual attitudes; indeed, when social interactions operate through learning, social networks do not constrain but rather represent a valuable tool that individuals use to learn about and cope with the uncertainty of their environments. Evidence for social influence, on the other hand, would provide some support for Caldwell's view.

Data and context

The analysis presented here is based on data from the Malawi Diffusion and Ideational Change Project (MDICP). The project's goal is to evaluate and analyse the role of informal conversations in changing behaviour and attitudes towards family planning and HIV/AIDS in rural Malawi, and the data collected as part of the project consist of a longitudinal household survey and a set of semi-structured interviews, focus groups, and observational field journals. The panel survey was initiated in 1998 with 1,541 women of childbearing age who had ever married and 1,065 male spouses, and was conducted in three districts of Malawi: Rumphi (in the north), Mchinji (centre), and Balaka (south). A follow-up survey that re-interviewed 1,200 women and 841 men was conducted in 2001. A detailed description of the survey, including aspects of data quality, is available in a special collection of papers in *Demographic Research* (Watkins et al. 2003).

Subsistence agriculture and small-scale retail outlets are common in rural Malawi, but there is also extensive wage labour, some of which requires migration to urban areas. Although each of the three sites of the survey has the foregoing features in

Table 1 Socio-economic characteristics of respondents to a survey of the effects of social interactions on attitudes to AIDS. Malawi 1998

	Women		Men	
	South + centre	North	South + centre	North
Age	31.2	30.9	37.2	37.1
	(9.5)	*(8.6)*	*(10.1)*	*(11.1)*
Children ever born	4.4	4.3	5.4	5.1
	(3.2)	*(2.8)*	*(4.2)*	*(4.2)*
Proportion of respondents				
Who ever used family planning	45.9	61.6*	58.4	62.5
With at least some primary education	47.2	96.8*	71.6	97.5*
With at least secondary education	1.7	10.6*	7.3	30.1*
Who speak English	0.6	10.6*	8.3	35.4*
With metal roof on house	5.2	10.8*	5.9	12.1*
Who own a radio	50.5	70.4*	63.5	76.2*
Who own a bicycle	55.7	43.4*	64.7	48.1*
Whose household has a pit latrine	66.1	88.8*	79.8	93.7*
Engaged in wage work	72.1	80.5*	98	95.8
In polygamous union	8.5	25.9*	n/a	n/a
N	814	386	575	240

*The difference between respondents in the south + centre and respondents in the north is significant at $p < 0.05$.
Note: Standard deviations are in parentheses.
Source: Malawi Diffusion and Ideational Change Project (MDICP).

common, there are also some differences (Table 1). For example, the north is wealthier, less densely populated, and has a higher level of education than the centre or the south (probably as a result of the early establishment of Christian missions in this area). Marriage patterns also differ across the regions. The Tumbuka ethnic group living in the north is typical of the 'father-right' societies described by Gluckman (1950): inheritance is primarily patrilineal, and residence of spouses after marriage is patrilocal. Polygyny is widespread and the age difference between spouses is large (Reniers 2003). In contrast, the main ethnic group (Yao) in the south follows a matrilineal system of inheritance, and a man usually moves into his spouse's household after marriage. The population in the central district is mostly Chewa and also follows a matrilineal system of descent, although less strictly than in the south. Indeed, the Chewas have been affected by an influx of patrilineal groups from southern Africa (Ngonis) and from the coast (Swahilis), and residence after marriage may thus be either matrilocal or patrilocal (Phiri 1983; Reniers 2003).

Estimates of HIV prevalence often indicate that close to 15 per cent of the Malawi population is currently infected with HIV (UNAIDS 2004), and concerns about HIV/AIDS are widespread. For instance, in the first wave of the MDICP survey 61 per cent of the women reported being 'very worried'; this expression of worry is taken as the respondent's perception of the risk of AIDS. Interestingly, as shown in Table 2, this level of worry declined by 2001, especially in the south, perhaps being associated with the adoption of prevention strategies that the respondents perceived to be effective (Smith and Watkins 2005). In addition to recognizing the risk of infection, respondents were also aware of different ways by which HIV/AIDS is transmitted, and most knew several methods of protection. Asked about the best way to protect themselves against AIDS, both men and women frequently cited marital fidelity as a strategy to prevent HIV infection. When husbands and wives talked with each other about AIDS, they often encouraged each other to 'take care', a euphemism for avoiding extramarital relations and other risky behaviour (Zulu and Chepngeno 2003). In addition, although attitudes towards condom use were generally negative, some men advised each other to use condoms with casual partners and criticized those who did not.

The epidemic in Malawi has also turned AIDS into an urgent topic of conversation, and discussions about HIV occur frequently and in a broad range of contexts. In order to measure the extent of these social interactions, the MDICP survey asked for information on up to four persons with whom the respondent had 'chatted' about AIDS. These persons are subsequently referred to as 'network partners', and the group that includes the respon-

Table 2 Attitudes towards HIV/AIDS among respondents to a survey of the effects of social interactions. Malawi 1998–2001. All men and women interviewed in both waves

	Women		Men	
	Wave 1	Wave 2	Wave 1	Wave 2
Proportion of respondents worried about getting AIDS				
Highly worried	61.5	47.0*	53.3	36.9*
A little worried	21.0	23.4	19.2	20.6
Not worried at all	17.5	28.6*	27.3	42.4*
Assessments of various HIV/AIDS risk-reduction strategies				
Proportion of respondents who consider efficient:[1]				
Spousal communication	46.6	37.8*	39.8	33.3*
Condom use with all partners except spouse	11.9	26.6*	17.4	40.8*
Marital fidelity	65.1	70.4	74.2	72.0
Proportion of respondents				
Most worried about getting HIV from spouse	30.9	50.5*	13.5	23.2*
Consider condom use with spouse acceptable	14.2	28.5*	11.1	24.4*
AIDS prevention effort				
Proportion of respondents who had heard of AIDS				
At the clinic	85.7	95.5*	83.3	95.7*
On the radio	89.7	96	97.8	99.0
From CBD[2] agent	23.6	35.9*	39.6	44.5
Proportion of respondents without AIDS network	16.1	5.2*	7.3	3.2*
N	1,200	1,200	815	815

[1]The survey question asked: 'What do you think are the best ways to protect yourself from AIDS?' without prompting. Multiple responses were allowed.
[2]Community-based distribution.
*The difference between the two waves is significant at $p < 0.05$.
Source: As for Table 1.

dent and his or her four network partners is referred to as his or her 'social network'. The term 'chat' was used in the interview to indicate to respondents that the research team was primarily interested in informal conversations rather than the lectures on AIDS given at government clinics and elsewhere. The network data were collected by first asking the respondents for the number of network partners with whom they had chatted about AIDS (i.e., the uncensored size of the respondent's AIDS network). Between 1998 and 2001, the percentage of female respondents who reported having had such discussions with at least one network partner increased from 85 to 95 per cent. After the respondents had listed all network partners with whom they had chatted about AIDS, they were asked a series of questions about up to four of these partners (the censored size of the network). These questions included the relationship to the respondent (co-wife, sibling, etc.), residence, and degree of closeness (confidant, friend, acquaintance), as well as education, condom usage, and worry about HIV/AIDS and current likelihood of HIV infection (using the wording 'How worried is [name of network partner] about AIDS?'). In addition, the respondent was asked whether each of her/his network partners knew each of the others, and how well. The MDICP data thus include information about the ties among *all* members of the respondent's AIDS discussion network. Descriptive statistics for these networks are reported in Table 3.

Methods

While there are almost no quantitative studies of the impact of social networks on the diffusion of AIDS-related behaviour or attitudes (one exception is Behrman et al. 2003), there are a number of studies of fertility-related behaviour that are based on empirical models of the form

$$Y = \alpha + X\beta + \delta\overline{Y} + \varepsilon \quad (1)$$

where X is a vector of observed covariates, $\overline{Y}$ represents the average outcome in a reference group (e.g., social network, village, sampling cluster), and δ is interpreted as the effect of social interactions on the outcome variable Y.

An important limitation of relation (1) is that it does not allow for the possibility that the effects of

Table 3 Characteristics of social networks, by region and sex, of respondents to a survey of the effects of social interactions on attitudes to HIV/AIDS. Malawi 1998–2001. Respondents with 2+ network partners in both waves

	Women				Men			
	South+centre		North		South+centre		North	
	Wave 1	Wave 2	Wave 1	Wave 2	Wave 1	Wave 2	Wave 1	Wave 2
(Uncensored) size of network	5.77 *(5.31)*	6.08† *(5.04)*	5.32 *(5.30)*	7.58* *(7.06)*	7.44† *(6.65)*	7.34† *(6.65)*	6.02 *(6.25)*	7.95* *(8.09)*
Density								
Average density of links among network partners	0.78† *(0.33)*	0.87* *(0.27)*	0.83 *(0.29)*	0.88* *(0.24)*	0.78† *(0.33)*	0.86* *(0.24)*	0.85* *(0.27)*	0.9 *(0.22)*
Average proportions of network partners who are								
Males	0.06	0.06	0.04	0.05	0.95	0.94	0.93	0.94
Females	0.94	0.94	0.96	0.95	0.05	0.06	0.07	0.06
Male relatives of respondent	0.02	0.02	0.01	0.04*	0.17†	0.16†	0.27	0.28
Female relatives of respondent	0.29†	0.25†	0.42	0.39	0.01	0.01	0.02	0.01
Members of the spouse's family (in-laws)	0.09†	0.10†	0.21	0.21	0.05	0.05	0.06	0.04*
Relationship of the network partners to the respondent								
Per cent confidants	0.21	0.20†	0.23	0.25	0.24	0.23	0.25	0.23
Per cent friends	0.53	0.57	0.55	0.59	0.53	0.57†	0.51	0.63*
Per cent acquaintances	0.17	0.15†	0.18	0.10*	0.14	0.13†	0.17	0.09*
Per cent met just once	0.09†	0.08	0.04	0.06	0.09	0.07	0.07	0.05
Average proportion of network partners who live								
On the same compound	0.07†	0.13*	0.17	0.15	0.03†	0.06†	0.10	0.10
In the same village (includes network partners living on same compound)	0.52	0.58*	0.56	0.60	0.40	0.47†	0.47	0.53*
In the same district (includes previous categories)	0.91†	0.94	0.95	0.93	0.84†	0.91*	0.92	0.92
Elsewhere (e.g., in the city, abroad, etc.)	0.09†	0.06*	0.05	0.07	0.16†	0.09*	0.08	0.08
N	548	256	548	256	462	462	186	186

*The difference between waves is significant at $p < 0.05$.
†The difference between respondents in the south+centre and respondents in the north is significant at $p < 0.05$.
Note: Standard deviations are in parentheses.
Source: As for Table 1.

social interactions may be modulated by the structure of social networks. For instance, the effects may differ depending on whether network partners represent a densely knit group of friends or family members, or a relatively loose group of individuals who may not even know each other. Moreover, the effect of the network structure is likely to vary fundamentally with the kind of mechanism through which social interactions affect individual behaviour and attitudes. This observation has previously been used to identify patterns of social learning and social influence in the diffusion of family planning methods in Kenya (Kohler et al. 2001), and the present study extends this approach to the diffusion of AIDS-related behaviour.

In situations where it is crucial to learn about opportunities, new practices, or potential health threats, individuals can 'search' their networks for the relevant information. For instance, a woman who suspects her husband of infidelity will ask her network partners if they know or have heard something (rumours, gossip, etc.) about her spouse's whereabouts. The implications of network structure for this learning process are complex: Granovetter (1973), and also Burt (1992), have argued that in situations where learning is the main focus, tightly knit network structures can significantly reduce information flows. Indeed, if the network partners all know each other, they may provide redundant information.

On the other hand, networks may also impose constraints on individual attitudes and behaviour, and the implications of network structure for processes of social influence have been well identified. Indeed, tightly knit structures such as 'cliques' exert a stronger normative influence on an individual's behaviour and attitudes (Moscovici 1985; Burt 1992), and are thus more efficient at defining what constitutes a socially acceptable attitude or behaviour.

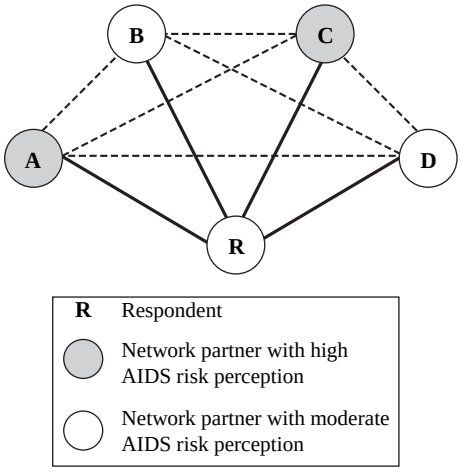

Figure 1 Social network with four network partners

The information in the MDICP data about the relationships of the respondent's network partners among themselves allows us to infer whether, and through which processes, networks affect respondents' risk perceptions and attitudes towards AIDS. Consider for instance the social network in Figure 1, depicting a respondent who has ties to four network partners. The MDICP data contain information on whether A, B, C, and D know each other directly, or only indirectly through their relation to the respondent. *Density* is the formal concept used to represent the degree of social connectedness among the network partners. It is defined as the proportion of all possible social links that actually exist in the observed network. In a network of four, for example, a total of six possible links exists; the density is the number of existing links divided by six. We will call a network *very dense* if the density equals 1. We will designate it as *very sparse* if the density is 0, that is, if A, B, C, and D do not share any direct links.

Social learning and social influence can be distinguished from each other by using the distinct implications of social networks with different densities (Kohler et al. 2001). If social learning dominates, the effect of density should be small; this is because both sparse and dense networks can be 'searched' for information (Watts et al. 2002). It should thus be expected that the proportion of network partners very worried about AIDS should be the main determinant of the probability of the respondent reporting being very worried. If social influence dominates, on the other hand, a different pattern should be expected: when a respondent's network is sparse, variations in the proportion of network partners who are very worried should exert only small effects on the respondent's probability of being very worried, whereas these variations should be associated quite strongly with a woman's risk perception in dense networks.

An important concern in identifying these network influences is that estimates of the effects of social interactions are potentially subject to omitted-variable bias. In particular, both the attitudes of the members of a respondent's social network and the structure within which these interactions occur, are likely to be correlated with unobserved factors that also determine the respondent's risk perception. Behrman et al. (2002) point to two reasons why this might occur. The first is homophily: respondents interact primarily with others much like themselves—people who share some of their characteristics or attitudes. For example, in rural Malawi, because of transportation and communication constraints, interaction occurs mostly with those who

live in the same village, or in the villages nearby, thus constraining the networks towards higher homogeneity and density. The second type of selectivity is strategic: respondents may deliberately choose network partners who are potentially valuable sources of information about the risk of infection, prevention strategies, or similar AIDS-related topics.

The longitudinal nature of the MDICP data, in combination with fixed-effects estimation, allows the analyst to control for observed and unobserved heterogeneity among MDICP respondents that affects the selection of social networks. In particular, by using fixed-effects estimation it is effectively possible to control for all *time-invariant* characteristics of respondents and their communities. To illustrate this approach to the analysis of AIDS-risk perceptions, we posit a logit model for the respondent's subjective HIV-risk perception that depends on social networks, observed individual characteristics, and unobserved fixed effects as

$$Y^*_{it} = X_{it-}\beta + \delta_1 \cdot N_{it-} + \delta_2 \cdot density_{it-} + \delta_3 \cdot N_{it-} \cdot density_{it-} + f_i + \varepsilon_{it}$$

$$Y_{it} = 1 \text{ if } Y^*_{it} > 0 \text{ and zero otherwise} \qquad (2)$$

where Y_{it} is subjective AIDS-risk perception by individual i at time t based on the question 'How worried are you that you might catch AIDS?', with responses coded as 1 = worried a lot and 0 = either not worried at all or worried a little. Y^*_{it} is the corresponding latent variable, N_{it-} is the average level of perceived risk of AIDS among the network partners of individual i before time t data (the subscript $t-$ for predetermined variables emphasizes that these variables refer to the time before t), and the measure $density_{it-}$ describes the structure of a social network. The interaction term between N_{it-} and $density_{it-}$ captures the fact that the effects of social interactions may be modulated by the structure of a network. In addition, X_{it-} is a vector of observed variables for individual i (e.g., age, marital status, parity, wealth); f_i is a vector of unobserved fixed factors that determine an individual's AIDS worries (e.g., unobserved community characteristics); and ε_{it} is a random, logistically distributed disturbance term that affects the risk perception by individual i at time t.

Social learning and social influence can be distinguished in this specification because of a different pattern of coefficients implied by the two mechanisms. When social learning is the most relevant mechanism through which networks affect attitudes and risk perceptions, the percentage of network partners who worry a lot about AIDS is the variable of primary importance. Coefficient δ_1 would therefore be expected to be quite large, positive, and significant, with δ_2 and δ_3 of little importance in explaining variations in risk perceptions. On the other hand, when social influence is the most relevant mechanism in social interactions, δ_2 and δ_3 would be expected to be the coefficients of primary importance, since sparse networks should have little effect on the respondents' attitudes while variation in the network partners' risk assessments in dense networks would be likely to exert strong pressure towards conformity of attitudes.

This analysis of social-interaction effects using the fixed-effects logit model above focuses on two independent variables: the respondent's perception of the risk of AIDS, and the respondent's assessment of spousal communication about AIDS, in particular whether the respondent thinks an effective strategy for preventing AIDS is to advise the spouse to 'take care' and avoid extramarital relations and other risky behaviour. This variable is given as 1 if the respondent gave appropriate answers to the open-ended question 'What do you think are the best ways to protect yourself from getting AIDS?' (multiple responses were allowed), and 0 otherwise. Summary statistics for these two dependent variables are reported in Table 2.

The central explanatory variables for the analysis presented in this paper are measures of the respondent's social interactions regarding AIDS. Based on the theoretical discussion above, social interactions are represented through three variables: the proportion of a respondent's network partners who are very worried about HIV; the density of a respondent's social network; and an interaction between both. In order to compute these different network measures, especially density, the analysis is restricted to the respondents recorded as having chatted with at least two network partners in both waves of the data (see also related discussions above and below). Summary statistics for these variables are reported in Table 3.

The fixed-effects approach presented here controls for all time-invariant characteristics of the respondent and his or her household and community. We therefore include only a small number of additional time-varying characteristics of the respondent: parity (number of children ever born); marital status (a dummy variable for being currently married); socio-economic status (based on proxy variables—whether the household has a metal roof or a radio or both—that indicate a household's wealth); and economic activity (a dummy variable entered as 1 if the respondent worked for income). Exposure to

AIDS-prevention programmes is also controlled for. The measure of programme activity shown here is based on the sum of three dummy variables, indicating whether or not the respondent has heard of AIDS-prevention strategies during a talk at a clinic or hospital, on the radio or TV, or from a community-based distribution worker—that is, by the main channels through which prevention programmes are conducted in rural Malawi. However, this variable does not capture occasional prevention efforts that occur outside these channels, such as dramas about AIDS that may sometimes be performed in villages, or in the nearby trading centres. 'Chishango' ('shield' in Chichewa) condoms may also be distributed in bars, local beer stores, or other outlets.

The random-effects models reported here for comparison with the fixed-effects models additionally include age and education in 1998 (the latter represented by dummy variables for completion of primary or secondary schooling or both). Because there are also secular trends in the dependent variables over time, our fixed-effects and random-effects analyses include a time trend that is given as 0 for the 1998 wave and 1 for the 2001 wave of data collection.

The major advantage of our preferred fixed-effects models is the ability to control for unobserved heterogeneity among respondents that affects the selection of social networks. In particular, fixed-effects models 'condition out' the fixed component $\mathbf{f}_i$ from the residual and from all explanatory variables included on the right-hand side of model (2) (Hsiao 2003). This approach can eliminate a potential correlation between the indicators of social interactions (N and density) and the residual that is due to unobserved fixed individual characteristics. In contrast, the residual in standard logit estimates of relation (2) includes the fixed effects (f_i), as well as ε_{it}. Standard logit analyses may thus misrepresent the role of social interactions if there is a correlation between the residual ($f_i, +\varepsilon_{it}$) and the right-hand-side variables of interest. This correlation occurs, for instance, if respondents select network partners who are similar to themselves with respect to characteristics that are unobserved in the data (homophily), or if the social context of individuals differs in (unobserved) aspects that provide differential opportunities for social interactions about HIV/AIDS (e.g., the presence or absence of other women, particularly female relatives, in the compound). In both of these cases, the composition and the density of the networks will depend on the fixed effects (f_i), resulting in biases of standard logit estimates of the parameters.

An important corollary of this approach is that all individuals who show no change in the value of the dependent variable between waves make no contribution to the likelihood function of the fixed-effects model and the identification of the coefficients of interest. This is because, for the respondents whose risk perceptions remain constant between the two waves, it is impossible to disentangle the effects on respondents' risk perceptions that are attributable to social interactions (or other time-varying variables) from those that are attributable to unobserved fixed characteristics (see Hsiao 2003). Fixed-effects models can thus be used to estimate the probability of an increase in worry in instances where there has been either an increase or a decrease in risk perceptions. This probability is *conditional* on the values of the fixed effects (f_i), and is solely a function of the *changes* in the values of the variables used to describe a respondent's risk perception.

In this model, therefore, the parameters of interest (δ_1, δ_2, and δ_3) are consistently estimated on the assumption that stochastic shocks that affect the representation of network partners before time t do not affect the current perception of the AIDS risk at time t. Qualitative evidence gathered as part of the MDICP suggests that the assumption of a simple fixed effect representing the unobserved heterogeneity in the selection of network partners is reasonable. When asked during in-depth interviews why they talked to a particular person about AIDS, women seldom described strategic search behaviour, and instead typically provided answers of the form 'she was at the borehole today' (Watkins 2004). The opportunity structure for social interactions, which is related to fixed characteristics such as personality, household location, and so on, thus seems to be the principal source of heterogeneity in the process of network selection and is adequately accounted for by the fixed-effects specification of relation (2).

The advantage of longitudinal data in controlling for unobserved heterogeneity and the endogenous selection of network partners is often thought to be limited by attrition, especially in less developed countries where attrition rates are likely to be high because of mortality and extended periods of absence from the household. However, recent studies have concluded that attrition in panel data, even when substantial, does not cause serious bias (Fitzgerald et al. 1998; Alderman et al. 2001; Bignami et al. 2003; Falaris 2003). Moreover, attrition is likely to be substantially determined by characteristics of the individual that do not vary across time (Ziliak and Klisner 1998), and fixed-effects models that control

for these time-invariant observed and unobserved characteristics are likely to be considerably less affected by bias than standard analyses.

A further potential problem for the present study follows from the fact that the analysis is based on respondents who report having discussed AIDS with at least two network partners. This could induce a sample selection bias because participation in social interactions determines inclusion in the study. However, to the extent that a social network with fewer than two members is determined by observed characteristics or unobserved fixed characteristics, such as age or constraints on social interactions caused by the location or demographic composition of the respondent's compound or village, the fixed-effects analysis controls for this selection and the estimated coefficients will remain unbiased, despite the focus on respondents with at least two network partners.

Results of basic analyses

This discussion begins with some basic estimates of relation (1). For comparability with subsequent analyses, these initial estimates are based on the subset of respondents who reported talking about AIDS with at least two network partners in both survey waves. The results in Table 4 show that the two dependent variables—the respondent's subjective worries about getting AIDS ('risk perception') and the respondent's assessment of communication about AIDS with his or her spouse as an effective AIDS prevention strategy ('spousal communication')—are, with few exceptions, not strongly predicted by socio-economic characteristics such as age, parity, schooling, marital status, or the indicators for wealth and earning activity (see Montgomery 2000 for similar remarks). This basic analysis, however, reveals two potentially important conse-

Table 4 Estimates of the associations between attitudes to HIV/AIDS and individual and network characteristics, using random-effects logit models. Malawi 1998–2001. Respondents with 2+network partners in both waves[1]

	Risk perception[2]		Spousal communication[3]	
	Women	Men	Women	Men
Intercept	−3.08***	−3.22***	0.15	0.70
	(0.39)	*(0.71)*	*(0.32)*	*(0.71)*
Age	0.01	−0.01	0.01	−0.01
	(0.01)	*(0.01)*	*(0.02)*	*(0.01)*
Parity	−0.03	−0.01	−0.01	0.02
	(0.03)	*(0.03)*	*(0.02)*	*(0.03)*
Primary schooling	0.29*	0.25	−0.07	−0.35**
	(0.15)	*(0.23)*	*(0.11)*	*(0.17)*
Currently married	−0.21	0.44	−0.77***	0.15
	(0.21)	*(0.45)*	*(0.19)*	*(0.46)*
House has a metal roof	0.31	0.38	−0.04	0.03
	(0.22)	*(0.28)*	*(0.18)*	*(0.21)*
Doing wage work	0.29*	0.40	−0.15	−1.18**
	(0.15)	*(0.33)*	*(0.11)*	*(0.48)*
AIDS prevention effort	0.17*	−0.01	0.18**	−0.01
	(0.09)	*(0.01)*	*(0.08)*	*(0.02)*
Per cent network partners highly worried about AIDS	2.97***	3.61***	0.11	0.04
	(0.18)	*(0.22)*	*(0.14)*	*(0.16)*
Time trend	0.44***	0.56***	−0.58***	0.06
	(0.15)	*(0.16)*	*(0.11)*	*(0.15)*
Dummy for south	4.28***	3.71***	–[4]	1.51***
	(0.64)	*(0.72)*		*(0.41)*
Time * south	−2.42***	−1.83***	–[4]	−0.95***
	(0.35)	*(0.41)*		*(0.26)*
N	814	648	814	648

[1]Standard errors are adjusted for the correlation of residuals across waves.
[2]The survey asked 'How worried are you that you might catch AIDS?'
[3]The survey asked 'What do you think are the best ways to protect yourself from AIDS?' Answers were not prompted.
[4]The dummy variable and interaction effect were not included because it was not significant for women in the south.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.
Source: As for Table 1.

quences for risk perceptions of the respondent's exposure to discussions about AIDS. First, more exposure to the efforts of organized programmes is associated both with more pessimistic perceptions of the risk of HIV and a higher probability of spousal communication about AIDS—but only for women. Second, social interactions with others seem to affect risk perceptions for both men and women. Table 4 shows that the proportion of social-network partners who are very worried about AIDS is significantly related to the respondent's own risk perception, but not to the probability of spousal communication about HIV/AIDS.

Fixed-effects analysis

In the following section, we turn to our preferred fixed-effects analysis of relation (2), which avoids the important limitations of the basic analysis of relation (1). In this analysis we focus on two issues. First, do the relations that can be estimated using the simple model above persist or change once we control for unobserved characteristics and potentially endogenous network selection? Second, can our analysis distinguish between the information a social network provides and the normative influence it exerts?

Self-perceived risk of HIV infection

Estimates for women. Table 5 presents estimates using model (2) for individual risk perceptions. For simplicity, we focus on the network variables of primary relevance for the study presented here. Initially it was found that the pattern of coefficients differed across regions, suggesting important local variation in the mechanisms underlying the effects of social interactions. Specifically, the coefficients of the network variables in relation (2) were allowed to differ between the pooled districts of the south and centre and the north.

The coefficients reported in Table 5 for the south + centre are typical of a situation in which social learning is relatively more important. The coefficient

Table 5 Estimates of the effects of social interactions on the probability of worrying about AIDS, using random-effects and fixed-effects logit models. Malawi 1998 and 2001. Respondents with 2+ partners in both waves

	Random effects[1]		Fixed effects[1,2,3,4]	
Women[5]	South+centre	North	South+centre	North
Per cent network partners worried a lot about AIDS (δ_1)	2.51***	−0.60	2.56***	−0.45
	(0.57)	*(0.80)*	*(1.02)*	*(1.20)*
Density (δ_2)	0.39	−1.24**	0.91	−2.45**
	(0.38)	*(0.5)*	*(0.71)*	*(0.87)*
Per cent network partners worried a lot about AIDS * density (δ_3)	0.59	2.48***	−0.29	3.86**
	(0.68)	*(0.89)*	*(1.11)*	*(1.52)*
N	*548*	*256*	*236*	*111*
Men	All districts		All districts	
Per cent network partners worried a lot about AIDS (δ_1)	3.06***		3.88***	
	(0.45)		*(1.01)*	
Density (δ_2)	−0.26		0.60	
	(0.32)		*(0.85)*	
Per cent network partners worried a lot about AIDS * density (δ_3)	0.86		−0.21	
	(0.75)		*(1.10)*	
N	*648*		*283*	

[1]All models include controls for age, education, marital status, AIDS prevention effort, economic activity, a dummy for metal roof on the house, and parity.
[2]Education and age are time-invariant and are subsumed under the fixed effect.
[3]The fixed-effects logit model is based only on respondents who changed their risk perceptions between the two waves.
[4]The main difference between fixed-effects and random-effects estimates is that fixed-effects models allow for the possibility that the fixed effects (f_i) are correlated with the independent variables of the logit model. Such a correlation is expected whenever network partners are not randomly assigned to the respondent. Random-effects models, just like ordinary models, assume that the fixed effects (f_i) are not correlated with the variables included in the analysis.
[5]A Wald test indicated that results for women could not be pooled across districts.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.
Source: As for Table 1.

δ_1 is large, positive, and highly significant, and the density of the network structure has no significant effect on the likelihood of worrying about AIDS. Figure 2 (for south+centre) shows the corresponding predicted effect that changes in that proportion of social-network partners who are highly worried about AIDS have on the respondent's own risk perception. The graph displays the probability that a woman worries a lot (vs. worrying a little or not at all) as a function of, first, the proportion of network partners who worry about AIDS (measured on the x-axis), and second, the density of the social network, ranging from a relatively sparse network with a density of 0.5 (dashed line) to a closely knit network with a density of 1 in which all network partners are tied to each other (solid line).

Several important conclusions follow from this analysis. First, the probability of a respondent being very worried about AIDS increases with the prevalence of AIDS concern in her network, and this effect does not vary significantly across network structures, contrary to what would be expected if social influence was the relevant mechanism. Second, as the level of concern in a network increases, a further worried network partner has a diminishing effect on the respondent's risk perceptions. These findings are consistent with a dominance of social learning in the social interactions about HIV/AIDS: in situations where it is primarily social networks that provide information about a new health threat, having one very worried network partner is likely to be enough to provide the basic information that is known throughout the community (e.g., that HIV is sexually transmitted and that AIDS is fatal). Additional partners are unlikely to provide much new information, so the marginal effect on the respondent's risk perception of additional network partners with AIDS worries diminishes.

The fixed-effects estimates for the north (Figure 3) show a strikingly different pattern. In particular, the interaction between the network partners' risk assessments and the density of the social network is positive and significant. On the one hand, a *dense* network with no network partners very worried about AIDS exerts a strong negative effect on the probability that the respondent is very worried; correspondingly, an increase in the level of concern in such a dense network has a strong positive effect on the respondent's risk assessment. On the other hand, in a *sparse* network (density below 0.5), variation in the level of concern across networks has only a weak effect on the respondent's risk perception, or none at all. Thus, it is primarily when the network is relatively dense that the level of concern in the network matters. In addition, increases in density have a positive effect on the respondent's AIDS worries only if the social network consists primarily of network partners who are very worried about AIDS. This pattern of social-interaction effects is typical of social influence: social interactions seem to exert pressure towards conformity in risk perceptions in a social network.

Since these results are derived from our fixed-effects estimates, it is important to assess whether controls for all time-invariant characteristics of individuals and communities make a difference. In the south+centre, the difference between model specifications is very small. The point estimate for δ_1 is quite similar in both specifications, and while the estimate for δ_3 differs, it is not statistically significant in either specification. This suggests that network variables in the south+centre are not strongly

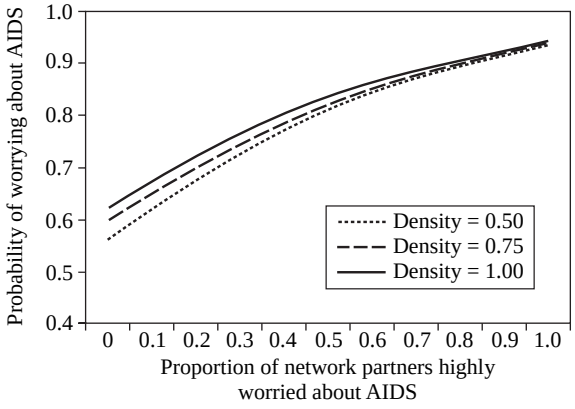

Figure 2 The effect of network partners' risk perceptions on the probability of worrying about AIDS, based on fixed-effects estimates for women reported in Table 5, south+centre regions
Source: As for Table 1

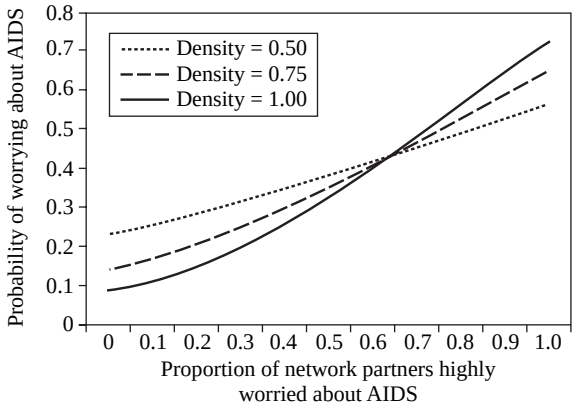

Figure 3 The effect of network partners' risk perceptions on the probability of worrying about AIDS, based on fixed-effects estimates for women reported in Table 5, northern region
Source: As for Table 1

correlated with unobserved individual and community characteristics. In the north, however, the differences between the random-effects and fixed-effects models are substantial, suggesting that random-effects models greatly underestimate the effect of density and its interaction with the proportion of network partners who are very worried. This may be due to a stronger selection of network partners by women that results in underestimating the extent of social influence in this region.

Estimates for men. The qualitative data collected as part of the MDICP show that not only women but also men spend considerable time engaging in informal conversations about HIV/AIDS, the threats posed to their health and their communities, and the possibilities of reducing infection risks by behavioural changes and partner selection (Watkins 2004). In the lower panel of Table 5 we therefore report the fixed-effects estimates of relation (2) for males. Because Wald tests for the differences in the coefficients across regions show that these estimates do not exhibit the same regional variation shown for females, in the present study the three regions are pooled to give a single set of coefficients. The results in Table 5 show that the coefficient δ_1 is sizable and highly significant, and that the effect of worries among social-network partners on the respondent's risk perception does not vary much across different network structures. This pattern suggests that social learning is the main mechanism behind social interactions for men in all three regions. This interpretation is corroborated by numerous descriptions of conversations in the observers' field reports: there are frequent conversations among males about whether a potential, current, or past sexual partner is likely to be infected. Topics include whether or not a woman has other partners, and whether one of her previous partners died of AIDS. (See Kaler 2004 and Watkins 2004 for detailed descriptions of these conversations.) It is also worth noting that the point estimates for δ_1 vary greatly between model specifications, and that random-effects models tend to underestimate the effects of social interactions on men's perceptions of risk.

Local variations in the effects of social interaction: the role of marriage patterns

To understand the distinct differences in the patterns of social learning and social influence between the south+centre and the north for females, and the uniform pattern of social learning across all three regions for males, it is important to consider how the north differs from the other regions. Two possible explanations seem most pertinent. First, social-interaction effects may differ because the networks in the north have a different composition and structure from those in the south+centre. Second, the differences in social-interaction effects may result from contextual differences in the nature of the interactions between the respondent and his or her network partners.

Socio-economic contexts and the size and structure of social networks do indeed differ between the north and south+centre. Table 1 shows that there are several systematic socio-economic differences between the regions, some of which may have implications for network dynamics. For instance, the average education level is much higher in the north, as is the proportion of respondents speaking English. A higher proportion of households there also have a radio or pit latrine, or a house roofed with metal sheeting. Our qualitative data, as well as our participation in the collection of the survey data, led us to expect that different settlement patterns and different ways of supplementing subsistence agriculture may be particularly important. Because the north is less densely settled than the south+centre, people are more likely to go to a trading centre for a casual conversation with a friend in the latter two regions. In addition, households in the south use small businesses as a way of supplementing subsistence agriculture. This leads to greater diversity in daily activities, and thus to more interactions with acquaintances than with confidants. In the north, on the other hand, most men find employment on tobacco plantations (the main export crop in Malawi) and thus have fewer incentives to look for work or income elsewhere. Table 3 shows that networks in the south+centre tend to include more network partners who are acquaintances, or have just met the respondent once, whereas networks in the north include a higher proportion of friends and confidants of the respondents. Responses to a question about the residence of network partners show that more respondents in the south+centre than in the north engage in conversations about AIDS with network partners from the cities or other regions of Malawi. As a corollary to these observations, the density of social networks tends to be lower in the southern and central regions, even though this difference tends to attenuate over time. This may indicate a higher

prevalence of 'weak ties' (Granovetter 1973) in the two districts of the south and centre.

However, these regional differences in network composition are similar for men and women, and thus do not provide an explanation for the differences by sex in the patterns of social interactions in Table 5. It is likely that this pattern of the effects of social interactions on respondents' risk perceptions is primarily related to the distinctive marriage patterns found in the north and in the south+centre, and the manner in which these different marriage patterns alter the composition of social networks. Marriage in the north is primarily patrilocal: women leave their families once marital unions are formed and start living in the husband's family, which means that women have to form new *local* networks after marriage. Marriage in the south+centre, on the other hand, is matrilocal, and it is thus men's networks that are altered at marriage. Table 3 supports the expectation that differences in marriage patterns between the north and the south+centre will be associated with different patterns of social interactions. Women's social networks in the north contain a large proportion of female relatives of the respondent (39 per cent in 2001), and a large fraction of female in-laws (21 per cent), whereas these proportions are much lower in the other two districts.

Moreover, the dispersed settlement pattern in the north makes it more difficult for women to talk to others outside the compound, and because the distances to a trading centre or clinic are greater, women from the same compound are likely to walk together, thus enabling a wife's interactions to be more readily influenced by her husband's female kin (Schatz 2002). In contrast, the denser settlement patterns in the south+centre make possible a wider range of casual network partners, with little or no supervision by a husband's female relatives.

While direct evidence is not available in the quantitative data used for the present study, we believe that, in the north, the over-representation of members of the husband's family among women's network partners for conversations about AIDS constrains their opportunities for learning and increases the extent to which networks exert social influence. In particular, the husband's female relatives (his mother and his unmarried sisters, as well as his sisters-in-law, who are all competing for compound resources) may effectively hinder a wife from learning about behaviour of her husband that would increase her worry about becoming infected, such as gossip about his extramarital relationships. In addition, the constraints that distance places on the ability to talk with unrelated women also impede the flow of information that would be a cause for concern. In contrast, semi-structured interviews with women in the south have shown that they know a great deal about the sexual partners of others in the community (Tawfik and Watkins 2003), and our observers' field reports show that information about a husband's infidelity reaches his wife quickly. Formal tests of these hypotheses are not possible with the present data, for such tests would require complete ('sociocentric') network data, and especially information about the centrality of female relatives and how this determines their ability to control information flows and act as cut points between various social groups (Granovetter 1973; Burt 1992).

In contrast to the pattern for women, there are no detectable differences in network composition for men between the three districts. Of particular note is the finding that men in the matrilineal regions of south+centre do not talk about AIDS with members of their spouse's family more often than do men in the north (Table 3). Phiri (1983) shows that men in the matrilineal societies of Malawi have 'invented' several institutions that protect them from the influence of their in-laws. Because men's AIDS conversation networks are less embedded in the wife's family, and because behavioural expectations are different for men, social-interaction effects on men's risk perceptions are not strongly affected by the different marriage patterns.

Social interactions and spousal communication

Spousal communication about HIV/AIDS is often seen as an important determinant of behavioural responses to the epidemic. In particular, the preventive strategies promoted by the international health community, which encourage the use of condoms or abstinence from sexual relationships altogether, do not appear adequate for married couples. Spouses in rural Malawi have also come to understand that their fates are joined (Watkins 2004), and that the management of the risk of HIV/AIDS requires the cooperation of husbands and wives. Initiating a discussion about the threat of AIDS within one's partnership is therefore seen as the first step in trying to persuade one's spouse to be faithful or to adopt risk-reduction strategies in extramarital relations (Zulu and Chepngeno 2003). However, open spousal communication about sexual behaviour and potential HIV infection is often

Table 6 Estimates of the effects of social interactions on the probability of spousal communication about AIDS, using random-effects (RE) and fixed-effects (FE) logit models. Malawi 1998 and 2001. Respondents with 2+network partners in both waves

	Women[1,2,3]		Men[1,2,3]	
	RE	FE	RE	FE
Per cent network partners worried a lot about AIDS (δ_1)	−0.65*	−0.72*	−0.14	−0.77
	(0.36)	*(0.43)*	*(0.40)*	*(0.60)*
Density (δ_2)	−0.26	−1.01*	−0.47	−0.84*
	(0.25)	*(0.61)*	*(0.31)*	*(0.51)*
Per cent network partners worried a lot about AIDS * density (δ_3)	0.76*	1.55**	0.36	1.07
	(0.39)	*(0.66)*	*(0.37)*	*(0.70)*
N	814	387	648	301

[1]All models include controls for age, education, marital status, AIDS prevention effort, economic activity, a dummy for metal roof on the house, and parity.
[2]Education and age are time-invariant and are subsumed under the fixed effect.
[3]The fixed-effects logit model is based only on respondents who changed their attitudes between the two waves.
***p <0.01; **p <0.05; *p <0.1.
Source: As for Table 1.

contrary to long-standing practices in sub-Saharan Africa, and discussing the likelihood of HIV infection with one's spouse is likely to provoke issues of trust or imply accusations of infidelity that can threaten the viability and stability of unions. Caldwell et al. (1992, p. 385) thus describe the 'near-prohibition on the discussion of sexual activity between ... spouses'.

Table 6 shows the results of the fixed-effects model (2) for the probability that a respondent considers spousal communication to be among the best ways to protect oneself from getting AIDS. The results for women, displayed in Figure 4, indicate that attitudes towards spousal communication vary strongly with network density. For instance, the proportion of network partners who are very worried about AIDS has almost no effect on the respondent's attitude toward spousal communication if the network is relatively sparse (density $\leq$ 0.5), while it has very strong effects if the network is dense (density =1). This pattern is typical of social influence. As a consequence, women indeed appear to be socially constrained towards not discussing HIV/AIDS with their husbands when the prevalence of AIDS concerns in their network is relatively low, and when their network partners form a closely linked group. On the other hand, when the prevalence of concern is high among densely knit network partners, women may be encouraged to discuss the risks of HIV infection with their husbands. These results are also uniform across districts, even though underlying sexual behaviour and patterns of extramarital relationships may be very different between patrilineal and matrilineal societies (Caldwell et al. 1992).

The fixed-effects estimates for men show a similar pattern for the probability that a husband considers spousal communication an effective prevention strategy. In particular, social-interaction effects are dominated by social influence, and interactions with densely knit networks can reduce the probability that men consider spousal communication important for AIDS prevention if the network is characterized by a generally low level of AIDS concern. The effect operates in the opposite direction if a high level of AIDS concern is found in a dense network. However, these results are only marginally significant. The relative weakness of social-interaction effects on men's attitudes towards spousal communication may be due to the fact that they do not perceive

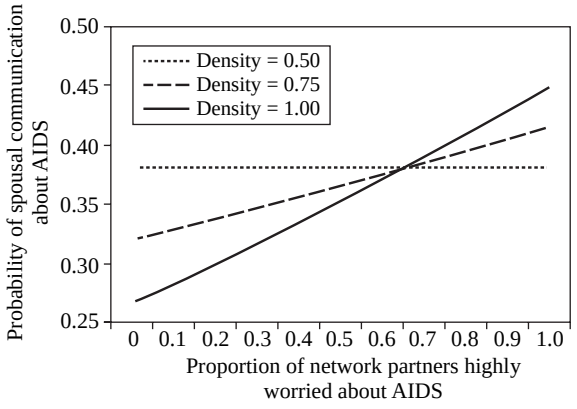

Figure 4 The effect of network partners' risk perceptions on the probability of spousal communication about AIDS, all regions, based on fixed-effects estimates for women reported in Table 6
Source: As for Table 1

themselves as being put at risk of infection by their spouse: in 1998 only 13 per cent of male respondents (25 per cent in 2001) cited their spouse as the potential source of infection that most worried them (Table 2). For comparison, in 2001 half the women in our sample reported being worried about getting infected by their spouse. In casual conversations about AIDS, men appear to discuss primarily the possibility of remaining faithful, or better ways of assessing the risk associated with certain types of partnerships.

Conclusions

The aim of the study presented in this paper was to investigate whether social interactions among friends, peers, relatives, and community members play an important role in developing strategies to reduce the risk of HIV/AIDS, and in evaluating the benefits of 'new' behaviour such as the adoption of condom use, increased marital fidelity, or more selective partner choices. The study provides clear evidence that social interactions do indeed have these functions. First, it shows that social interactions on the subject of HIV/AIDS have significant and substantial effects on respondents' perceptions of the risk of HIV/AIDS, even after controlling for unobserved characteristics affecting both respondents' risk perceptions and their social networks, and that a larger proportion of network partners who are worried about HIV/AIDS tends to increase the respondent's own perception of risk. Second, it suggests that social networks do not necessarily constrain individuals towards the formation of fatalistic risk perceptions, or the adoption of risky behaviour. On the contrary, respondents in the sample tended to use their social networks to gather information about the disease and to assess their own risk of infection. Rather than a constraint or a 'barrier', social networks appear as a resource for individuals to learn about and evaluate new behavioural strategies in the face of the epidemic. Third, we find that the dominant mechanisms—social learning and social influence—through which social interactions shape attitudes towards AIDS vary by sex and by region, and that marriage patterns play a major role in defining the mechanisms of social interactions. In particular, our analysis suggests that women in the patrilocal region of the study have fewer opportunities to make use of social interactions to learn about threats to their sexual health because networks are deeply embedded in the spouse's family and therefore impose tighter forms of social control and social influence.

Notes

1 Stéphane Helleringer is a PhD candidate in the Population Studies Center, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA 19104-6299, USA. E-mail: hellerin@ssc.upenn.edu

2 Hans-Peter Kohler is Associate Professor of Sociology and Research Associate in the Population Studies Center, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA 19104-6299, USA. E-mail: hpkohler@pop.upenn.edu

3 We are grateful for the many helpful comments that we have received from Susan Watkins, Jere Behrman, Irma Elo, Georges Reniers, Philip Anglewicz, and two anonymous referees. We also gratefully acknowledge the support for this research through NIH grants RO1 HD044228 and RO1 HD/MH41713.

References

Alderman, Harold, Jere R. Behrman, Hans-Peter Kohler, John A. Maluccio, and Susan C. Watkins. 2001. Attrition in longitudinal household survey data: some tests for three developing-country samples, *Demographic Research* 5: 79–123.

Axinn, W. G. and Scott T. Yabiku. 2001. Social change, the social organization of families, and fertility limitation, *American Journal of Sociology* 106: 1219–1261.

Barnett, Tony and Piers Blaikie. 1992. *AIDS in Africa: Its Present and Future Impact*. New York: Guilford Press.

Behrman, Jere R., Hans-Peter Kohler, and Susan C. Watkins. 2002. Social networks and changes in contraceptive use over time: evidence from a longitudinal study in rural Kenya, *Demography* 39: 713–738.

Behrman, Jere R., Hans-Peter Kohler, and Susan C. Watkins. 2004. Social networks and HIV/AIDS risk perceptions. Mimeo, University of Pennsylvania, Philadelphia.

Bernardi, Laura. 2003. Channels of social influence on reproduction, *Population Research and Policy Review* 22(5/6): 527–555.

Bignami-Van Assche, Simona, Georges Reniers, and Alex Weinreb. 2003. An assessment of the quality of KDICP and MDICP data, *Demographic Research*, Special Collection 1: 32–69.

Bond, Virginia and Paul Dover. 1997. Men, women and the trouble with condoms: problems associated with condom use by migrant workers in rural Zambia, *Health Transition Review* 7(Suppl.): 377–391.

Bongaarts, John and Susan C. Watkins. 1996. Social interactions and contemporary fertility transitions, *Population and Development Review* 22(4): 639–682.

Burt, Ronald S. 1992. *Structural Holes: The Social Structure of Competition*. Cambridge, MA: Harvard University Press.

Caldwell, John C., Pat Caldwell, and Pat Quiggin. 1989. The social context of AIDS in sub-Saharan Africa, *Population and Development Review* 15(2): 185–234.

Caldwell, John C., Pat Caldwell, and I. O. Orubuloye. 1992. The family and sexual networking in sub-Saharan Africa: historical regional differences and present-day implications, *Population Studies* 46(3): 385–410.

Caldwell, John C. 2000. Rethinking the African AIDS epidemic, *Population and Development Review* 26(1): 117–135.

Campbell, Catherine. 2003. *'Letting Them Die': Why HIV/AIDS Prevention Programmes Fail*. Bloomington and Indianapolis: Indiana University Press.

Casterline, John B. 2001. The pace of fertility transition: national patterns in the second half of the twentieth century, *Population and Development Review* 27(S2: Suppl.: Global Fertility Transition): 17–52.

Entwisle, Barbara, Albert I. Hermalin, Peerasit Kamnuansilpa, and Apichat Chamratrithirong. 1996. A multilevel model of family planning availability and contraceptive use in rural Thailand, *Demography* 21(4): 559–574.

Falaris, Evangelos M. 2003. The effect of survey attrition in longitudinal surveys: evidence from Peru, Côte d'Ivoire and Vietnam, *Journal of Development Economics* 70: 133–157.

Fitzgerald, John, Peter Gottschalk, and Robert Moffitt. 1998. An analysis of sample attrition in panel data: the Michigan Panel Study of Income Dynamics, *Journal of Human Resources* (Special Issue: Attrition in Longitudinal Surveys) 33(2): 251–299.

Gluckman, Max. 1950. Kinship and marriage among the Lozi of Northern Rhodesia and the Zulu of Natal, in A. R. Radcliffe-Brown and Daryll Forde (eds.), *African Systems of Kinship and Marriage*. London: Oxford University Press (published for the International African Institute).

Granovetter, Mark S. 1973. The strength of weak ties, *American Journal of Sociology* 78(6): 1360–1380.

Hsiao, Cheng. 2003 (1st edn 1986). *Analysis of Panel Data*. Cambridge: Cambridge University Press.

Kaler, Amy. 2004. AIDS-talk in everyday life: the presence of HIV/AIDS in men's informal conversation in Southern Malawi, *Social Science & Medicine* 59: 285–297.

Kohler, Hans-Peter. 2000. Fertility decline as a coordination problem, *Journal of Development Economics* 63: 231–263.

Kohler, Hans-Peter. 2001. *Fertility and Social Interaction: An Economic Perspective*. Oxford: Oxford University Press.

Kohler, Hans-Peter, Jere R. Behrman, and Susan C. Watkins. 2001. The density of social networks and fertility decisions: evidence from South Nyanza District, Kenya, *Demography* 38(1): 43–58.

Kravdal, Øystein. 2002. Education and fertility in sub-Saharan Africa: individual and community effects, *Demography* 39(2): 233–250.

Low-Beer, Daniel and Rand L. Stoneburner. 2004. Uganda and the challenge of AIDS, in K. Poku Nana and Alan Whiteside (eds.), *The Political Economy of AIDS in Africa*. Aldershot: Ashgate, pp. 165–190.

Manski, Charles. 1995. *Identification Problems in the Social Sciences*. Cambridge, MA: Harvard University Press.

Montgomery, Mark R. and John B. Casterline. 1993. The diffusion of fertility control in Taiwan: evidence from pooled cross-section time-series models, *Population Studies* 47(3): 457–479.

Montgomery, Mark R. and John B. Casterline. 1996. Social learning, social influence, and new models of fertility, *Population and Development Review* 22(Suppl.: Fertility in the United States: New Patterns, New Theories): 151–175.

Montgomery, Mark R. and W. S Chung. 1998. Social networks and the diffusion of fertility control in the Republic of Korea, in R. Leete (ed.), *The Dynamics of Values in Fertility Change*. Oxford: Oxford University Press, pp. 179–209.

Montgomery, Mark R. 2000. Perceiving mortality decline, *Population and Development Review* 26(4): 795–819.

Moscovici, Serge. 1985. Social influences and conformity, in G. Lindzey and E. Aronson (eds.), *Handbook of Social Psychology*, Volume 2. New York: Random House, pp. 347–412.

Moursund, Anne and Øystein Kravdal. 2003. Individual and community effects of women's education and autonomy on contraceptive use in India, *Population Studies* 57(3): 285–301.

Munshi, Kaivan and Myaux Jacques. 2002. Development as a process of social change: an application to the fertility transition. Mimeo, University of Pennsylvania, Philadelphia.

Nzioka, Charles. 1996. Lay perceptions of risk of HIV infection and the social construction of safer sex: some experiences from Kenya, *AIDS Care* 8(5): 565–579.

Orubuloye, I. O., John C. Caldwell, and Pat Caldwell. 1997. Perceived male sexual needs and male sexual behaviour in southwest Nigeria, *Social Science & Medicine* 44(8): 1195–1207.

Phiri, Kings M. 1983. Some changes in the matrilineal family system among the Chewa of Malawi since the

nineteenth century, *Journal of African History* 24(2): 257–274.

Reniers, Georges. 2003. Divorce and remarriage in rural Malawi, *Demographic Research*, Special Collection 1: 174–202.

Rutenberg, Naomi and Susan C. Watkins. 1997. The buzz outside the clinics: conversations and contraception in Nyanza Province, Kenya, *Studies in Family Planning* 28(4): 290–307.

Schatz, Enid. 2002. Numbers and narratives: making sense of gender and context in rural Malawi. Unpublished PhD dissertation, University of Pennsylvania, Philadelphia.

Setel, Philip W. 1999. *A Plague of Paradoxes. AIDS, Culture and Demography in Northern Tanzania*. Chicago: University of Chicago Press.

Smith, Kirsten P. and Susan C. Watkins . 2005. Perceptions of risk and strategies for prevention: responses to HIV/AIDS in rural Malawi, *Social Science & Medicine* 60(3): 649–660.

Tawfik, Linda. 2003. Soap, sweetness and revenge: patterns of sexual onset and partnerships amidst AIDS in rural southern Malawi. Unpublished PhD dissertation, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD.

Tawfik, Linda and Susan C. Watkins. 2003. Sex in Geneva, sex in Lilongwe and sex in Balaka. Paper presented at the Population Association of America Annual Meeting, Minneapolis, MN.

UNAIDS. 2004. Epidemiological Fact Sheet, Malawi, 2004 update.

Watkins, Susan C. 2000. Local and foreign models of reproduction in Nyanza province, Kenya, 1930–1998, *Population and Development Review* 26(4): 725–759.

Watkins, Susan C., Jere R. Behrman, Hans-Peter Kohler, and Eliya M. Zulu. 2003. Introduction to 'Research on Demographic Aspects of HIV/AIDS in Rural Africa', *Demographic Research*, Special Collection 1: 1–30.

Watkins, Susan C. 2004. Navigating the AIDS epidemic in rural Malawi, *Population and Development Review* 30(4): 673–706.

Watts, Duncan J., Peter S. Dodds, and Mark E. J. Newman. 2002. Identity and search in social networks, *Science* 296: 1302–1305.

Ziliak, James P. and Thomas J. Kniesner. 1998. The importance of sample attrition in life cycle labor supply estimation, *Journal of Human Resources* (Special Issue: Attrition in Longitudinal Surveys) 33(2): 507–530.

Zulu, Eliya M. and Gloria Chepngeno. 2003. Spousal communication about the risk of contracting HIV/AIDS in rural Malawi, *Demographic Research*, Special Collection 8: 247–278.