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Risk factors of sexually transmitted infections among migrant and non-migrant sexual partnerships from rural South Africa

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SUMMARY

In October 1998, cohorts of circular migrant men and their non-migrant sexual partners, and non-migrant men and their non-migrant sexual partners from rural South Africa were recruited and followed-up every 4 months until October 2001. At each visit, information on socio-demographic, sexual behaviour, sexually transmitted infections (STIs) and HIV was collected. In total, 553 individuals aged between 18 and 69 years were recruited. A man and his sexual partner(s) form a sexual partnership. Migration status, age, marital status, age at sexual debut, recent sexual partners and HIV status were found to be important determinants of STI. The risk of STI varies ($\sigma^2 = 1{\cdot}45$, $P < 0{\cdot}001$) significantly across sexual partnerships even after controlling for important determinants. The variance implies substantial correlation (0·59) between members of the same sexual partnership. Ignoring this correlation leads to incorrect inference. Migration contributes significantly to the spread of STIs. Community interventions of HIV/STI should target co-transmitter sexual partnerships rather than high-risk individuals.

INTRODUCTION

The spread of sexually transmitted infections (STIs) results from a complex interaction of factors related to demography, socio-economic and sexual behaviour. A significant factor in the spread of HIV/STI from one place to another is the migration of people [1]. The contribution of migration to the geographical spread of HIV/STI has been the topic of discussion for some time [1–3]. In South Africa, the predominant type of migration is circular labour migration [4–6]. In circular migration, young men migrate to work in urban areas leaving behind their sexual partners, to whom they return periodically [4, 7]. The common theme is that migrant men get infected with HIV/STI from partners acquired during migration periods and infect their rural female partners when they return [4, 8]. In some cases, migrant men establish parallel families between urban and rural areas [5]. In this way, migrant men form linked sexual partnerships, which become a critical bridge for transmitting HIV/STI between rural and urban areas. However, the situation becomes complex as the women left behind sometimes have to exchange sex for favours as a

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survival strategy [9] and this introduces another dimension in which migration contributes to the spread of STIs [10].

The formation of groups of sexual partnerships plays an important role in the transmission dynamics of STIs [11]. An important dynamic feature of infections taking place within the constraints of sexually linked partnerships is the high rate at which members of the same sexual partnership have the same infection status [12]. For example, many infected individuals also have their sexual partners infected since they either infected their partners, or vice versa. The consequent inherent classification of individuals into subgroups of linked sexual partners introduces clusters of correlated, with respect to their infection status, individuals within a cluster [a man and his sexual partner(s)] and introduces extra variability associated with the cluster. Estimators of variance that do not control for this clustering would be biased downwards. This results in confidence intervals that are too narrow, and differences that appear to be more significant than they actually are.

In this paper, we investigate the possible socio-demographic, behavioural and biomedical risk factors determining the presence of at least one STI among cohorts of sexual partnerships of migrant men and their rural non-migrant female partners, and non-migrant men and their rural non-migrant female partners from a rural district of KwaZulu/Natal, South Africa. The evidence shows that presence of any STI facilitates transmission of HIV [13]. However, these two types of infections also share the same behavioural risk factors. Understanding transmission dynamics and possible risk factors of STIs could help control further transmission of HIV [14]. The estimated parameters are corrected for the extra variability introduced by clustering of sexual partnerships. The study was designed to investigate the effects of urban–rural circular labour migration on the spread of HIV and other STIs in rural South Africa [7].

MATERIAL AND METHODS

Sampling method and data structure

The data comes from cohorts of migrant men from a rural district of South Africa working at two common migration destinations. Migrant men were eligible to participate if they had at least one non-migrant regular sexual partner living in the district, and have been migrants for at least the last 6 months. Once migrant men were enrolled, they provided contact details of their rural sexual partners who were then recruited. In the neighbourhood of each migrant man's rural household, the household of a non-migrant man was identified and the non-migrant man and his rural female partner(s) were recruited. A non-migrant man was defined as someone who spent most nights at home, and had not been a migrant for more than a total of 6 months in the last 5 years, and whose regular partner was not a migrant. Some men identified more than one steady sexual partner. The man and his sexual partner(s) form a sexual partnership. The partnerships are distinct in the sense that no woman was identified by more than one man as the sexual partner.

A professional nurse physically examined study participants for presence of any STI. Blood and urine specimen were collected for laboratory examination of STI and HIV. Syndromic management was completed according to standard provincial guidelines [15]. Infections detected by laboratory analysis were treated 10 days after examination. Participants were visited every 4 months between October 1998 and October 2001. A detailed questionnaire was administered at each visit to elicit information on socio-demographic, sexual behavioural and other biomedical characteristics.

The outcome of interest is a binary indicator of the presence or absence of at least one STI in an individual at each of the first four (including baseline) clinical examination visits. The STIs considered are the laboratory-diagnosed active syphilis, gonorrhoea and chlamydia; syndromically diagnosed genital sores and genital discharge. There was high correlation between the laboratory-diagnosed and syndromically diagnosed STIs. HIV infection was excluded when formulating the outcome because it is non-recurrent and has been analysed elsewhere [7].

Parameter estimation and interpretation

It is the variability of the population of sexual partnerships that is of interest and not just the individual member of the sexual partnership. This variability is best modelled as a random effect rather than a fixed effect [16, 17]. The random effect refers to an underlying unobserved random variable shared by members of the same sexual partnership, which introduces correlation within a sexual partnership. The random effect variable is assumed to be normally distributed with mean 0, and unknown variance (σ^2). However, any continuous symmetric unimodal distribution can be assumed for the random effect variable. The series of binary indicators of STI status over time is represented by a binomial distribution [18]. The expectation-maximization (EM) algorithm [19] is used to estimate parameters since unobservable random effects can be viewed as incomplete data [16, 17, 20]. The EM algorithm finds the maximum of the observed data likelihood by alternating between finding the expectation of the unobserved part of the data (random effect), given the observed data (E-step), and maximizing the complete data likelihood as if the unobserved data were actually observed (M-step) [21]. In this approach, estimation amounts to iteratively fitting a weighted logistic regression model with the weights depending on estimated parameters [16].

The exponent of the coefficient of fixed effects is interpreted as the odds ratio (OR). The estimate of σ^2 represents the degree of variability (heterogeneity) across sexual partnerships in the propensity for an STI not attributable to measured variables [20, 22]. A large estimate of σ^2 implies a high degree of heterogeneity between sexual partnerships thus indicating high correlation (ρ) between members of the same sexual partnership. Manda [17] presents formulae translating estimates of heterogeneity into correlation. A P value of $<5\%$ was considered significant. We report 95% confidence intervals (CIs).

Ethical approval

The human subjects committees of Johns Hopkins University School of Hygiene and Public Health and the University of Natal, Durban approved the study.

RESULTS

Descriptive analysis

The analysis focuses on 553 men and women aged between 18 and 69 years. The proportion of males (56%) was slightly higher than that of females (45%). Only 17% of sexual partners of migrant men could not be recruited; in these cases migrant men either provided incorrect information about their partners or their identified partners refused to participate. Out of 553 participants migrant men constituted 35%, partners of migrant men (19%), non-migrant men (22%) and partners of non-migrant men (24%). Migrant men and their partners were on average younger than non-migrant men and their partners. Women were generally younger than their partners with average age difference of 3·4 years.

Table 1 presents the baseline distribution of possible determinants of STI and baseline prevalence of STI. Migrant men were at higher risk of having at least one STI compared to any other migratory category at baseline. The baseline risk of STI is also high among those who were never married. Having two or more recent sexual contacts or being infected with HIV are associated with an increased risk of STI at baseline.

Table 2 presents the composition of sexual partnerships and prevalence of STI at each visit. The prevalence of STI is highest among partnerships of size four (30·0%) followed by men whose partners were not recruited (29·0%). There are small proportions of sexual partnerships of size greater than three to make valid comparisons. The risk varies considerably between sexual partnership sizes over time (Table 2). This indicates the importance of considering the sexual partnership random effect in this analysis. The proportion infected with at least one STI from baseline to the final visit was 27·4, 15·9, 11·6 and 13·6 respectively. Twenty-two people were diagnosed with the same STI in two consecutive visits, with 4·5% co-infected with both active syphilis and gonorrhoea. Out of five people re-infected with an STI, three were re-infected with active syphilis and two with gonorrhoea. No one was re-infected with chlamydia. Re-infection is considered where there is at least one negative diagnosis of a particular STI between two positive diagnoses.

Multivariate analysis

Stepwise regression analysis identified migration status, age at recruitment, marital status, age at first sexual intercourse, number of recent sexual contact partners, HIV status at recruitment and visit number as important independent fixed effects to be included in the regression model (data not shown). The model without random effect was fitted first (Table 3). Results show that migrant men (OR 1·54) and their partners (OR 1·20) are at higher risk of contracting an STI compared to partners of non-migrant men. Non-migrant men were at lesser risk of STI than their partners (OR 0·91). Sexual partnerships consisting of a migrant man were at higher risk of infection than sexual partnerships where a man was a non-migrant ($P=0·031$). The risk did not differ significantly between males and females ($P=0·652$). Age was

Table 1. *Baseline description of possible determinants of STIs*

Variable	Total	Percentage	Baseline prevalence of STI (%) (95% CI)*
Migration status			
Migrant men	195	35·3	33·9 (27·3–40·9)
Partners of migrant men	119	21·5	21·0 (14·1–29·4)
Non-migrant men	105	19·0	20·9 (13·6–29·9)
Partners of non-migrant men	134	24·2	20·2 (13·7–27·9)
Age <35 years			
Yes	35	64·7	23·7 (19·4–28·5)
No	195	35·3	28·2 (22·0–35·1)
Never married			
Yes	146	26·4	33·6 (25·9–41·8)
No	407	73·6	22·4 (18·4–26·7)
Age first sexual contact			
16 years or younger	174	31·5	28·2 (21·6–35·5)
More than 16 years	379	68·5	24·0 (19·8–28·6)
Recent sexual contact partners			
One or none	427	77·2	22·5 (18·6–26·7)
Two or more	126	22·8	34·9 (26·7–43·9)
HIV status			
Positive	130	23·5	30·8 (23·0–39·5)
Negative	423	76·5	23·6 (19·7–28·0)

* 95% Exact binomial confidence interval.

Table 2. *Partnerships and prevalence of STIs at each visit by sexual partnership size*

Partnership size	Partnerships *N* (%)	Baseline *n** (%)	Visit 2 *n** (%)	Visit 3 *n** (%)	Visit 4 *n** (%)
Singles†	140 (42·9)	41 (29·3)	17 (19·5)	6 (12·0)	4 (13·8)
Couples	152 (46·6)	72 (23·7)	31 (13·9)	11 (10·5)	10 (15·5)
Man+2 partners	28 (8·6)	21 (25·0)	10 (16·4)	4 (8·7)	3 (9·4)
Man+3 partners	5 (1·5)	20 (30·0)	0 (0·0)	0 (0·0)	0 (0·0)
Man+4 partners	1 (0·3)	0 (0·0)	0 (0·0)	0 (0·0)	0 (0·0)

* Number of infected individuals within a sexual partnership.
† Men whose partners were not recruited.

univariately associated with the risk of STI. However, the effect of age diminished when migration status was considered. Individuals who had never been married were at higher risk of STI (OR 1·44, $P=0{\cdot}039$) compared to those who were married or had ever been married.

Earlier commencement (16 years or younger) of sexual activity was significantly associated with high risk of STI (OR 1·43, $P=0{\cdot}023$). The risk was significantly higher among those who reported recent sexual contact with at least two partners (OR 2·34, $P=0{\cdot}003$) compared to those who reported no recent sexual contacts. A larger number of lifetime partners increases the risk of STI. However, its effects completely diminished when the number of recent sexual contact partners was included in the model.

Presence of HIV is associated with a significantly increased risk of contracting an STI (OR 1·53, $P=0{\cdot}012$). For every clinical visit attended, the odds of having at least one STI were reduced by an OR of 0·75. The reduction in the risk of STIs is evidence for the importance of continuous treatment of STIs, sexual behavioural education and appropriate health-seeking behaviour.

The model with random effect presents the results of the analysis correcting for correlation in the data

Table 3. *Parameter estimates of risk factors of STI and sexual partnership variance*

	Model without random effects		Model with random effect	
Variable	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Migration status				
Migrant men	1·54 (1·00–2·37)	0·049	1·74 (1·08–2·81)	0·023
Partners of migrant men	1·20 (0·76–1·88)	0·438	1·07 (0·66–1·76)	0·779
Non-migrant men	0·91 (0·55–1·51)	0·711	0·90 (0·52–1·57)	0·715
Partners of non-migrant men	1		1	
Age <35 years				
1 = Yes, 0 = No	1·16 (0·83–1·64)	0·382	1·21 (0·83–1·76)	0·332
Never married				
1 = Yes, 0 = No	1·44 (1·02–2·04)	0·039	1·66 (1·12–2·43)	0·012
Age first sexual contact				
16 years or younger	1·43 (1·05–1·94)	0·023	1·62 (1·16–2·27)	0·005
More than 16 years	1		1	
Recent sexual contact partners				
Two or more	2·34 (1·24–4·44)	0·009	2·87 (1·43–5·78)	0·003
One	1·42 (0·79–2·55)	0·239	1·50 (0·80–2·82)	0·206
None	1		1	
HIV status				
1 = Positive, 0 = Negative	1·53 (1·09–2·12)	0·012	1·49 (1·03–2·15)	0·033
Visit number				
Linear	0·75 (0·65–0·86)	<0·001	0·70 (0·59–0·81)	<0·001
Sexual partnership				
Variance estimate (S error)			1·46 (0·11)	<0·001

OR, Odds ratio; CI, confidence interval.

(Table 3). The results indicate that variation across sexual partnerships has a sizable impact on the risk of STI. The estimates of fixed effects were slightly magnified in this model, with an exception of HIV status. The corresponding standard errors were consistently larger, indicating that parameters are now estimated with less precision. However, most variables remained significant and inference remained unchanged.

The notable change in the risk of other STIs is the effect of HIV status. In the model without random effect, the OR of an STI was 1·53 times higher ($P=0{\cdot}012$) among those infected with HIV. The OR of HIV infection in the model with random effect was reduced by ~6%. Transmission of HIV in a sexual partnership is high if at least one partner is infected with HIV. Therefore, inclusion of sexual partnership random effect that accounts for unmeasurable common sexual partnership behaviour is likely to reduce the magnitude of the effect of HIV. However, HIV status remained significant ($P=0{\cdot}033$).

The estimate of sexual partnership variance is 1·46, which is considerably greater than zero at the 5% level of significance based on the one-sided upper tail of a normal distribution with a critical value of 1·645 [23]. The estimate indicates a high degree of variability across sexual partnerships. The variance estimate implies substantial association between members of the same sexual partnership with respect to the risk of STI even after adjusting for other individual specific covariates in the model. The corresponding estimated correlation is 0·59.

DISCUSSION

The results of this study show that circular migration contributes significantly towards the transmission dynamics of STIs. Contacts between migrant men and highly sexually active women during migration bring the epidemic of HIV/STI into local regions, through their less sexually active rural partners [5]. However, an ongoing local epidemic of HIV/STI in rural areas is also responsible for sustaining the epidemic of HIV/STI [10]. Efficient transport systems between urban and rural areas provides adequate conditions for the formation of linear sexual partnerships that are an important reservoir for the maintenance of STIs, particularly gonorrhoea [11].

The risk factors considered in the analysis are interdependent and thus make it difficult to isolate the effect of individual factors. Age and marital status are interrelated in that older people are more likely to be married than younger people. This phenomenon overshadows the importance of other variables in the model. Partnerships involving a migrant man are more likely to be younger than partnerships involving a non-migrant man as migrant men are often at their working age. Certain variables commonly considered in such analysis, for example education and income, were not considered either because of collinearity between variables such as income, job status and migration status or because there was little variation in the data for any valid statistical analysis. For example, all migrant men were recruited at their workplaces, and therefore all employed whilst few non-migrant men were employed.

Sexual mixing between older men and younger women has the potential to introduce infections into younger women [24]. In our model, age was not a significant risk factor for STI after adjusting for other factors. However, it was kept in the model due to its epidemiological importance. The risk of STI increases exponentially with an increase in the number of recent sexual contact partners. This indicates the intensity of STIs in the presence of multiple partners as confirmed by stochastic simulation models [25]. The risk associated with the number of recent sexual contact partners increased in the model with random effect, thus indicating underestimation of the effects of multiple partners in the transmission dynamics of STIs in the model without random effect.

HIV transmission in this society is mainly heterosexual [26]. Therefore, its presence is a good indicator of the history of risky sexual behaviour. Inclusion of unobserved random effect variables that account for sexual partnership specific behaviour is likely to reduce the magnitude of the effect of HIV. However, the importance of HIV was not completely removed. The remaining importance could be that the reduced immune system response caused by HIV infection increases the likelihood of acquiring an STI during unprotected sexual contact with an infected partner. The most unfavourable scenario is that people infected with HIV continue to engage in unprotected sexual contact even though efforts are made to educate them about the importance of safe sex.

Heterogeneity across sexual partnerships has important implications for transmission dynamics of HIV/STI [27]. The main source of heterogeneity in HIV/STI studies arises from patterns of sexual mixing and structural composition of sexual partnerships. Migrant men frequent prostitutes or have sexual contacts with sexually active women during their migration periods [4]. The risky behaviour of migrant men is followed by sexual contacts with their less sexually active rural partners. Their rural partners may have other short-term relationships while their partners are away [5, 24]. If this mixing pattern occurs, a multiple peaked epidemic of HIV/STI may occur and the epidemic will spread rapidly through the small proportion of sexually active men and women but more slowly through the less sexually active group of men and women [28].

The estimates obtained in both models are subject to some reporting bias. It is possible that not all relationships were divulged to the interviewers. Societal values play an important role in the formation of sexual partnerships and their structure. In this society, extra-marital relationships among women are not as accepted as they are among men. Thus, women may underreport their sexual activity whilst men may overstate theirs. The sampling method used starts from a random sample of people, thus sexual behavioural aspects are expected to be the same as in the true sexual partnership formations. However, refusal to participate or identify sexual partners leads to underestimation of sexual mixing.

The analysis accounted for correlation in the data. Ignoring this correlation leads to spurious associations between STI and some covariates due to underestimation of variability. In our data, standard errors of the model that ignore correlation were underestimated by at most 11% compared to the model that corrected for correlation. Therefore, treating each individual as independent gives a false impression that there is more information in the data than there really is.

The results have important implications for epidemiology and control of STIs. Control measures of STIs should extend further from focusing on high-risk individuals to considering high-risk sexual partnerships such as those that involve casual or multiple partners. This is more imperative for women who are in disadvantaged positions to negotiate safe sex or prevent their partners from having extra relationships. Partners of people with STI should be encouraged to be tested and treated in order to stop the continuing transmission cycle of STIs and further transmission of HIV within sexual partnerships. Interventions targeted at local communities will attain only short-term success in the presence of urban–rural migration that creates opportunities for re-entry of STIs. Therefore, interventions should fully incorporate the effects of migration and sexual partnership structures in their approaches.

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