Modeling the Course of the HIV/AIDS Epidemic in China:
An Application of a Bio-Behavioral Macrosimulation Model of the Spread of
HIV/AIDS

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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. 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 injection drug users (IDUs) and villages with faulty plasma collection practices in rural Henan province. Today there are an estimated 3 to 3.5 million IDUs in China (Reid and Costigan 2002). HIV prevalence in this population has risen from 0.5% in 1995 to recently reported rates of 5%, 10% and 80% in some areas of Xinjiang and Yunnan province (China Ministry of Health and UN Theme Group on HIV/AIDS in China 2003; Zheng et al. 1997), and is associated with Burmese and Laotian heroine trafficking routes (Beyrer et al. 1999). Very high prevalence rates have also been reported for some Henan villages, with up to 62% of their population infected (Hua 2001). Sharing of infected

needles among drug users and faulty plasma collection practices 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 (FSW), with an estimated 1.32% infected in 2000 (United States Embassy in China 2001), and with recorded high prevalence pockets among the FSW population of Yunnan province (2%), Guangzhou (2%) and Guanxi province, bordering Vietnam (10%). Behavioral-risk assessment data collected among FSW reveal that a large proportion never use condoms, ranging from 31% in Beijing to 70% in economically backward Anhui province (WHO 2001). Between 1995 and 2000, the percentage of FSW always using condoms with clients in sentinel sites in Yunnan, Guangzhou and Guangxi has remained stable at around 10% (MAP 2001:7).

The early phases of the Chinese epidemic resemble those already seen in other Asian countries, 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%, soon followed by increases in seroprevalence among female sex workers (FSWs) and, in 1988, in the heterosexual population (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). In the early 1990's, more than 80% of all new adult infections were among sex workers and their clients. Currently, around 50% of new adult infections are women who have been infected by their husbands or sex partners, 25% are due to

injection drug use, and only about 20% occur among sex workers and their clients (World Bank 2000; UNAIDS 2000).

In China too, there is great concern 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). Projections of the future impact of HIV/AIDS (if no interventions are implemented) range from 10 million people infected by 2010 (UN Theme Group HIV/AIDS in China 2002; Kaufman and Jing 2002) to 20 million infected (Brady et al. 2001; Morrison and Gill 2003).

These gloomy prospects are resonating widely in the international aid community and among foreign governments and their national security circles, because of the epidemic's potential impact on population structure (UN 1991, UN 1998), family and social relations (Barnett and Blaikie 1992; Palloni and Lee 1992), economic growth (Ainsworth and Over 1999; Bell, Devarajan and Gersbach 2003), and international security and governance. In a recent report prepared for several United States government agencies, the CIA places China, together with India and Russia, at the epicenter of the HIV/AIDS pandemic in the decades to come, with potential threats for the economic promise of the region and the global balance of power (National Intelligence Council 2002; Eberstadt 2002). 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, 2002c, 2200d, 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 a very high fraction of the 45 million new infections projected globally between 2002 and 2010 if the pandemic continues on its current course (Stover et al. 2002).

The need for accurate predictions of the future impact of HIV in the world's largest population is clear. The official UNAIDS estimate of 10 million cases in 2010 was produced by a simple model applied to countries with low prevalence and epidemics concentrated in high risk populations (Walker et al. 2003). Complex bio-behavioral models of the spread of the epidemic could not be implemented for China because they require a large number of biological and behavioral parameters for which data are not available (The UNAIDS Reference Group on Estimates, Modeling and Projections 2002:w2-w3). But the failure to model sexual behavior is tantamount to ignoring the most fundamental engine of the epidemic. The prevalent regime of sexual relations is an especially relevant feature for an accurate evaluation of the potential for the spread of HIV infection driven by heterosexual transmission.

Recent data from a nationally representative sexual behavior survey, the Chinese Health and Family Life Survey (CHFLS), provide the empirical basis for the application of mathematical models for the spread of HIV to China.

In this paper, we implement and apply to China a bio-behavioral macrosimulation model of the spread of HIV/AIDS driven by realistic input parameters extracted from the CHFLS and from the biomedical literature. The application of this model produces 50- and 100-year projections of HIV/AIDS incidence and prevalence for China. Results based on these realistic inputs can yield accurate predictions of the course of the HIV/AIDS epidemic in the world's largest population for both short- and long-term projection horizons.

The paper is organized as follows: In Section II, we evaluate current discussions about the potential spread of HIV infection in China with an eye to the specific Chinese context. Section III examines the relationship between the distribution of sexual behavior and the spread of HIV. Section IV describes the main features of the macrosimulation model, especially its treatment of heterogeneity in sexual behavior and patterns of inter-group sexual mixing. Section V 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 VI. These include results from baseline scenarios which rely on the empirical data provided by the CHFLS and results from alternative scenarios which evaluate the consequences for the trajectory of the Chinese HIV/AIDS epidemic based largely on China's projected economic and social changes and their implications for sexual norms and behaviors.

II. The potential for spread of HIV/AIDS in China

Despite the uncertainty about the future course of the Chinese HIV/AIDS epidemic, there is considerable agreement about the population groups who are expected to contribute to

the spread of the virus. These include populations practicing high risk behaviors, such as prostitutes and their clients, young male migrant workers, IDUs with multiple sex partners; and adolescents, poor rural women, the sexual partners of prostitutes' clients and ethnic minorities as population groups vulnerable to HIV infection either because of their partners' risky behavior or because of their own disadvantaged social position (UN Theme Group on HIV/AIDS in China 2002; McCarthy 1999; Zhang and Ma 2002; Bates, Chang and Parker 2002; Anderson et al. 2003). Present discussions about the potential for spread of HIV/AIDS in China underscore the importance of sexual behaviors adopted by these specific population groups and of patterns of sexual mixing which channel transmission from high to low risk populations.

The rationale for the warning of an impending explosion of HIV infections in China and for the selective emphasis on specific population groups is provided by the swift process of social and economic change, widening urban rural disparities and by the transformations in norms and behaviors about relationships and sexual lives this process is inducing (e.g. Farrer 2002). China's economic reforms of the last three decades have been accompanied by the emergence of new social groups striving to reap the benefits of a changing opportunity structure. In particular, three groups are thought to be epidemiologically important for the spread of HIV: rural migrants to China's budding urban centers, commercial sex workers and their clients. The population of internal migrants is of special concern because of its size, which was estimated at 120 million at any point in time in the 1990s, and which 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 their disadvantaged position, 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). 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 connectedness between prostitutes and their clients but also for the transmission link between prostitutes and their spouses or long-term partners. Finally, rising per capita incomes and increasing opportunities for travel are thought to be associated with male patronage of commercial sex, especially among the emerging Chinese middle class, more prominently entrepreneurs and businessmen (Kaufman and Jing 2002; Yuan et al. 2002; Thomson 2003). Men who visit prostitutes may become a bridge of infections to their wives and other short-term partners.

Concerns about the spread of HIV to the general population are also fueled by the rising prevalence of sexually transmitted diseases (STDs) in China. After the virtual eradication of STDs under Mao (Cohen et al. 2000), data from the national program for STD surveillance are showing a significant increase in incidence. The number of reported cases of STDs has risen from 5,800 in 1985 to 795,612 in 2001 (Chen et al.

2000; Gong et al. 2003). Of the eight STDs which are tracked by the surveillance

system, bacterial vaginosis and gonorrhea are the most common with respectively

253,116 and 234,561 new cases reported in 2001. 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 STD 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). The Chinese Health

and Family Life Survey collected urine specimens from a nationally representative

sample of the general adult population. An analysis of these data revealed that

Chlamydial infection, a STD which is not tracked by the public health reporting system,

is more common than gonorrhea in the general population (Parish et al. 2003). 3.5% of

sexually active women and 3.6% of men were infected with Chlamydia at the time of the

survey. Prevalence was 7.4% among urban women aged 20-44, and 3.0% among urban

men in the same age group. These rates are higher than rates documented in Europe and

the US (Parish et al. 2003). Prevalence of STDs is especially high among commercial

sex workers. A survey of female sex workers in Guangzhou found a 38% prevalence of

Chlamydia, more common than syphilis (14%) and gonorrhea (8%) (van den Hoek et al.

2001, cited in Parish et al. 2003). Soaring prevalence of STDs in China are 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 behaviors, but also because STDs

are cofactors for HIV transmission whereby STDs enhance the infectivity of and

susceptibility to HIV, with the potential to amplify the spread of HIV (Fleming and Wasserheit 1999).

III. 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 of prostitutes and IDUs and do not cover individuals who operate outside of public view. Moreover, most surveillance sites are located in urban areas, and coverage of the rural population is very limited. Lastly, behavioral surveillance has yet to become established (China CDC and US CDC 2002). In particular, little attention is being given to the clients of prostitutes, a group that is poorly characterized, and 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 CHECK). 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 bio-behavioral parameters is an important step towards understanding the implications of the Chinese regime of sexual behavior for the potential spread of HIV/AIDS and its impact beyond 2010.

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. The 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. As a macro-simulation model, it deals with population aggregates and models heterogeneity by partitioning the population into self-contained, homogenous subgroups. Like other macro-simulation models, it is limited by the fact that one can only handle a relatively

small number of groups. However, as shown below, the low amount of heterogeneity in sexual behavior which presently characterizes the Chinese regime of sexual relations can be easily built into this model.

IV. The model

IV.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, δ_1 and δ_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. μ_1, μ_2, and μ_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, δ_1, the rate of incubation δ_2, and the identification of the critical parameters required for modeling these transitions. As the most important transitions underlying the spread of HIV/AIDS, δ_1 and δ_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.

δ_1, or the probability that someone who is susceptible will contract HIV, is unarguably, 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, variously, 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, by and large, 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; Ahmed 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 (NHSLS) (Laumann et al. 1994) and limited information on patterns of sexual mixing collected in developing 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.

δ_2 refers to the progression from HIV seroconversion to AIDS and $1/\delta_2$ is the median incubation time. 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.

IV. 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, θ_2. To model θ_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 (Zheng et al. 2000; 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).

θ_1, 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 for 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 from a study conducted in Uganda's rural Rakai district which identified and followed prospectively 415 HIV-1

discordant couples for up to 30 months (Gray et al 2001).[1] We assume that HIV is trebly

infectious during the first year after seroconversion and again after progression to AIDS

(Mastro and de Vincenzi 1006; 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.[2]   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 when

the rules that allocate people into the various groups and the rules that determine sexual

contacts within and among groups are selected. 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

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[1] 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
the former study's 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.

[2] 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.

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 preference 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 intergroup sexual mixing, all other behavioral parameters required by the model are extracted from the CHFLS.

V. The Chinese Health and Family Life Survey

The Chinese Health and Family Life Survey is the most recent and comprehensive survey on sexual behavior ever conducted 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. 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 Chlamydial 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. The data description presented below refers to the subset of 3,821 respondents who completed the interview. 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).

V.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 partner 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 sexual consumption. Questions were asked on whether respondents ever paid for sex, whether the recipient of payment was a female, a male prostitute or a non-prostitute, the lifetime number of prostitutes, and the number of prostitutes visited in the last three months. From these 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.[3] Because information was elicited only

about the most recent partner of each kind, 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 developing countries (Mensch

et al. 2003): if respondents are asked to report on the details of each partnership, this

may discourage over-reporting, as this would require a special effort to make up all the

partnership details. 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.[4] This was a 1997 sexual behavior survey of a probability sample of 1,057

respondent age 15-49 representative of the rural population of Anhui province. The

count of number of sex partners reported by respondents in this survey was not

significantly different from that reported by a comparable subset of the CHFLS (p>0.05).

Table 1 shows the distribution of respondents by number of partners last year in

China and the United States (U.S.). Clearly, the present sexual behavior profile of the

Chinese population is quite homogeneous, especially if compared with the US profile

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[3] 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.
[4] 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 represent the general population.

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. Like in most other settings, a larger fraction of Chinese men than women report two or more partners. Compared with the U.S., Chinese men and women report, on average, fewer partners. While high sexual activity in China means two, maximum three partners in the previous year, in the U.S. it means three, four, five or more partners.

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 by focusing on married and unmarried men and women who report any combination of different types of partners in the previous year

Table 2 displays the distribution of men and women by marital status and combination of types of partners in the previous year. 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. Nine percent of married/cohabiting men reported at least one extra partner in the previous year apart from their spouse/cohabiting partner: 4.1% report one long-term partner, 2% report at least one prostitute partner, 1.2% report one short term partner and 1.3% report some combination of partners. Chinese

women show very low levels of long- or short-term partnership. The proportion of women who are not currently married who report one long term or one short term partner last year is just above 2 percent. The CHFLS proportion of married men and women who are promiscuous is very low if compared with 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 the consumption of 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.[5] 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). Commercial sex in China, however, is far less prevalent than in Thailand in the early 1990s, when 24% of urban married men and 9.5% of rural married men reported commercial sex in the last year, while, among unmarried men, these proportions rose to 40% and 38% in urban and rural areas respectively (Sittitrai et al. 1994). The contribution of commercial sex to non-marital sexual encounters in China is also lower than in most developing countries. 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

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[5] These estimates are based on the consumption of 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.

lower than 75% reported in the Central Africa Republic, Tanzania, Thailand and

Singapore, (Caraël 1995:116).

In sum, sexual behavior is relatively homogenous in China, with the majority of

Chinese reporting one or maximum two partners in the previous year, few reporting a

high rate of partner change, and moderate levels of commercial sex, quite low especially

if compared with Thailand, where widespread male patronage of commercial sex has

fueled the HIV/AIDS epidemic.

V.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 rapid process of

socioeconomic transformation and opening up to the outside world may induce more

significant changes in sexual norms and behaviors in some social groups relative to

others, with important implication 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, from

Table 1, a significantly greater percentage of men than women reported 2 or more

partners last year, and a larger percentage of men aged 20-44 reported two or more

partnerships last year relative to their older counterparts (12.2% compared with 2.7%, not

shown in Table). Also, we 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: there is a significantly

higher fraction of men in the top income quartiles who 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. The most

virtuous profession is that of a government cadre, though being a government cadre may

provide an incentive for underreporting promiscuous sexual behavior. Only 2% of men

in this category report 2 or more partners last year. Promiscuous sexual behavior is more

marked among residents of urban areas. Urban centers serve as conduits for new

influences. Social interaction is also higher in urban areas with clear implications for

patterns of sexual behavior and disease transmission (Dyson 2003). Lastly, the region

where you live is also an important marker of multiple partnerships. 21% of men who

reside in the South and Central coastal regions (Shanghai, Fujian and Guangdong,

bordering Honk Kong) report 2 or more partners last year compared with 8% of men

elsewhere. These are regions that have experienced the market transition earlier and

where the pace of per capita income growth has been most rapid. Because of the direct

connection between per capita 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[6] 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 the urban public opinion, and, according to most reports, highly vulnerable to HIV infection by virtue of their high risk behavior, show levels of sexual partnership that are only marginally higher than those displayed by non migrants.

VI. Macrosimulations of the spread of HIV/AIDS in China

VI.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. Age- and sex-specific mortality rates are assumed to decrease linearly between year 1 and year 25 according to the mortality decline projected between 1990 and 2040 by the US Bureau of the Census. After year 25, mortality rates remain constant at the 2040 level.

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

Table 4 shows the behavioral inputs extracted from the CHFLS. In addition to the inputs already evaluated in Section V, this table includes average coital frequency per partner and the average proportion of an individual's coiti that are condom protected. Because misreporting of coital frequency typically plagues sexual behavior surveys, we compared the average number of coiti per partner reported by CHFLS respondents in the monogamous group (1 non-prostitute partner in the past year) with the average 73 coiti per partner per annum reported by 7,074 married volunteers age 18-62 interviewed in 1989-1990 (Liu et al. 1997). Based on this documented consistency of reports, we conclude that reporting of coital frequency in the CHFLS is acceptable. Condom use becomes 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 coiti 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.

VI.2. Outputs

Figure 2 displays the four baseline scenarios informed by the parameter inputs extracted from the CHFLS. Scenarios A and B imply a probability of HIV transmission per sexual act from male to female of 0.0009 and female to male of 0.0013, corresponding to values estimated for the Rakai population (Gray et al. 2001), and 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%

(0.0009x3x2.25 = 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% (0.006075x2.25=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 currently observed Chinese regime of sexual relations, characterized by low levels of sexual activity and substantial homogeneity in sexual behavior, will produce a small epidemic. From these scenarios, HIV/AIDS will become entrenched in the population at below 1% prevalence.

Given China's fast pace of economic and social change, it is reasonable to assume that the regime of sexual behavior may change in the direction of increased promiscuity and widespread male patronage of commercial sex. In particular, in the short-run, per capita income growth may affect most directly the consumption of commercial sex. From 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 7% projected annual per capita income growth.[7] Relative to the baseline scenarios, these scenarios produce higher prevalence after 25 projection 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 projection period.

Figure 4 shows the impact of imposing a more heterogeneous regime of sexual relations by increasing the average number of non-prostitute partners and the size of the with high rates of partner change to resemble the distribution observed in the U.S.. 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

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[7] Based on China's average annual per capita income growth in the 1995-2002 period of 7% (World Bank 2004).

contributes to the spread of HIV/AIDS. In 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, will produce a larger epidemic peaking at 5% prevalence after 30 years and dropping to just above 1% after 50 years. Given China's rapidity of changes in sexual norms and sexual relations and the growing exposure to the outside world, it is not too unrealistic to expect that Chinese levels of sexual activity in the not too distant future may come closer to those observed in the United States.

Alternatively, we could imagine a scenario in which the practice of male patronage of commercial sex grows more rapidly than per capita 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. In Figure 5, 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 an elevated frequency of contact with prostitutes of 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 2002). While 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 when this is combined with higher frequency of contacts with prostitutes, as shown in Figure 6 where projections horizons are extended to 100 years to capture the full impact of the HIV/AIDS epidemic. Under assortative mixing, adult HIV prevalence begins a steep climb in year 25 and reaches 20% in year 100. Under random mixing, the climb is even steeper: prevalence starts rising in year 15 to plateau at just below 35% in year 100. 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 (and their wives and other non-regular sexual partners) at increased risk of infection from highly infectious prostitutes.

Lastly, 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). The simulated impact of this intervention is remarkable. 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.

VII. Conclusions

The Chinese population is believed to be in the early stages of an HIV/AIDS epidemic and concerns are great that HIV infection may soon spread to the general population via heterosexual transmission. To assess the future course of HIV/AIDS in the world's most populous country, we implement a bio-behavioral macrosimulation model (Palloni and Lamas 1991) driven by a range of realistic parameters that describe the prevalent regime of sexual relations in China. Except for the contact rates within and between groups for which there is no empirical guidance, all behavioral parameters are extracted from the CHFLS. To represent sexual mixing patterns, we rely 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, which assumes that there is no selection bias and partner choice is determined by availability. To assess the potential spread of HIV/AIDS in China, we simulate numerous scenarios based on the current sexual behavior profile of the Chinese population and possible evolutions of the regime of sexual relations. Simulation results indicate 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 also reveal that the sexual behavior of Chinese is still too homogeneous, the average level of sexual activity 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 considered introduce a higher degree of heterogeneity in sexual behavior with larger fractions of individuals in groups characterized by a high number of partners in the previous year and several assumptions about the increase in the demand for commercial sex and frequency of contacts with prostitutes. Clearly, for the size of the Chinese HIV/AIDS epidemic to increase beyond that simulated in baseline scenarios, requires a larger proportion of the population 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 will reach levels similar to those currently observed in Sub-Saharan African countries. The impact of the explosive epidemic simulated in this scenario will be devastating. Life expectancy will drop from the present 71 years to 58 years in the 50th year of the epidemic, reversing the impressive course of mortality decline experienced by China between 1950 and 2000 (Banister and Hill 2004).

In Table 5, we summarize estimates of the number of adult infections simulated under various scenarios for simulation year 20, roughly corresponding to calendar year 2010 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 resembles 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 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 higher 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 prevalent in China may be ascertained only through data collection on sexual networks.

Our results reveal several important aspects of the future course of the Chinese HIV/AIDS epidemic which extant projections of the spread of HIV/AIDS cannot

consider. First, they predict the course of the epidemic for horizons beyond 2010,

second, they clarify 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; and, third, they evaluate the potential for

spread of HIV/AIDS under simulated scenarios of sexual relations which could

reasonably arise in China's not too distant future. In particular, increased promiscuity

and a higher degree of heterogeneity in sexual behavior, a rise in the demand for

commercial sex in combination with bi-monthly contacts with prostitutes would produce

much larger, devastating epidemics. These gloomy scenarios could be prevented by

means of an effective policy intervention promoting 100% condom use with prostitutes.

The Chinese government has the capacity to coordinate outreach activities, increase

AIDS education and awareness, promote condom use and prevent mother-to-child

transmission. Its role in promoting and sustaining prevention activities could indeed be

substantial.

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Table 1: Percent distribution by number of sex partners last year for Chinese and US men and women, age 20-59

Number of partners	Chinese men	Chinese women	US men	US women
0	11.22	9.43	9.90	13.60
1	79.99	88.31	66.70	74.70
2-4	5.41	2.23	18.30	10.00
5	3.39	0.03	5.10	1.70
N	1,814	1,823	1,407	1,748

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

Table 2: Percentage by type and combination of partners in the last 12 months and marital status. Chinese men and women aged 20-64

Type of partner	Married/Cohabiting	Not married & not cohabiting	Total
Men			
No other partner	90.83%	57.20%	84.27
Long-term	4.10	37.58	10.63
Long & short	0.52	1.57	0.72
Short-term	1.25	1.02	1.21
Prostitute	1.97	0.13	1.61
Prostitute and short-term	0.90	0.17	0.76
Prostitute and long-term	0.32	2.06	0.66
Prostitute, long-term and short-term	0.11	0.26	0.14
N	1,526	364	1,890
Women			
No other partner	97.67%	57.82%	91.46
Long-term	1.55	40.18	7.57
Long & short	0	1.07	0.22
Short-term	0.72	0.93	0.75
Prostitute	0	0	0
Prostitute and short-term	0	0	0
Prostitute and long-term	0	0	0
Prostitute, long-term and short-term	0	0	0
N	1,526	381	1907

Source: CHFLS

Table 3. Percentage men with two or more partners in past 12 months by age and selected social characteristics, Chinese men, 2000

	Men age 20-64	Men age 20-44
Income		
IV	**25%**	**29%**
III	12	12
I, II	5	9
Occupation		
Managers	**40%**	**68%**
Government cadres	2	3
Other	8	12
Residence		
Urban		
Rural	**15.4%**	**19.7%**
	5.5	8.9
Province		
S-E Coast	**21%**	**27%**
Other	8	10
Migrant		
Yes		
No	**18%**	19%
	8	12

Bolded cells reflect differences that are statistically significant at p<0.01
Source: CHFLS

Table 4: Behavioral inputs for baseline scenarios

Non-prostitute partners	0	1	2	3
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 coiti/partner	0	75	87	79
Proportion coiti 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 coiti with prostitutes condom protected	0.098	0.209	0.357	0.410

Source: CHFLS

Table 5. Projected number of adults (age 15-49) living with HIV/AIDS under various simulated scenarios. China, 2010

	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
Scenarios C & D (Baseline)	**0.18**	**1.531**	**1,359,42**	**11,542,405**
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 p.c. 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.

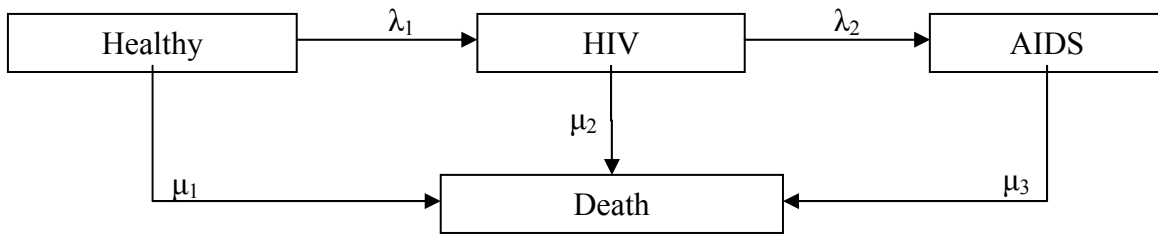Figure 1: States and flows in the Palloni and Lamas macrosimulation model

Figure 2: Baseline sexual relations regimes observed in the CHFLS with and without Chlamydia co-infection
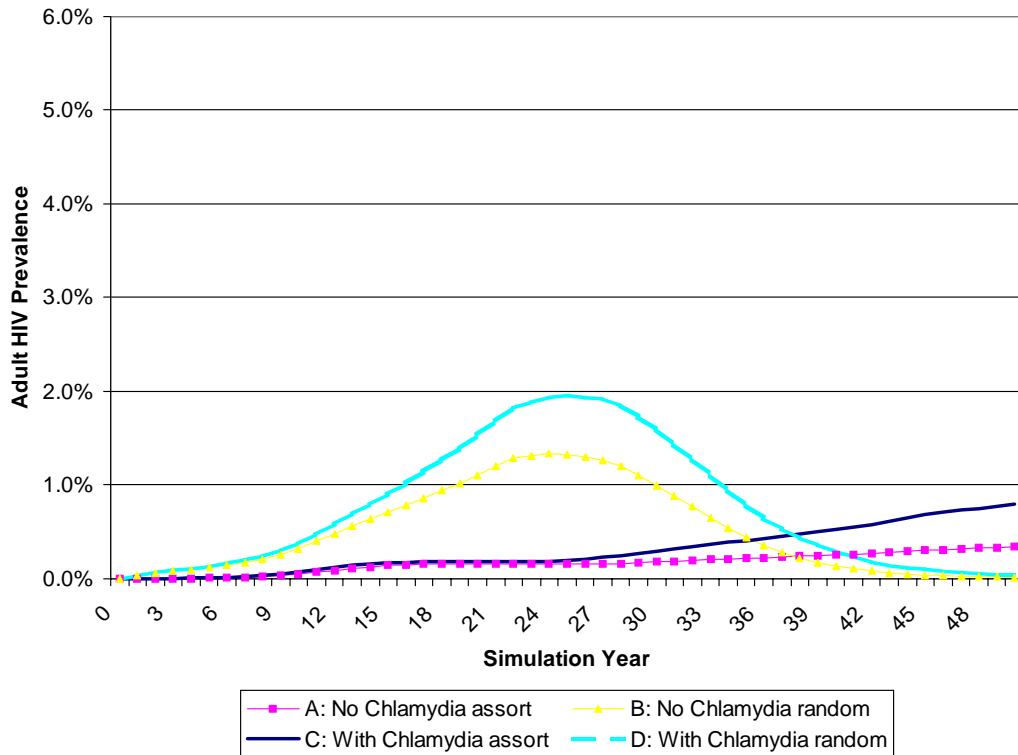
Figure 3: What if commercial sexual activity increases along with per capita income growth?
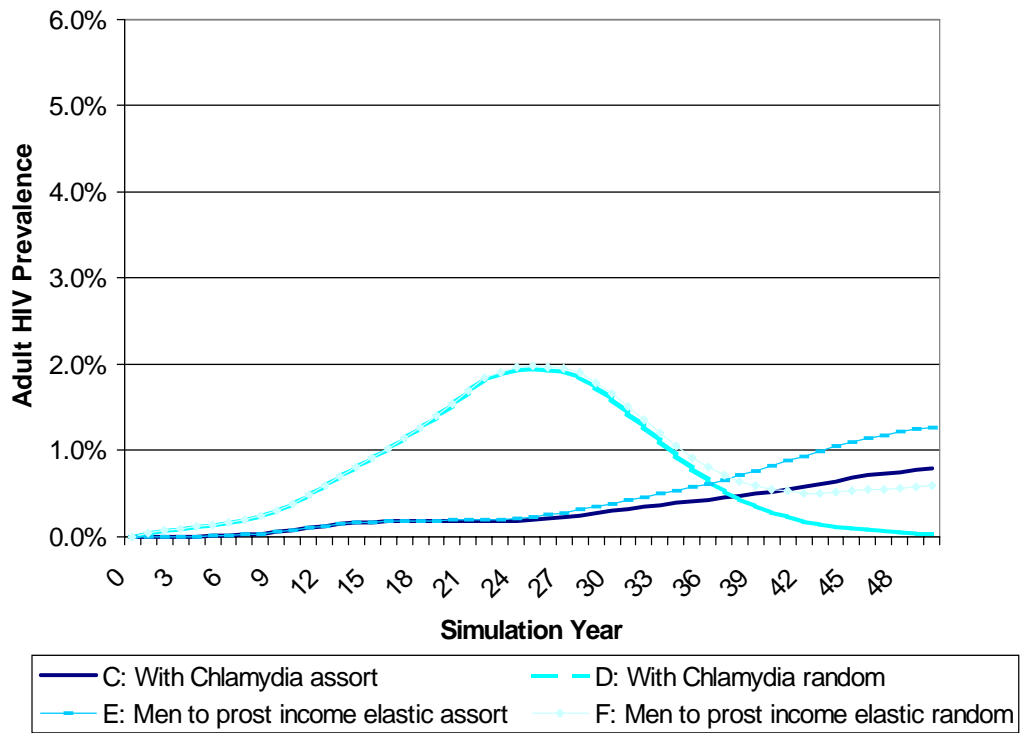
Figure 4: What if the distribution of people in groups characterized by rate of partner change in China were like the US?
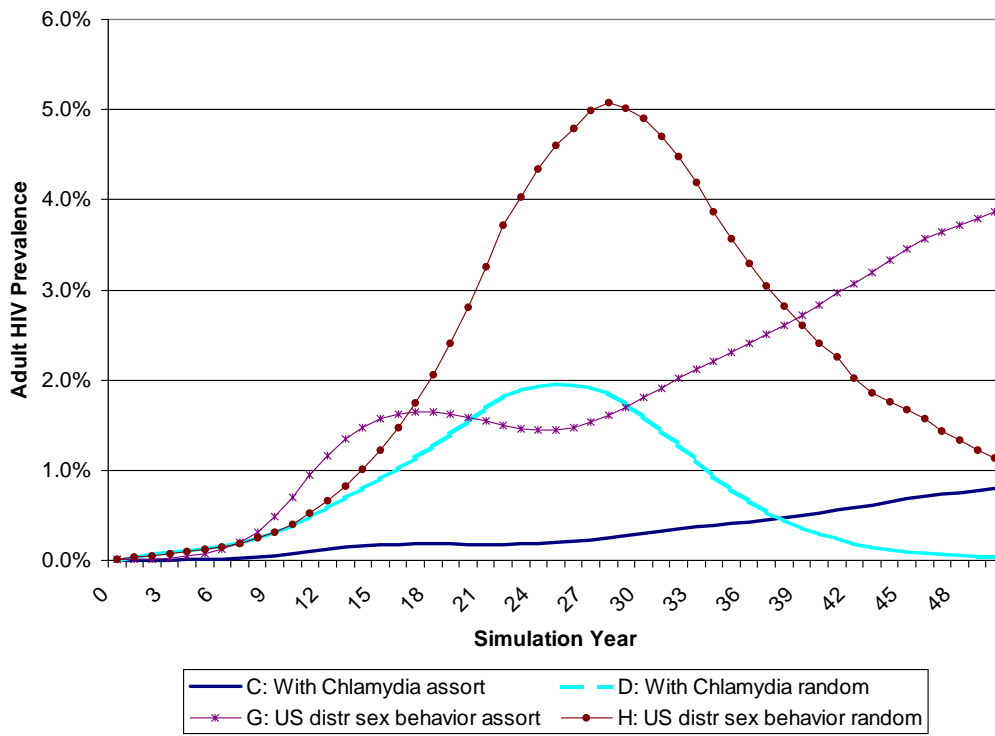
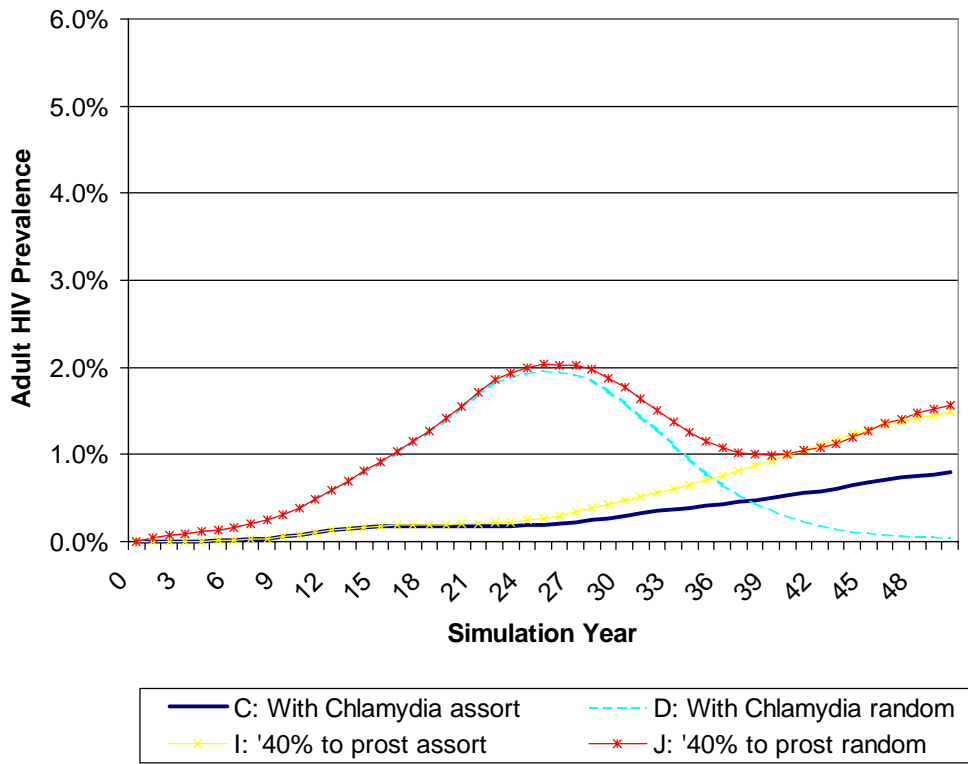Figure 5: What if male patronage of prostitutes grows to 40% of men to prostitutes in year 20 and beyond?

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?