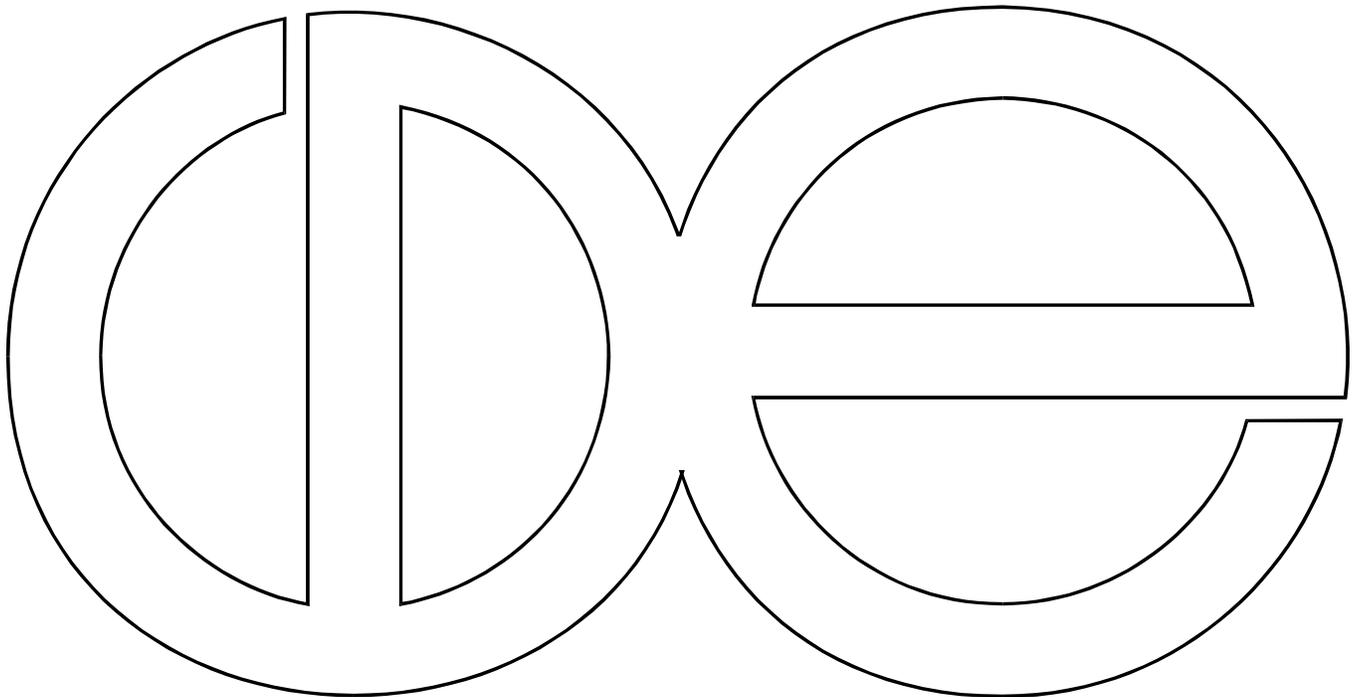


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**Modeling the Spread of HIV/AIDS in China**

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## **Abstract**

The Chinese population is believed to be in the early stages of an HIV/AIDS epidemic, and concerns are great that the epidemic may soon spread to the general population via heterosexual transmission. Using a bio-behavioral macrosimulation model driven by realistic input parameters from the Chinese Health and Family Life Survey (CHFLS), we evaluate the implications of China's regime of sexual relations for the future course of HIV/AIDS in the world's largest population. Our results illustrate the importance of accounting for prevailing patterns of sexual behavior in the Chinese population. They show that, under the prevailing regime of sexual relations, as measured by the CHFLS, the simulated adult HIV prevalence rate for 50-year projection horizons remains below one or two percent, depending on which sexual mixing scenarios we ascribe to.

Alternative scenarios based on assumptions about changes in sexual norms and behaviors, consistent with the strong relationship between average income and risky sexual behavior observed in the CHFLS, produce much larger epidemics. In particular, a simulated rise in the demand for commercial sex in combination with bi-monthly contacts with prostitutes will produce an explosive epidemic, but could be prevented by means of an effective policy intervention promoting 100% condom use with prostitutes.

**KEYWORDS: HIV, AIDS, models, China, sex behavior**

## **I. Introduction**

The magnitude of the HIV/AIDS epidemic has exceeded all expectations since the virus was first identified 20 years ago. Today, an estimated 42 million people are infected with HIV, and more than 20 million have already died. The epidemic has hit hardest in Sub-Saharan Africa. AIDS deaths in this region account for over three quarters of the global death toll (UNAIDS 2003). Because of its large population, Asia is the home to the largest number of people living with HIV/AIDS of any region beside Sub-Saharan Africa. In Thailand, Cambodia and Myanmar adult prevalence rates range from 1.8% to 3%. It is expected that HIV may soon spread in the world's most populous countries, India and China.

In China, after a decade of generally low levels of infection, the Ministry of Health reported that HIV infections have risen by 30% a year since 1994 (Plafker 2001). The overall number of infections was estimated at more than 1 million at the end of 2001, based on HIV surveillance (UNAIDS 2002c). According to the national surveillance system, the epidemic has, until recently, been contained within high-risk populations, such as injecting drug users (IDUs) and villages in rural Henan province with faulty plasma collection practices. These two modes of transmission are thought to account for almost 90% of the cumulative number of HIV infections in China (Yuan et al. 2002).

More recently, infection rates have risen among female sex workers (FSWs), with an estimated 1.32% infected in 2000 (United States Embassy in China 2001), and with recorded high prevalence pockets in the FSW populations of Yunnan province (2%), Guangzhou (2%) and Guanxi province, bordering Vietnam (10%). Behavioral-risk

assessment data reveal that large fractions of FSWs never use condoms. These range from 31% in Beijing to 70% in economically backward Anhui province (WHO 2001).

The early phases of the Chinese epidemic resemble those already seen in Thailand, where infection has spread from high-risk to low-risk populations. In Thailand, the first cases of HIV were detected in 1984, but the rapid growth of the epidemic did not occur until 1987 when seroprevalence among IDUs reached 44% (Brown, Mulhall and Sittitrai 1994; Brown, Sittitrai, Vanichseni and Thisyakorn 1994). Seroprevalence among Thai FSWs peaked at 33% in 1994 but has since declined to around 22%, following an aggressive 100% condom program among commercial sex workers in the 1990s (Rojanapithayakorn and Hanenberg 1996). Currently, around 50% of new adult infections are women who have been infected by their husbands or sex partners, 25% are due to injecting drug use, and only about 20% occur among sex workers and their clients (World Bank 2000; UNAIDS 2000).

In China too, the concern is great that HIV/AIDS may soon spread to the general population and that it will become an endemic disease sustained by heterosexual transmission (United Nations Team Group on HIV/AIDS in China 2002; Brady et al. 2001; Kaufman and Jing 2002). Short-term projections of the number of HIV cases (if no interventions are implemented) range from 10 million people infected by 2010 (UN Theme Group on HIV/AIDS in China 2002) to 20 million infected (Brady et al. 2001; Morrison and Gill 2003).

Reasons for alarm have no doubt to do with the sheer size of current estimates and projected new infections. Because China has the largest population in the world, rates that might appear very low imply a very large number of infections and projected AIDS

deaths. One million HIV cases in 2001 correspond to an adult HIV prevalence rate of 0.1%, much lower than in Cambodia (3%), Thailand (1.8%) or India (0.8%), and extremely low if compared to prevalence rates of 25% in South Africa, 34% in Zimbabwe and 39% in Botswana (UNAIDS 2002a, 2002b, 2002d, 2002e, 2002f, 2002g). With a projected annual growth rate of the Chinese population of just below 1% in the next 10 years, 10 million cases in 2010 will correspond to just above 1% of the adult population, still a comparatively low rate. However, the number of new HIV infections in China implied by 10 or 20 million cases in 2010 will represent significant portions of the 45 million new infections projected globally between 2002 and 2010 if the pandemic continues on its current course (Stover et al. 2002).

But the rationale for the warning of an impending explosion of HIV infections in China fueled by heterosexual transmission is also provided by the swift process of social and economic change, widening urban-rural disparities, the emergence of new social groups striving to reap the benefits of a changing opportunity structure, and transformations in norms and behaviors about relationships and sexual lives this process is inducing (e.g., Farrer 2002; Sigley and Jeffreys 1999). In particular, three groups are regarded as epidemiologically important for the spread of HIV: rural migrants to China's budding urban centers, prostitutes and their clients.

Rural migration is of special concern for the spread of HIV because of its size. This was estimated at 120 million at any point in time in the 1990s, and accounts for about 8% of the total Chinese population (Wang, Zuo and Ruan 2002). Young male migrant workers experience long separations from their families and meet institutional barriers which keep them in a position of second class citizens within the host cities

(Solinger 1999). Because of these factors, Chinese rural migrants are expected to adopt high risk behaviors that will lead them to acquire HIV and become bridges of infection to the rural populations (Anderson et al. 2003; Guangxi Centre for HIV/AIDS Prevention and Control 2001; du Guerny, Hsu and Hong 2003; Zhang and Ma 2002; Bates, Chang and Palmer 2002; Kaufman and Jing 2002).

Poverty and lack of economic opportunities for the less educated in rural areas, and increasing joblessness in urban areas are thought to lure many Chinese women into prostitution, an activity with promising prospects of quick earnings (Hershatter 1997; Yuan et al. 2002). China's sex industry is large and growing but is also amorphous. Sex work is often a part time job that women cycle in and out of when they need cash (Gil et al. 1996; Hershatter 1997). Prostitutes are an epidemiologically relevant population for the assessment of the spread of HIV, not only because of the nature of the connection between prostitutes and their clients but also for the transmission link between prostitutes and their spouses or long-term partners, especially in contexts in which demand for and supply of prostitution are widespread.

In China, rising average incomes and increasing opportunities for moneymaking and travel are associated with male patronage of commercial sex (Hershatter 1997:338-339). Patronage of commercial sex has been found to be more prevalent among men in high income strata (Kaufman and Jing 2002; Yuan et al. 2002; Thompson 2003). The cost of one-time sex services is high, ranging from 15% to 100% of an average worker's monthly salary, depending on location and type of service (Pan 1999). Relative to individuals in less profitable occupations, entrepreneurs, managers and businessmen, the most prominent members of China's emerging middle class, are better able to afford

these services. Men who visit prostitutes become a bridge of infection to their wives and non-regular partners.

Concerns about the spread of HIV to the general population are further fueled by the rising incidence of sexually transmitted diseases (STDs). After the virtual eradication of STDs under Mao (Cohen et al. 2000), the national STD surveillance system recorded a rise in the number of STD cases from 5,800 in 1985 to 795,612 in 2001 (Chen et al. 2000; Gong et al. 2002), with bacterial vaginosis and gonorrhea being the most common. Despite rising STD incidence, the overall annual incidence for 2001 was only 0.063 per 100. This low reported figure can be explained by asymptomatic infections, the incidence being reported for the total population rather than the adult population, incomplete coverage of STDs by the national surveillance system, and underreporting especially for men who are more likely to seek treatment in private clinics (Cohen et al. 2000; Parish et al. 2003). Prevalence of chlamydia, an STD which is not tracked by the public health reporting system, was recorded by the Chinese Health and Family Life Survey which collected urine specimens from a nationally representative sample of China's adult population in 2000. The prevalence rates of chlamydia documented by this survey were higher than or equivalent to those documented for comparable populations in the West or Sub-Saharan Africa: 3.5% of sexually active women and 3.6% of men were infected with chlamydia at the time of the survey. Prevalence was higher at 7.4% among urban women aged 20-44 (Parish et al. 2003). Other studies have shown that chlamydia is especially prevalent among female sex workers in Guangzhou, with 38% infected, compared with 14% infected with syphilis and 8% infected with gonorrhea (van den Hoek et al. 2001, cited in Parish et al. 2003).

Soaring STD prevalence in China is particularly relevant to the spread of HIV not only because STDs provide a strong indication that a growing number of people are engaging in high-risk sex behaviors, but also because STDs are cofactors for HIV transmission whereby STDs enhance the infectivity of and susceptibility to HIV (Fleming and Wasserheit 1999; Gray et al. 2001), with the potential to amplify the spread of HIV.

A realistic assessment of the progression of HIV/AIDS in China needs to consider the sexual behavior dynamics of its population. Current estimates of the future number of HIV infections do not take into consideration the prevalent regime of sexual relations. This has no doubt to do with the lack of appropriate data which has prevented the application of models that incorporate sexual behavior parameters to describe the spread of the epidemic (The UNAIDS Reference Group on Estimates, Modeling and Projections 2002:w2-w3). However, failure to explicitly incorporate sexual behavior in modeling efforts is tantamount to ignoring the most fundamental engine of the epidemic, an especially relevant feature for a context-sensitive evaluation of the potential for the spread of HIV/AIDS in China.

The primary objective of this paper is to enhance understanding of the implications of China's sexual behavior regime for the potential spread of HIV/AIDS. We assess this potential with a bio-behavioral macrosimulation model of the spread of HIV/AIDS and implement this model with realistic input parameters obtained from the Chinese Health and Family Life Survey (CHFLS), a recently released data set which uniquely describes Chinese patterns of sexual behavior.

The bio-behavioral model we apply to China was developed by Palloni and Lamas (1991) to describe the spread of HIV/AIDS in a predominantly heterosexual

population. As a macrosimulation model, this model deals with population aggregates and models heterogeneity by partitioning the population into self-contained, homogeneous subgroups. Like other macrosimulation models, it is limited by the fact that it can only handle a relatively small number of groups, thus limiting the amount of heterogeneity one can represent. The Palloni and Lamas model represents rather well heterogeneity in sexual behavior by incorporating parameters that describe the distribution of the population by classes characterized by the rate of partner change and patterns of inter-group sexual mixing.

For the sake of preserving model tractability and the realism of simulations, the model forgoes the differentiation of population groups by urban and rural residence. The empirical foundation of a model that accommodates population groups by residence would require detailed information on China's regional demographic regimes, rates of rural outmigration and return migration and the distribution of the rural and urban populations by level of sexual activity, information that is presently unavailable or incomplete for China. Arbitrary input parameters which drive urban and rural projections would add little value to our primary goal of understanding the extent to which sexual behavior dynamics determine the spread of HIV/AIDS in China and would betray our purpose of implementing an empirically founded simulation model.

As a consequence of this methodological choice, this paper does not intend to produce forecasts of the HIV/AIDS epidemic for China. Instead, we use the outcomes of the model as a guide to understand and interpret the potential implications of current and prospective changes in sexual behavior for the spread of HIV/AIDS in the population at large.

We organize the paper as follows: In Section II, we examine the relationship between the distribution of sexual behavior and the spread of HIV. In Section III we describe the main features of the macrosimulation model, especially its treatment of heterogeneity in sexual behavior and patterns of inter-group sexual mixing. Section IV presents a description of the CHFLS data used to extract the behavioral input parameters that drive the macrosimulations. Model inputs and outputs are presented and discussed in Section V. These include results from baseline scenarios which rely on the empirical data provided by the CHFLS and results from alternative scenarios based largely on assumptions about changes in sexual norms and behaviors induced by economic and social transformations.

## **II. Sexual behavior and the spread of HIV**

Sexual behavior, especially the rate of sexual partner change, has been identified in mathematical models of disease spread as probably the most important factor underlying the transmission dynamics of HIV (Hyman and Stanley 1988, May and Anderson 1987, Anderson 1992a, Anderson, Gupta and Ng 1990). Similarly, the degree of inter-group sexual mixing determines the rate and the extent to which HIV is spread through sexual relations. Findings from simulations based on selective mixing models (i.e., who mixes with whom) (Morris 1997) have shown that tight assortative (within-group) mixing produces a more rapid initial spread of HIV, multi-peak epidemics in a population (Anderson, Gupta and Ng 1990; Gupta and Anderson 1989), with sequential waves of infection (Hyman and Stanley 1988), but a smaller overall epidemic. On the other hand, random or disassortative mixing tends to generate slower growing but larger epidemics in the long run (Gupta and Anderson 1989; Anderson 1992b; Palloni 1996).

In China, behavioral data that allow the identification of high-risk groups and patterns of sexual mixing are scarce. Due to the youth of the Chinese epidemic and other context-specific factors, HIV surveillance of high risk populations has begun only recently, does not cover all high-risk groups or covers them incompletely (China CDC and CDC 2002). For example, China's national surveillance system does not monitor men who have sex with men (MSMs) (Choi et al. 2003). Commercial sex and intravenous drug use are illicit behaviors in China. Most seroprevalence surveillance points are detention centers for prostitutes and IDUs and do not cover individuals who operate outside of public view. Most surveillance sites are located in urban areas, and coverage of the rural population is very limited. Behavioral surveillance has yet to become established (China CDC and US CDC 2002). Little attention is being given to the clients of prostitutes, a group that is poorly characterized, and to their sexual networks (Brady et al. 2001).

The UNAIDS approach to estimate current prevalence of HIV and its future impact combines efforts to capture the dynamics of HIV transmission from high- to low-risk populations with the features of a simple model designed for countries with low prevalence and concentrated epidemics where behavioral data are not available. Their approach for China consists of two main steps: The first step produces estimates of the size and HIV prevalence of high-risk populations and of populations exposed to HIV infection through the behavior of their partners, with assumptions about time to saturation and saturation levels in high-risk populations based on the experience of neighboring South-east Asian countries, assumptions about secondary transmissions from high risk individuals to their sexual partners and about plasma selling (Neff Walker, UNAIDS,

personal communication, August 2003). The second step takes point prevalence data and applies curve fitting procedures to retrieve past HIV incidence and to project forward HIV incidence, AIDS mortality and prevalence of both (Walker et al. 2003). When applied to China, this procedure has several weaknesses, some of which are recognized by UNAIDS (Walker et al. 2003). First, in China, coverage of key subgroups is incomplete, and the size of these populations is difficult to estimate. Second, although curve fitting in the second step relies on several points, an improvement on the two-point fitted EPIMODEL, the extent to which this curve describes the temporal trend of the epidemic will depend on the number of seroprevalence points and on the degree of population heterogeneity in sexual behavior which may produce different time trends of the epidemic. When heterogeneity of sexual behavior is present, forecasts can be off the mark even for short-term projection horizons (Anderson 1992b; Palloni 1996). For recent epidemics, such as the Chinese one, the number of prevalence points is small and the number of curves that will fit these points is large. In the absence of information on sexual behavior, there are many curves which may produce 10 million infections in 2010 for China. By the same token, the trajectory of HIV/AIDS for long-term projection horizons could be catastrophic or could fail to sustain an epidemic, and this will depend on the underlying regime of sexual relations. Therefore, the application of an empirically founded macrosimulation model of the spread of HIV/AIDS which incorporates realistic bio-behavioral parameters is an important step towards understanding the implications of the prevailing regime of sexual behavior for the potential spread of HIV/AIDS in China.

### **III. The model**

#### ***III.1. States and Flows***

The Palloni and Lamas (1991) model for describing the spread of HIV/AIDS is a generalization of a cohort population projection with multiple states and multiple flows. The model distinguishes three states (Healthy, Infected with HIV but asymptomatic, and Symptomatic AIDS) and models transitions between these states and from these states to death (see Figure 1). Unlike other macrosimulation models that simply apply multi-state life tables, this one allows for duration of infection and age dependency to reflect the fact that the health effects and the infectivity of infected persons vary with time spent in the asymptomatic infectious state and in the symptomatic AIDS stage.

The basic structure of the model is determined by the definition of the groups of risk-related populations as they move through the various states. The groups are defined by a combination of age, sex, and sexual behavior characteristics. The number of people in the groups and changes in the size of the groups are updated each year according to transition rates between states. A set of demographic and behavioral parameters determine these transition rates, whose evolution is described by a system of differential equations. The realism of the parameters governing these transitions is essential to obtain accurate projections. In Figure 1,  $\beta_1$  and  $\beta_2$  refer respectively to the rate of infection and the rate of incubation, that is the transitions from healthy to HIV infected and from infected but asymptomatic to AIDS.  $\mu_1$ ,  $\mu_2$ , and  $\mu_3$  are the mortality rates for those who are healthy, those who are infected but asymptomatic, and those with clinical manifestations of AIDS.

A detailed explanation of the model is not the purpose of this paper and can be found elsewhere (Palloni and Lamas 1991; Palloni 1996). Here, we shall focus on the most salient aspects of this model; the rate of infection,  $\beta_1$ , the rate of incubation  $\beta_2$ , and

the identification of the critical parameters required for modeling these transitions. As the most important transitions underlying the spread of HIV/AIDS,  $\beta_1$  and  $\beta_2$  are determined by the complex interaction of biological and behavioral factors. Biological factors include the natural history of HIV and the synergies between HIV and STDs. Behavioral factors include the number and type of sexual partners, and rules determining preferences for sexual partners.

$\beta_1$ , or the probability that someone who is susceptible will contract HIV, is the most important transition for the spread of HIV (Palloni 1996) and incorporates two main components: (a) *Infectivity per sexual act* is determined by the natural history of HIV. Infectivity is higher among infected individuals who have recently acquired HIV or in individuals who have symptomatic AIDS because of the higher viral load in these two stages (Ambroziak and Levy 1999). Infectivity also depends on the existence of other STDs, both ulcerative (syphilis, chancroid, and genital herpes) and discharge (gonorrhea, chlamydia, and bacterial vaginosis) diseases, whereby STDs enhance the infectiousness of HIV by increasing HIV concentration in genital ulcer exudates, in seminal plasma, or increasing HIV shedding in the genital tract (Fleming and Wasserheit 1999). STD-infected individuals also have an increased susceptibility to HIV. The prevalence of STD is a factor that depends on behavior (the rate of partner change) as well as on the availability of health care for treatment of STDs, because effective treatment of symptomatic STDs reduces the infectivity of HIV. Condom use and condom efficiency protect from HIV and STD by reducing infectivity per sexual act (Saracco et al. 1993; Seidlin et al. 1993; Saifuddin et al. 2001); (b) *The rules that allocate people into the various groups and the rules of sexual contact among groups*. Consider for example  $k$

groups, each defined by sexual activity identified by the number of sexual partners in a year. Membership in a group determines the population distribution by the number of sexual partners per year, and a preference function defining the probability that a member in group  $i$  will choose a member in group  $j$ ,  $p_{ij}$ . What determines this probability is an empirical question. However, information on patterns of inter-group sexual mixing is rarely available. Their empirical estimation requires data collection on sexual networks, i.e., information on respondents' partners and on their partners' partners. Except for information collected in the United States in the National Health and Social Life Survey (NHSL) (Laumann et al. 1994) and limited information on patterns of sexual mixing collected in less developed countries (Caraël 1995; Morris 1997; IUSSP 2000), little is known about sexual mixing patterns within and between sexual activity groups, or, more broadly, among major risk groups. Most studies rely on simulations of scenarios that incorporate assumptions about mixing patterns.

$\beta_2$  refers to the progression from HIV seroconversion to AIDS. This parameter depends on the functioning of the virus, on the way in which the virus invades the body, and on the reaction of the body to its attack (Nowak and McMichael 1995; Ambroziak and Levy 1999). There is a lot of variability in the incubation time. The mode of transmission, the degree of exposure to other infectious diseases, levels of nutrition and conditions of the host, such as age and health status, all affect the length of the incubation time.

### *III. 2 Modeling Transitions between States*

For ease of exposition, we start with a description of the parameters required to model progression from HIV seroconversion to AIDS,  $\beta_2$ . To model  $\beta_2$ , we assume that the

incubation follows a Weibull distribution (Weibull shape parameter 5). The parameters of this function are set to correspond to a mean incubation time of 8 years for adults, in line with the Chinese epidemiological literature (Li et al. 2001; Chau et al. 2003), and 2 yrs for children (Churat et al. 2000); and mean (exponential) survival with AIDS of 1 year for adults and children (Ambroziak and Levy 1999).

$\beta_i$ , the transition from healthy to infected but asymptomatic, depends on the proportion of infected individuals in each sexual activity group, and the rate of infection per coital act of those in group  $i$  with those in group  $j$ . Infection occurs as a result of multiple sexual acts, each carrying a constant probability of infection from the infected to the uninfected partner. The rate of infection for a non-infected member of a couple depends upon the partner's infectious status, the frequency of sexual contact per unit of time and the infectivity per sexual act. We assume a default baseline per-coitus probability of male-to-female HIV transmission of 0.0009 and a probability of female-to-male transmission of 0.0013, in line with the findings for 174 HIV discordant monogamous couples who were retrospectively identified from a population cohort in Rakai, Uganda (Gray et al 2001).<sup>1</sup> We assume that HIV is treble infectious during the first year after seroconversion and again after progression to AIDS (Mastro and de Vincenzi 1996; Ambroziak and Levy 1999). HIV-positive individuals who are also infected with an STD are more infectious and individuals with an STD have an increased susceptibility to HIV. For example, HIV is 2.25 times more infectious with chlamydia, and doubly infectious with gonorrhea.<sup>2</sup> Lastly, infectivity of sexual contact will be reduced by the probability of using a condom multiplied by a value reflecting condom efficiency.

The probability of infection through sexual contact is completely defined by the rules that allocate people into the various groups and the rules that determine sexual contacts within and among groups. The model distinguishes between the following sexual activity groups: monogamous and non-monogamous males, and monogamous and non-monogamous females. In addition, a given fraction of females are assumed to be prostitutes. Sexual activity groups are defined according to the number of non-prostitute partners per unit of time. Monogamous males (females) enter steady relationships with females (males) who may be monogamous or non-monogamous; a non-monogamous male (female) can have contacts with an arbitrary number of monogamous and non-monogamous partners. Both monogamous and non-monogamous males may seek sexual contacts with prostitutes.

The definition of sexual contacts between groups is a key process that drives the spread of HIV. However, while the information necessary to identify sexual activity groups is available from the CHFLS, empirical guidance about the actual partner selection process is not available for China. To model the rules of sexual contact among groups, we rely on two simulated scenarios of sexual mixing: an assortative mixing scenario is one where partners are selected only within one's own group (communication between groups is constrained so that  $p_{ij}=0$  for  $j \neq i$ ). Individuals enter into unions only with partners with their own preferences. For example, where groups are defined according to the rate of partner change, monogamous men will choose monogamous women, while men with  $n$  partners in the past year will choose women from the same sexual activity group. The second scenario, proportionate (random) mixing, is one where sexual relations are controlled by random mating within and across groups, where the

probability of mixing between groups is proportional to the size of each group. Mixing occurs every projection cycle and the probabilities of infection are calculated anew every cycle for each group.

Population renewal does not take into consideration tastes and preferences of parental generations. Renewal occurs with each new projection cycle when new entrants (births) are allocated into sexual activity groups according to the distribution specified at the outset (simulation year zero). For the reproduction of prostitutes, it is assumed that the timing of becoming a prostitute follows a Coale-McNeil marriage function, with the proportion of a female cohort who will become prostitutes approximated by the proportion of prostitutes in the female population. We set this equal to 2%, based on an estimated 6 million prostitutes ages 15-39 (Yuan et al. 2002; Horizon Market Research and Futures Group Europe 2002b) and on the age distribution of the female population from China's 2000 census.

Except for the rules of inter-group sexual mixing, all other behavioral parameters required by the model are extracted from the Chinese Health and Family Life Survey.

#### **IV. The Chinese Health and Family Life Survey**

The Chinese Health and Family Life Survey (CHFLS) is the most recent and comprehensive survey on sexual behavior in China. It was implemented between August 1999 and August 2000 by a team of researchers led by William Parish and Edward Laumann at the University of Chicago and Pan Suiming at People's University of China in Beijing. The CHFLS is a national stratified probability survey of the Chinese adult population ages 20 to 64. Respondents were sampled from registers of households and temporary migrants held by urban neighborhoods and rural townships. After being

administered a questionnaire covering childhood sexual contact, intimate partner violence, forced sex, sexual harassment, body image concerns, sexual well-being, risk behaviors, marital history and extramarital partnership history, survey participants were asked to provide a urine sample to test for gonorrhea and chlamydia infection. Of the 5,000 individuals who were initially selected, 3,821 completed the interview and 3,426 provided a urine sample yielding a 69% participation rate. Participant and data losses included (1) those who refused to be interviewed (897); (2) those who did not provide a urine sample (340); and (3) those for whom data were not obtained (337) (Parish et al. 2003: 1267). Although no information is provided on the characteristics of the first group, we know more about the latter two groups. In the second group, those who did not provide a urine samples were only marginally different from those who did and rural respondents were more likely to give urine samples than their urban counterparts (Parish et al. 2003:1267). The third group mainly comprised many men and some women in their early 20s who had left their place of residence and could not be located by interviewers (Parish et al. 2003: 1272). The study also suffered from incomplete enumerations of migrants who were not registered in the official registration lists of migrants, a sparse set of primary sampling unit and few rural respondents (Parish et al. 2003:1272). In this paper, our description of Chinese sexual behavior in China relies on the subset of 3,821 respondents who completed the interview, with the understanding that the data may understate the degree of risk among 20-24 year old men and among rural migrants. Moreover, because of the underrepresentation of rural respondents in this sample, inference can be drawn with more confidence to the urban population.

Due the sensitive nature of most sections of the survey and to preserve confidentiality of responses, most of the questionnaire was administered by audio-computer and interviews were conducted away from the respondent's home. Evaluation of agreement on selected sexual behavior items reported by 50 husband-wife pairs and 50 respondents who were interviewed twice at an interval of two months yielded moderate to high agreement scores (Parish et al. 2003).

#### ***IV.1. Measuring the Number and Type of Sexual Partners in the Past Year***

The most important piece of information for the implementation of the macromodel is the number of non-prostitute partners in the previous year. This allows the identification of the boundaries of sexual activity groups. The CHFLS includes a question on the number of partners last year but this question yielded a lot of missing or inapplicable responses even for currently married individuals who should have reported at least one sexual partner in the past 12 months. CHFLS respondents were also asked about their current spouse/cohabiting partner (Partner A), one most recent long-term sexual partner (sexual relationship lasted for more than a month) other than their current spouse/partner (Partner B) and one most recent short-term partner (sexual relationship lasted for less than a month) regardless of whether this was a commercial sexual partner or not (Partner C). For these three types of partners, questions were asked on respondent's age at start and end of each relationship (if ended). Information was also obtained which allows one to assess the social context of each relationship (where relationship started, partner's regional origin, age, education and other characteristics). An additional module was collected on commercial sex. Questions were asked on whether respondents ever paid for sex, whether the recipient of payment was a female prostitute or a non-prostitute, the

lifetime number of prostitutes, and the number of prostitutes visited in the last three months. From this information, we generate two variables representing the counts and type of partners in the last 12 months by combining information provided for partners A, B, C and commercial sex partners.<sup>3</sup> Because information was elicited only about the most recent partner of each type, the CHFLS fails to identify key details of the sexual history of highly sexually active individuals with a high rate of partner change. Thus our partner count should be regarded as a minimum estimate of the number of partners in the past year. However, an important advantage of our measure over the question which directly elicits a count is that it minimizes over-reporting of sexual activity, a bias which has been noted among young men in less developed countries (Mensch et al. 2003). Asking respondents to report on the details of each partnership may discourage over-reporting, because making up all the partnership details would require a special effort. Our measure also compares well with information on number of partners collected in the only other study of sexual behavior of the Chinese general population we are aware of.<sup>4</sup> This was a 1997 survey of a probability sample of 1,057 respondent age 15-49 representative of the rural population of Anhui province. The percentage of male and female respondents who reported two or more partners in the Anhui survey were respectively 9 percentage points lower and 0.6 percentage point higher than those recorded among CHFLS respondents but these differences were not statistically significant (for males: 95%C.I. [-18.6%, 0.4%],  $p = 0.06$ ; for females: 95%C.I. [-3.9%, 5.1%],  $p = 0.79$ ).

Table 1 shows the distribution of respondents by number of partners last year in China and the United States (U.S.). Compared with the U.S., Chinese men and women

report, on average, fewer partners. CHFLS data display a profile of sexual behavior which is more homogeneous than in the U.S. The overwhelming majority of Chinese men and women report 1 partner, and less than 10% of men and about 2% of women report 2 or more partners in the past 12 months. In the U.S. the fraction of men with multiple partners is more than double that in China while it is six times greater for women.

Multipartnership may imply a series of exclusive relationships or several concurrent partnerships. These behaviors have important implications for disease transmission, because they permit an assessment of the connectedness among partners of individuals displaying high-risk behavior and the identification of bridges between high-risk and low-risk populations (Morris and Kretzschmar 1997; Morris 1997). Although the CHFLS cannot identify individuals whose recent history involves sequential or concurrent short-term relations with commercial and non-commercial sex partners, we can get a sense of the diversification of partnerships from Table 2. This table distinguishes long term partners (relationship lasted for more than one month), short term partners (relationship lasted for less than a month) and prostitutes and displays the distribution of men and women by marital status and combination of types of partners in the previous year. A total of 9 percent of married/cohabiting men reported at least one extra partner in the previous year apart from their spouse/cohabiting partner. Chinese women show very low levels of long- or short-term partnership. The percentage of Chinese married men and women who are sexually active outside of marriage is smaller than those documented for African or Thai populations in the early 1990s. For example, in Côte d'Ivoire, 48% of urban and 39% of rural married men and 11% of urban and 7%

of rural married women reported at least one extra partner in the last year (Caraël 1995). In Thailand, 17% of married men reported sex outside of their primary relationship (Sittitrai et al. 1994).

To put commercial sex in comparative perspective, from Table 2, 3.3% of Chinese married/cohabiting men and 2.6% of unmarried men reported commercial sex in the last year.<sup>5</sup> These figures are higher than in the US, where about 0.3% of those interviewed in the 1992 NHFLS reported paying for sex in the past year (Lauman et al. 1994) and closer to the 3.3% figure yielded by reports of 18-64 year old French men (ACSF Investigators 1992). But patronage of prostitutes among Chinese men is far less prevalent than among Thai men. In the early 1990s in Thailand, 24% of urban married men and 9.5% of rural married men reported paying for commercial sex services in the last year, while, among unmarried men, these percentages rose to 40% and 38% in urban and rural areas respectively (Sittitrai et al. 1994). In the CHFLS, men who reported commercial sex comprise 20% of all men who report a non-marital, non-cohabiting partnership in the previous year. This is close to the low end of the range of 25%-40% recorded in many Sub-Saharan African and a few Asian countries but much lower than 75% reported in the Central Africa Republic, Tanzania and Thailand where widespread male patronage of commercial sex has fueled the HIV/AIDS epidemic (Caraël 1995:116).

#### ***IV.2. The Distribution of Sex Partners by Social Characteristics***

The number of sexual partners is *per se* a very parsimonious indicator. It does not reflect the highly variable process by which one selects sex partners in different social contexts (Laumann et al. 1994). This is especially relevant for China where the ongoing process of socioeconomic transformation and opening up to the outside world may induce more

rapid changes in sexual norms and behaviors in certain social groups than others, with important implications for social variation in risks of disease infection and transmission. By knowing the demographic, social and economic circumstances in which someone reports one, two or more sexual partners in the 12 months prior to the survey, we will be better informed about the social context of sexual behavior and the possible consequences of these behaviors for the spread of infection.

Table 3 shows the distribution of sex partners by selected social characteristics for all Chinese men and for men aged 20-44. We selectively illustrate the data because a significantly greater percentage of Chinese men than women reported 2 or more partners last year (see Table 1), and the percentage of men reporting two or more partners last year is greater in the 20-44 age group than in the 20-64 age group. We also limit the illustration of the social context of sexual behavior to statistically significant relationships between number of partners and social characteristics. Income, occupation, urban/rural residence and the region where one lives are the most important markers of multiple partnerships. The relationship between income and number of partners last year is strongly positive. A significantly higher fraction of men in the top income quartiles report two or more partners relative to those in the bottom income quartiles. Men in occupations which provide high income and opportunities for travel and socializing outside of home report more partners than men in occupations that do not provide such opportunities. Most notably, 40% of men who are managers, factory directors and business owners report two or more partners last year, compared with 8 percent of men in other occupations. The difference is even greater when we restrict the comparison to 20-44 year old men. Government cadres report the lowest level of sexual activity in the

previous year of any occupation, though being a government cadre may provide an incentive for underreporting extramarital sexual behavior. Multiple partnerships are more prevalent among residents of urban areas. Urban centers serve as conduits for new influences and urban lifestyle provides the opportunity for contacts with people not embedded in primary social networks. The region where one lives is also an important marker of multiple partnerships. A greater fraction of men who reside in the South and Central coastal regions (Shanghai, Fujian and Guangdong, bordering Hong Kong) report 2 or more partners last year than men who reside elsewhere. These are regions that have experienced the market transition earlier and where the pace of average income growth has been most rapid. Because of the direct connection between average income and patronage of commercial sex, men residing in these areas also report higher consumption of commercial sex than in the rest of China (8% versus 2.5%, not shown in table). Although 18% of male migrants<sup>6</sup> report two or more partners compared with 8% of non-migrants, this difference is muted when we restrict the comparison to younger males (20-44), because of a much higher sexual activity reported by younger non-migrant men relative to their older counterparts. Young male migrants to urban areas, the vessel of many social ills in the eyes of the Chinese government and urban public opinion, show levels of sexual partnership that are only marginally higher than those displayed by non-migrants.<sup>7</sup>

## **V. Macrosimulations of the spread of HIV/AIDS in China**

### ***V.1. Inputs***

To model the HIV/AIDS epidemic in China, we combine a set of conventional demographic inputs with behavioral input parameters extracted from the CHLFS and

biological inputs obtained from the biomedical literature. Modeling starts with a simulated population with the initial age distribution of China's 1990 census. The demographic inputs driving population projections assume constant fertility rates at 2 children per woman throughout the simulation period and age- and sex-specific mortality rates which reflect the Chinese mortality decline projected between 1990 and 2040 by the US Bureau of the Census.

In order to define the population of HIV infected individuals at simulation year zero, we calculate age-specific HIV prevalence rates according to the age distribution of HIV cases recorded for the Thai population and corresponding to the overall HIV prevalence documented for China in 2000. At the outset of the simulation, HIV infection is introduced by applying these age-specific HIV prevalence rates to men and women in the most promiscuous sexual activity group (those with the greatest number of non-prostitute partners) and to the population of prostitutes. Men and women in the other sexual activity groups begin the simulation period with no HIV prevalence and are introduced to the risk of infection during the simulation period only through sexual contacts with infected partners.

Table 4 shows the behavioral inputs extracted from the CHFLS. In addition to the inputs already evaluated in Section IV, this table includes average coital frequency per partner and the average proportion of an individual's coituses that are condom protected. Because misreporting of coital frequency typically plagues sexual behavior surveys, we compared the average number of coituses per partner reported by CHFLS respondents in the monogamous group (1 non-prostitute partner in the past year) with the average 73 coituses per partner per annum reported by 7,074 married volunteers age 18-62

interviewed in 1989-1990 (Liu et al. 1997). Because of consistency of reports between the two data sources, we conclude that reporting of coital frequency in the CHFLS is acceptable. Condom use is more frequent as the number of partners increases, which is consistent with more frequent condom use with non-regular partners than with regular partners. Because of the incomplete information on condom use with prostitutes in the CHFLS, we double the proportion of coituses with prostitutes which are condom protected relative to that with non-prostitute partners observed in the CHFLS, to reflect typically higher condom use with prostitutes than with regular partners.

## ***V.2. Outputs***

Figure 2 displays the four scenarios informed by the parameter inputs extracted from the CHFLS. Scenarios A and B differ with respect to the simulated pattern of sexual mixing. When people select only partners like themselves (assortative mixing, Scenario A), levels of adult HIV prevalence remain very low throughout the projection period. These range from 0.05% 10 years after the onset of infection to 0.3% forty years later. “Random” mixing within and across three sexual activity groups (Scenario B) also produces a small epidemic, though about 10 times bigger than that simulated under “assortative” mixing, with a peak in adult prevalence of 1.3% after 25 years, and declining thereafter to approach 0 at year 50.

To reflect the substantial prevalence of chlamydia in the Chinese population (Parish et al. 2003), Scenarios C and D, which are in effect our baseline scenarios, account for the higher infectivity per sexual contact due to the synergy between HIV and chlamydia. From these scenarios, a man recently infected with HIV who also has chlamydia has a per coitus probability of transmitting HIV to his partner of 0.6%

( $0.0009 \times 3 \times 2.25 = 0.006075$ ) where 2.25 is the chlamydia infectivity co-factor and 3 reflects triple infectiousness of HIV associated with a higher viral load in the first year since seroconversion. If his partner also has chlamydia, her per-coitus probability of seroconversion rises to 1.3% ( $0.006075 \times 2.25 = 0.0136$ ) (Bracher, Santow and Watkins 2003). To calculate the proportions of contacts that involve two partners without chlamydia, two partners with chlamydia, and only one partner with chlamydia and estimate average male-to-female and female-to-male per coitus infectivity rates in the presence of chlamydia, we use the overall male and female chlamydia prevalence rates in the CHFLS and assume them constant across sexual activity groups. Higher infectivity per sexual contact given 3.6% of sexually active men and 3.5% of sexually active women infected with chlamydia yields a level of HIV prevalence which is two to three times the level produced by HIV transmission probabilities with no chlamydia co-factor, depending on the sexual mixing scenario and the year of simulation. In particular, under random mixing, the epidemic peaks at 2% prevalence, and drops to 0.7% prevalence after 50 years under assortative mixing.

Scenarios C and D suggest that simulations based on the Chinese regime of sexual relations reported in the CHFLS, characterized by low average levels of sexual activity, considerable homogeneity in sexual behavior and small fractions of the population in high sexual activity groups, will produce a small epidemic. From these scenarios, HIV/AIDS will become endemic in the population at below 1% prevalence. However, there are several sources of understatement of the degree of risk in the CHFLS: both underreporting of sexual behavior and undercoverage of population groups displaying higher risk behaviors are possible. The extent of multipartnership and patronage of

prostitutes may be greater than the data suggest. The alternative scenarios we present below all assume a higher prevalence of high-risk behaviors consistent with a larger fraction of the population with multiple sexual partners and more extensive male patronage of commercial sex. These scenarios are informed by the positive association between income and high-risk behaviors measured by the CHFLS and rely on the assumption that subsequent changes in patterns of sexual behavior can be ascribed to this relationship and to the growing influence of the modern sexual revolution in the West.

Because in the short-run, annual average income growth may affect most directly the consumption of commercial sex, in scenarios E and F in Figure 3, we increase the proportion of men who visit prostitutes and the average number of prostitutes per patron linearly for the first 20 simulation years, in line with an income elasticity of demand for commercial sex of 0.6243 calculated from the CHFLS and a projected annual average income growth of 7%.<sup>8</sup> Compared with baseline scenarios C and D, scenarios E and F produce higher prevalence after 25 years. These levels, still low in absolute terms, will stabilize at 1.2% under assortative mixing, and 0.6% under random mixing at the end of the simulation period.

Figure 4 shows the impact of imposing a more heterogeneous regime of sexual relations by increasing the size of the groups with high rates of partner change to resemble the distribution of sexual activity observed in the United States. This change will produce a much worse epidemic under both sexual mixing scenarios because the greater fraction of individuals with very high sexual activity disproportionately contributes to the spread of HIV/AIDS. Scenario G, a simulation based on assortative mixing, yields a more rapid initial spread and a multi-peaked epidemic with prevalence

rates as high as 3.8% after 50 years. Scenario H, based on random mixing, produces a larger epidemic peaking at 5% prevalence after 30 years and dropping to just above 1% after 50 years.

In Figure 5, we simulate a scenario in which the practice of male patronage of commercial sex grows more rapidly than annual average income, one consistent with rapidly changing norms about premarital and extramarital sexual behavior for men but persistently strong expectations of virginity at marriage and post-marital fidelity for women. This is a Thai-like scenario where men will increasingly seek sexual encounters with commercial sex workers both before and during marriage. Scenarios I and J describe a situation in which the proportion of men in each sexual activity group who consume commercial sex increases at a constant rate of 14.9% per year to reach 40% in year 20 and stays constant thereafter. In Figure 6, Scenarios K and L combine this widespread practice of male patronage of prostitutes with a frequency of contacts with prostitutes elevated to twice per month, in line with the results of a behavioral surveillance study conducted in China's Yunnan and Sichuan provinces among 818 males age 20-50 recruited through fixed-position interception on high traffic streets (Horizon Market Research and Futures Group Europe 2002a). While in Figure 5 the increase to 40% in the level of male patronage of commercial sex alone drives adult HIV prevalence to 1.5% after 50 years under both assortative and random mixing scenarios, the epidemic explodes in Figure 6 when this is combined with higher frequency of contacts with prostitutes.<sup>9</sup> Under assortative mixing, adult HIV prevalence begins a steep climb in year 25 to reach 8% by year 50. Under random mixing, the climb is steeper: prevalence starts rising in year 15 and reaches 23% by year 50. In the face of an

unchanging supply of prostitutes and a growing demand for commercial sex, sexual contacts between prostitutes and their clients in settings where prostitutes have many concurrent partnerships will place more susceptible men, together with their wives and their non-regular sexual partners, at increased risk of infection from highly infectious prostitutes.

Scenarios M and N in Figure 6 evaluate the impact of an exogenous policy intervention aimed at inducing behavioral change. Suppose a 100 percent condom program is implemented starting in year 10 which reduces infectivity per sexual act by actively promoting condom use among commercial sex workers and their clients. Further suppose that this will result in the widespread utilization of condoms in 90% of sexual acts between prostitutes and their patrons and that condoms are 80% effective in preventing HIV transmission. This scenario is comparable to the 100% condom program implemented by the Thai Ministry of Health in the early 1990s (Rojanapithayakorn and Hanenberg 1996). Under both assortative and random mixing, at the end of the simulation period, the epidemic is reduced to about one fourth of the size simulated in the absence of any condom program.

## **VI. Conclusions**

The Chinese population is in the early stages of an HIV/AIDS epidemic. Despite great concerns that HIV infection may soon spread to the general population via heterosexual transmission, extant assessments of the future course of HIV/AIDS in China pay no heed to the potential role played by the Chinese regime of sexual relations in fueling the epidemic. In this paper, we have implemented an *empirically grounded* macrosimulation model of the spread of HIV/AIDS to evaluate the implications of Chinese sexual

behavior dynamics for the future course of an HIV/AIDS epidemic in China. Except for the contact rates within and between groups for which there is no empirical guidance, all other behavioral parameters driving our macrosimulation model were extracted from the Chinese Health and Family Life Survey. This goal of implementing a macrosimulation model with realistic input parameters has been rarely achieved by previous efforts to simulate the spread of HIV/AIDS for any country. To represent sexual mixing patterns, we have relied on two simulated scenarios: one in which the pattern of sexual partner choice according to sexual activity is assortative (individuals choose partners with like characteristics) and the other in which this pattern is random. The latter assumes that there is no selection bias and partner choice is determined by availability.

To assess the implications of the Chinese regime of sexual relations for the course of HIV/AIDS in China, we have simulated scenarios arising from the current sexual behavior profile of the Chinese population and from possible evolutions of the sexual relations regime. Simulation results have indicated that the potential for spread of HIV/AIDS in China is clearly a function of infectivity per sexual act, the distribution of sexual behavior in the population, the size of groups characterized by high rates of sexual partner change, patterns of sexual mixing within and across these groups, and the extent of patronage of prostitutes, especially if combined with frequent contacts with prostitutes. Simulations have also revealed that the average level of sexual activity in China is too low and the size of the groups characterized by high rates of partner change too small to yield a substantial epidemic. This holds true even when we take into account the documented substantial prevalence of chlamydia in the Chinese population, and its role in enhancing HIV infectivity.

Alternative scenarios implied by the association between income and risky sexual behavior observed in the CHFLS have shown that, for the size of the Chinese HIV/AIDS epidemic to increase beyond that simulated in the baseline scenarios, a larger proportion of the population needs to be allocated to highly sexually active groups. The impact of the epidemic will be especially devastating in the event of widespread male patronage of commercial sex combined with frequent contacts with prostitutes. Under this worst case scenario, in the long run, adult HIV prevalence rates may reach levels similar to those currently observed in Sub-Saharan African countries and life expectancy will drop from 69 years in simulation year 0 to 58 years in the 50<sup>th</sup> year of the epidemic.

In Table 5, we summarize estimates of the number of adult infections simulated under various scenarios for simulation year 20<sup>10</sup> and compare these estimates with the number of infections in 2010 projected by UNAIDS. From the scenarios we implemented, the number of projected HIV infections range from 1.2 million, consistent with a scenario of low infectivity in the absence of other STDs, the distribution of sexual behavior observed in the CHFLS and assortative sexual mixing, to 21 million infections consistent with a scenario of higher infectivity accounted for by the documented prevalence of chlamydia in the Chinese population, random sexual mixing and a distribution of sexual behavior which, for practical purposes, was set to resemble that in the US. The closest description of Chinese sexual behavior implied by the CHFLS yields 1.4 million adults living with HIV/AIDS in 2010 under an assortative sexual mixing scenario and 11.5 million under a random mixing scenario (in bold). These estimates are produced by simulated baseline scenarios driven by the CHFLS input parameters and infectivity per sexual act boosted by the synergy between chlamydia and HIV.

Adjudicating between the two patterns of sexual mixing is more difficult. If Chinese patterns of sexual partner choice according to levels of sexual activity are moderately assortative, i.e., the majority of the Chinese population is strictly monogamous and promiscuous behavior remains a prerogative of men in high income strata who have sex with commercial sex partners and a small group of highly sexually active non-regular, non-prostitute female partners, in 2010 the HIV/AIDS epidemic will be smaller than the 10 million infections projected by UNAIDS. A scenario in which partners are selected based on availability (proportional to the size of the groups) is probably a less accurate description of the prevalent Chinese sexual regime, especially in these early stages of the sexual revolution. However, if we are wrong and random mixing is indeed a more accurate description of true patterns of partner selection, 11.5 million adults living with HIV/AIDS in 2010 is still very close to the UNAIDS estimate. Which one of these sexual mixing patterns is actually prevalent in China may be ascertained only through data collection on sexual networks.

Our results have clarified the importance of accounting for the prevalent regime of sexual relations in evaluations of the potential for spread of HIV/AIDS when heterosexual contact is the primary mode of transmission. In a population like the Chinese one which displays average low levels of sexual activity with a small fraction of individuals engaging in multiple partnerships and patronage of commercial sex, the adult HIV prevalence will remain below 1% or 2%, depending on which sexual mixing scenarios we ascribe to. Simulations driven by assumptions about changes in sexual norms and behaviors consistent with the strongly positive relationship between income and risky sexual behavior observed in the CHFLS will produce much larger epidemics.

In particular, a significant rise in the demand for commercial sex in combination with bi-monthly contacts with prostitutes will produce an explosive epidemic, but this could be prevented by means of an effective policy intervention promoting 100% condom use with prostitutes.

In fertility control, the Chinese government has demonstrated a capacity to coordinate outreach activities and carry out family planning education and propaganda work. The government has also shown no compunction about universal surveillance of the contraceptive and reproductive lives of women of reproductive age, as indicated all too clearly by the powerful bureaucracy and the extensive network of family planning clinics set up to enforce its pervasive birth control policy. In the fight against HIV/AIDS, the Chinese government could play a substantial role in increasing AIDS education and awareness, promoting and sustaining prevention activities, and preventing mother-to-child transmission. Given the size and scope of its previous outreach activities in the health and social realms, this will not be an impossible task.

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**Table 1: Percent distribution of men and women age 20-59, by number of sex partners last year. China, 2000 and United States, 1992**

Number of partners	Chinese men	Chinese women	US men	US women
0	11.2	9.4	9.9	13.6
1	80.0	88.3	66.7	74.7
2-4	5.4	2.2	18.3	10.0
5	3.4	0.0	5.1	1.7
N	1,814	1,823	1,407	1,748

Sources: Laumann et al. 1994, Table 5.1.A and CHFLS.

Note: All CHFLS percentages reflect sampling weights, but the N row reports the unweighted denominators.

**Table 2: Percent distribution of men and women age 20-64 by type and combination of partners in the last 12 months and marital status. China, 2000**

Type of partner	Married/Cohabiting	Not married & not cohabiting	Total
<b>Men</b>			
No (other) partner	90.8%	57.2%	84.3
Long-term	4.1	37.6	10.6
Long & short	0.5	1.6	0.7
Short-term	1.2	1.0	1.2
Prostitute	2.0	0.1	1.6
Prostitute and short-term	0.9	0.2	0.8
Prostitute and long-term	0.3	2.1	0.7
Prostitute, long-term and short-term	0.1	0.3	0.1
N	1,526	364	1,890
<b>Women</b>			
No (other) partner	97.7%	57.8%	91.5
Long-term	1.5	40.2	7.6
Long & short	0.0	1.1	0.2
Short-term	0.7	0.9	0.7
Prostitute	0.0	0.0	0.0
Prostitute and short-term	0.0	0.0	0.0
Prostitute and long-term	0.0	0.0	0.0
Prostitute, long-term and short-term	0.0	0.0	0.0
N	1,526	381	1,907

Source: CHFLS

Note: All percentages reflect sampling weights, but the N rows report the unweighted denominators.

**Table 3. Percent distribution of men (n) with two or more partners in the past 12 months by age and selected social characteristics. China, 2000**

	<b>Men 20-64</b>	<b>Men 20-44</b>
<b>Income (quartile)</b>		
IV	<b>25%</b> (325)	<b>29%</b> (223)
III	<b>12</b> (768)	<b>12</b> (546)
I, II	<b>5</b> (811)	<b>9</b> (528)
<b>Occupation</b>		
Managers	<b>40%</b> (59)	<b>68%</b> (31)
Government Cadres	<b>2</b> (67)	<b>3</b> (29)
Other	<b>8</b> (1,779)	<b>12</b> (1,238)
<b>Residence</b>		
Urban	<b>15%</b> (1,516)	<b>20%</b> (1,029)
Rural	<b>5</b> (389)	<b>9</b> (269)
<b>Province</b>		
S-E Coast	<b>21%</b> (825)	<b>27%</b> (569)
Other	<b>8</b> (1,080)	<b>10</b> (729)
<b>Migrant</b>		
Yes	<b>18%</b> (243)	<b>19%</b> (227)
No	<b>8</b> (1,662)	<b>12</b> (1,071)
<b>Total</b>	<b>8%</b> (1,905)	<b>12%</b> (1,298)

Source: CHFLS

Notes. Bolded cells reflect differences that are statistically significant at  $p < 0.01$ . All percentages reflect sampling weights, but their denominators (shown in parentheses) are the unweighted cell sizes.

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**Table 4: Behavioral inputs for baseline simulated scenarios**

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<b>Non-prostitute partners</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>
Proportion of men	0.039	0.891	0.064	0.007
Proportion of women	0.029	0.948	0.022	0.001
Average number of coituses/partner	0	75	87	79
Proportion coituses condom protected	0	0.105	0.179	0.205
Proportion of men to prostitutes	0.002	0.023	0.188	0.205
Average number of prostitutes	4	5	8	8
Proportion coituses with prostitutes condom protected	0.098	0.209	0.357	0.410

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Source: CHFLS

Note: All proportions reflect sampling weights.

<b>Table 5. Estimated number of adults (age 15-49) living with HIV/AIDS under various simulated scenarios. China, 2010</b>				
	Adult prevalence (%)		Number of adult infections	
	Assortative mixing	Random mixing	Assortative mixing	Random mixing
Scenarios A & B	0.16	1.11	1,229,097	8,367,566
<b>Scenarios C &amp; D (Baseline)</b>	<b>0.18</b>	<b>1.531</b>	<b>1,359,42</b>	<b>11,542,405</b>
Scenarios E & F	0.19	1.54	1,443,073	11,626,878
Scenarios G & H	1.59	2.81	11,955,381	21,150,147
Scenarios I & J	0.20	1.56	1,525,151	11,746,165
Scenarios K & L	0.36	1.78	2,748,555	13,431,418
Scenarios M & N	0.27	1.63	2,017,779	12,286,015
Scenarios A & B. Sexual relation regime observed in CHFLS (without chlamydia). Scenarios C & D. With chlamydia (Baseline) Scenarios E & F. Increase in demand for commercial sex commensurate to average income growth. Scenarios G & H. What if the distribution by sex activity groups were like US? Scenarios I & J. 40% men with prostitutes after 20 years Scenarios K & L. 40% men with prostitutes after 20 years and 2 contacts per month. Scenarios M & N: 40% men with prostitutes after 20 years, 2 contacts per month and 100% condom program.				

Figure 1: States and flows in the Palloni and Lamas macrosimulation model

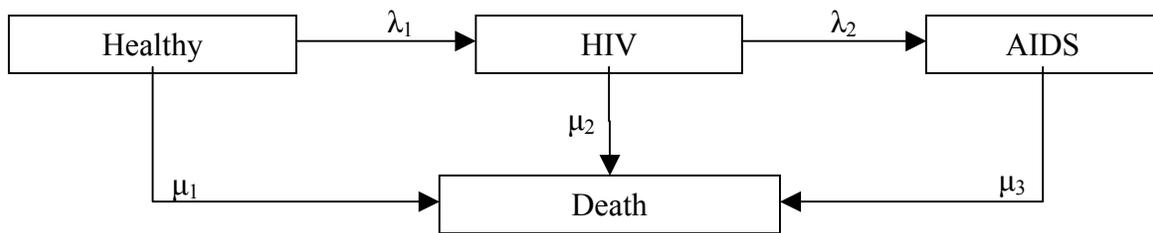


Figure 2: Sexual relations regimes observed in the CHFLS with and without chlamydia co-infection

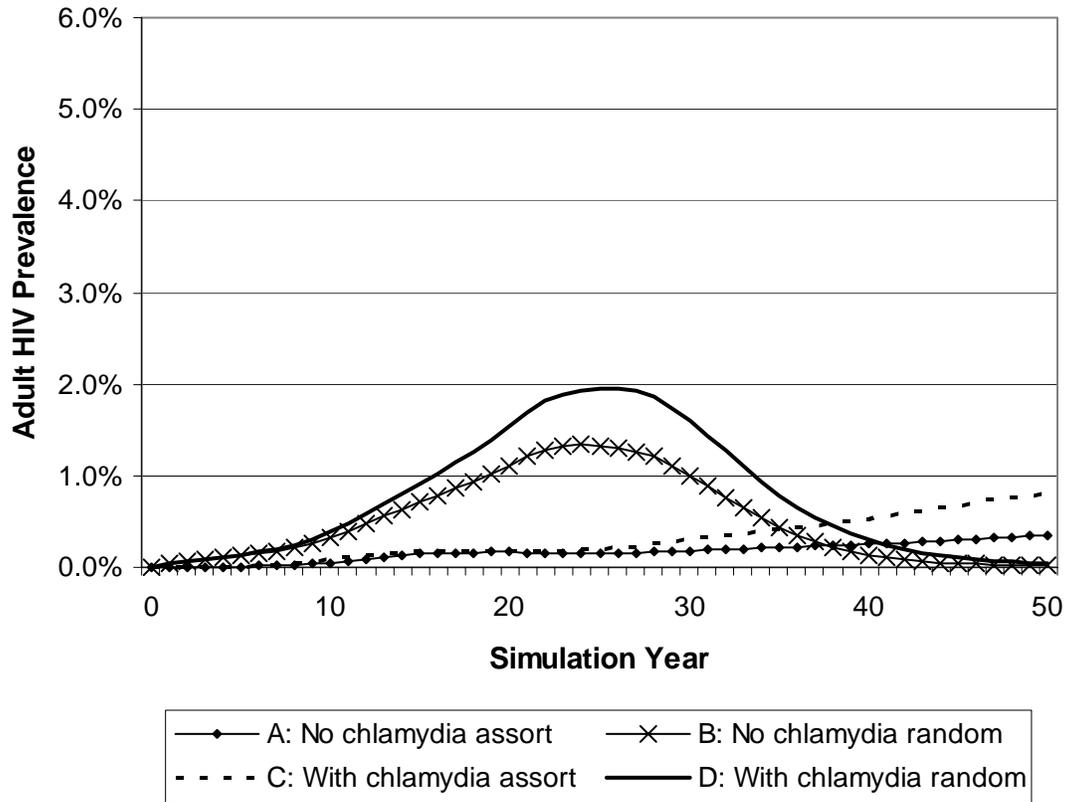


Figure 3: What if patronage of prostitutes increases along with annual average income growth?

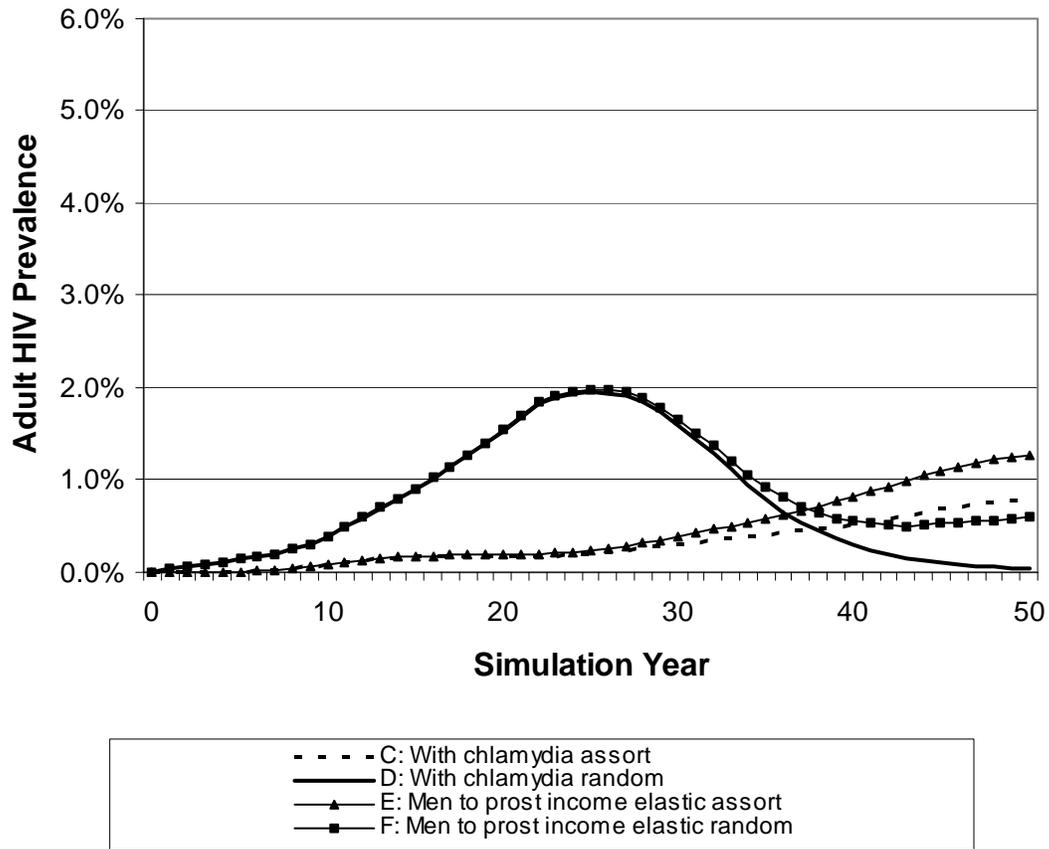


Figure 4: What if the distribution of people in groups characterized by rate of partner change in China were like the US?

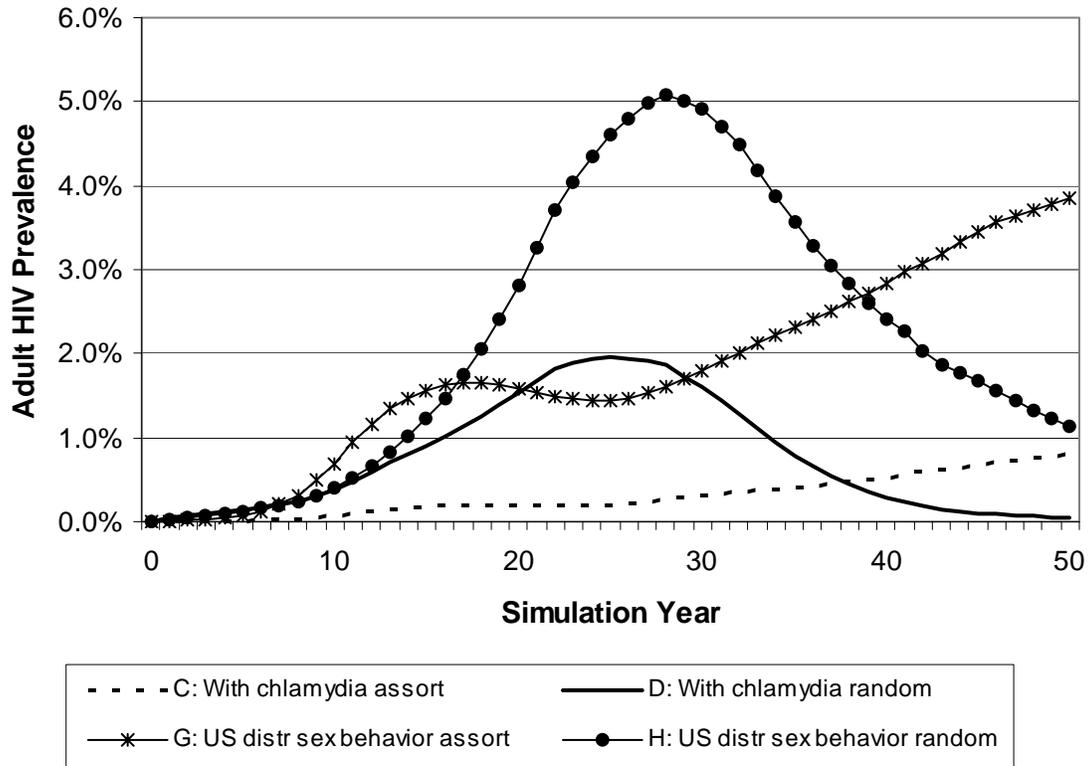


Figure 5: What if patronage of prostitutes grows to 40% of men to prostitutes in year 20 and beyond?

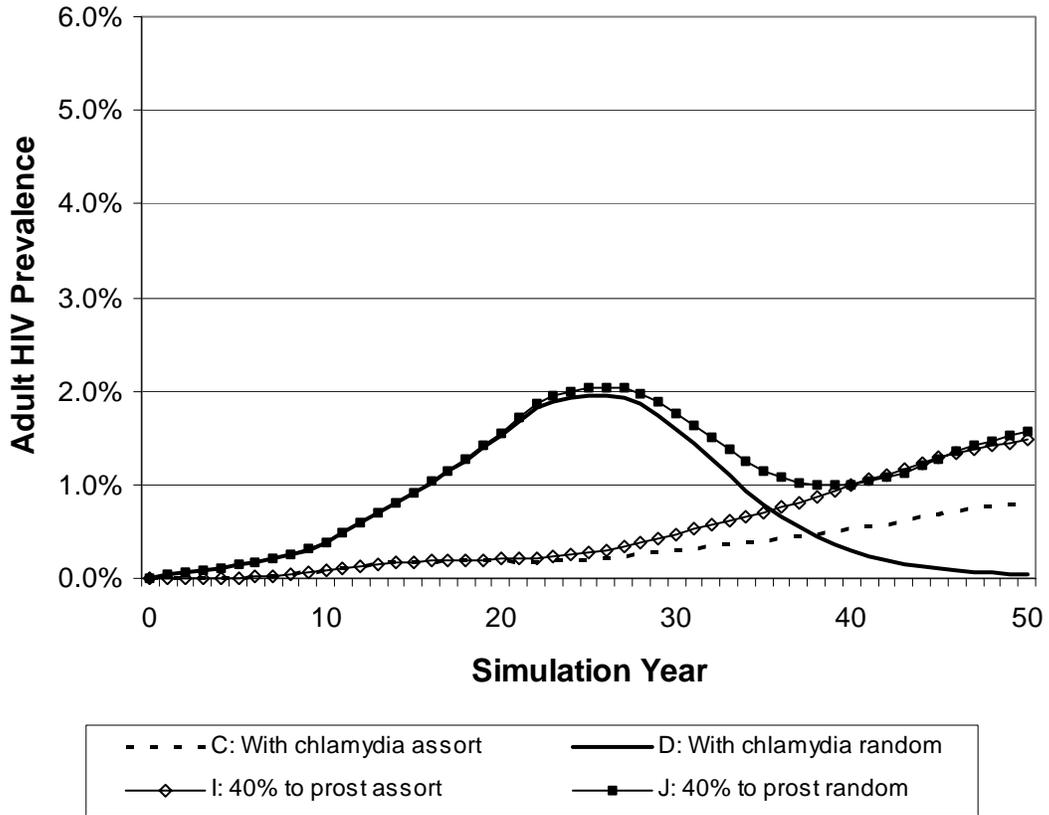
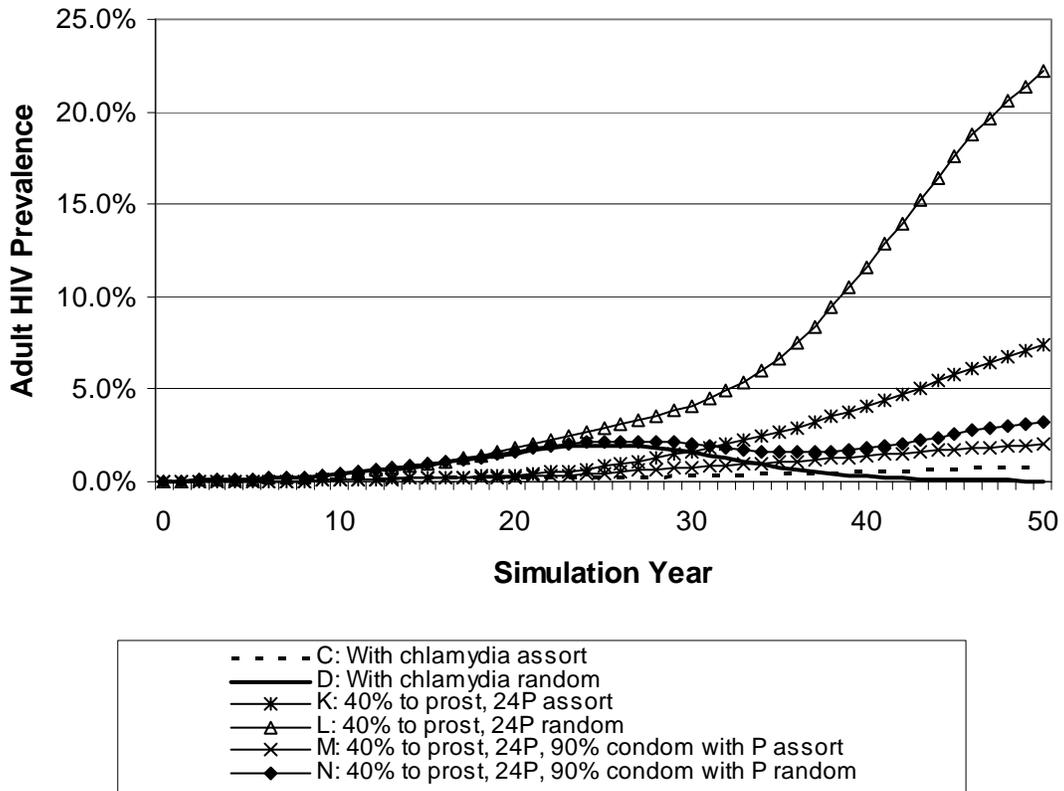


Figure 6: What if male patronage of prostitutes grows to 40% of men to prostitutes in year 20 and beyond and the average man who goes to prostitutes does so twice per month? And what if a 100% condom program with prostitute is implemented?



## Endnotes

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<sup>1</sup> It should be noted that the probabilities of HIV transmission per coital act estimated by Gray and colleagues are at the low end of a range of transmission probabilities per act of 0.0005-0.002 reported for prospective studies of heterosexual couples in Europe, the US and Thailand (Mastro and de Vincenzi 1996). Moreover, unlike most other studies which consistently find higher M-F than F-M HIV transmission probabilities, Gray et al. find no significant difference ( $p = 0.34$ ). We choose the values of transmission probabilities reported by Gray and colleagues over values reported in other studies because of their careful assessment of the validity of their estimates. Compared to other studies of transmission probability per sexual act, theirs is the only one that adjusts for co-factors of infectivity such as viral shedding in the genital tract as influenced by the presence of STDs and condom use. Transmission probabilities reported in most other studies may be biased upward by a combination of these factors which have not been controlled for in the estimation procedure. Lastly, unlike most studies of transmission probabilities per sexual act, Gray et al. assess the reliability of coital frequency through husband and wife consistency of reports.

<sup>2</sup> A detailed review of the biomedical literature on synergies between HIV and STDs is provided in Bracher, Santow and Watkins 2003 (Table 3). The choice of several input parameters related to HIV and STDs we use in the model rely on this review.

<sup>3</sup> To estimate the annual number of commercial sex partners for men who report visiting prostitutes in the last three months, we simply quadruplicate the number of prostitutes visited in the previous trimester.

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<sup>4</sup> Most studies on sexual behavior in China have focused on pre-defined risk groups such as drug users, patients attending STD clinics, and commercial sex workers (Liu and Detels 1999). Patterns of sexual behavior in the general population have been explored less frequently and have been generally based on surveys of very modest size with a focus on workers, peasants living in areas surrounding urban centers, government cadres and university students, the "standard" categories of the People's Republic of China (Sigley and Jeffreys 1999). None of these studies can be compared with results from the CHFLS survey, because they do not rely on probability sampling, nor do the populations covered come close to representing the general population.

<sup>5</sup> These estimates are based on commercial sex in the last three months and are biased downward by the exclusion of men who may have visited prostitutes earlier in the year.

<sup>6</sup> Our definition of migrants is the same as that adopted by Parish et al. (2003:1268), who define migrants as residents in a locale for less than 5 years who do not have a local household registration.

<sup>7</sup> As noted above, this result may understate the degree of risk among young migrants, because unregistered migrants not covered by the CHFLS may engage in riskier sexual behavior than those who were successfully interviewed.

<sup>8</sup> Based on China's annual average income growth in the period between 1995 and 2002 of 7% (World Bank 2004).

<sup>9</sup> This scenario assumes no feedback of the epidemic on behavior.

<sup>10</sup> Given the demographic inputs and the HIV prevalence values used to prime the model, simulation year 20 corresponds roughly to 2010.

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