

‘Bare Branches’, Prostitution, and HIV in China:
A Demographic Analysis

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1 Introduction

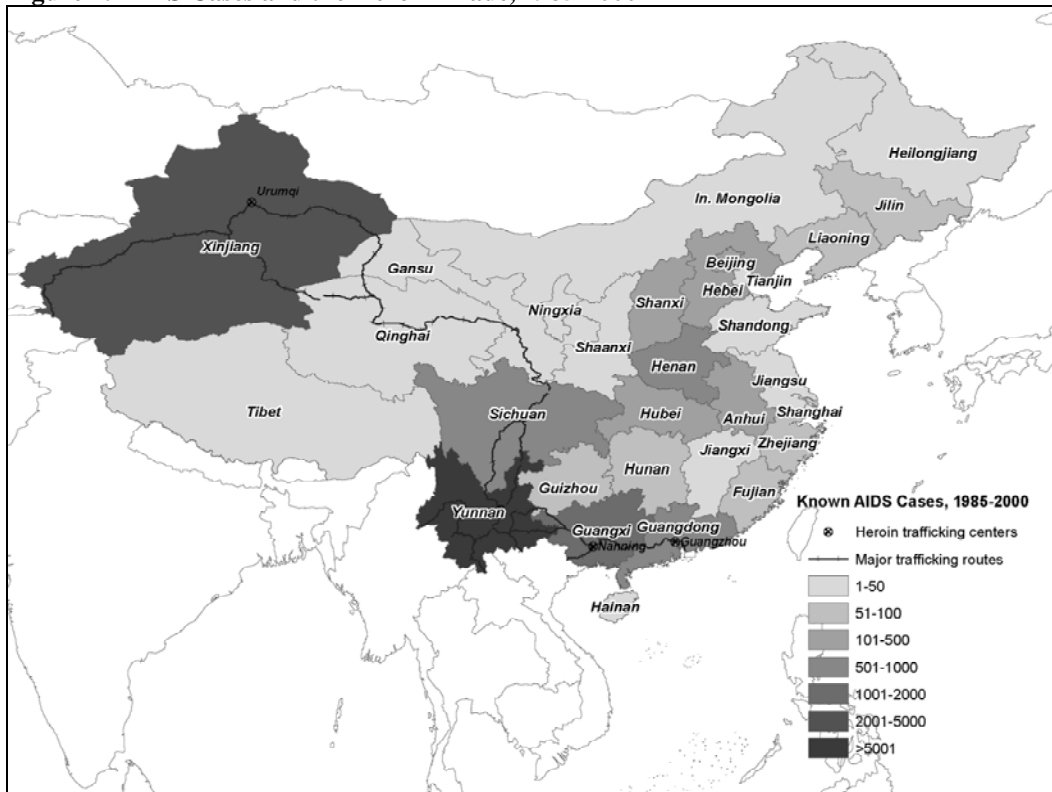
The alarming rise in China's reported HIV cases in the last decade has caused concern among government officials and public health researchers. The increase in reported HIV cases is especially worrying because the majority of new cases are not observed in traditional at-risk populations (such as intravenous drug users and recipients of former plasma donors), but are sexually transmitted. This chapter analyzes the demographic patterns in China that may be an important determinant of the increase in sexually transmitted HIV infections. High sex ratios, numbers of men relative to numbers of women, in young cohorts of Chinese men and women contribute to the increasing failure of Chinese men to marry. These men, referred to as "bare branches (*guang gun*)" since they will be unable to extend the family tree, are more likely to migrate to regions with more favorable marriage markets, and may be more likely to purchase sex. This behavior in turn increases men's risk of sexually transmitted infections, including HIV. We also analyze how further increases in sex ratios among Chinese men and women of marrying ages may affect migration patterns, commercial sex demand, and the spread of HIV.

We begin the analysis in section two with a brief history of HIV in China during the last two decades. In section three, we present forecasts for demographic changes in China in the 21st century, describing how the entry of cohorts with highly skewed sex ratios into the marriage pool may result in large numbers of males marrying late, or failing to marry. Section four considers how the imbalanced sex ratios and socio-economic trends may promote an outmigration from rural to urban areas in search of wives and jobs. Such groups of young, poor, single men may have increased sexual risk compared to their rural counterparts. In section five we present evidence that areas within China with large numbers of unmarried men are associated with higher reported rates of purchasing sex among men, and explore via simulation how the failure of men to marry may increase STI and/or HIV incidence in the future. Section six discusses the actions currently being taken by the Chinese government to reduce sex ratios at birth and to curb the spread of HIV in at-risk populations. We conclude in section seven with a brief discussion of China's policy options in light of the results of our analysis.

2 The Spread of HIV in China

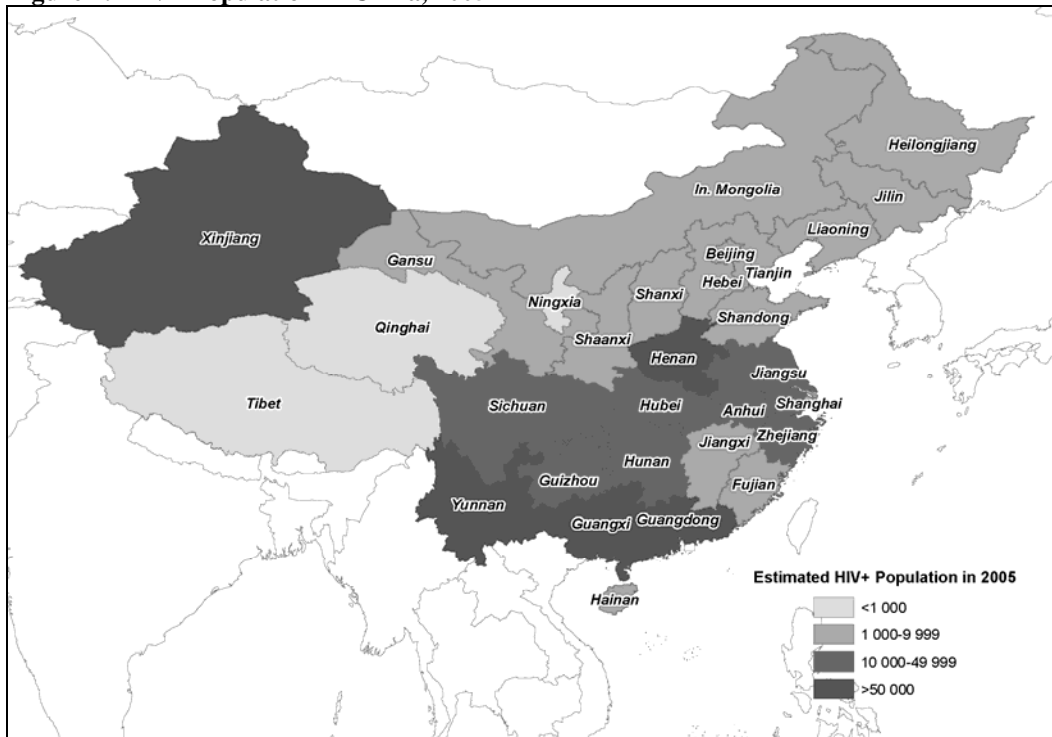
While this article focuses primarily on the spread of HIV among sex workers and their clientele, new reported HIV cases during the 1990s were concentrated among IVDU and blood transfusion recipients. During the mid-1990s, however, HIV spread to new regions and populations previously not considered at risk. Sexual transmission has recently overtaken IVDU as the most common route of HIV transmission in China. High risk sexual activities between traditional high risk groups and the general population has promoted the spread of HIV.

Figure 1: AIDS Cases and the Heroin Trade, 1985-2000



Source: Hesketh et al. 2002; Beyrer et al. 2000.

Figure 2: HIV+ Population in China, 2005



Source: Lu et al. 2006.

In the early 1990s, over 80 percent of identified HIV cases were located in the southern province of Yunnan; many of these cases represent non-Han Chinese farm laborers who were intravenous drug users. A significant proportion world's heroin in the 1990s and early 2000s was produced in the Southeast Asian countries of Myanmar, Laos, Vietnam, and Thailand, collectively known as the Golden Triangle. From border towns in Myanmar, heroin is transported by road to Kunming, a major city in Yunnan Province. The heroin then continues east by road or air via the city of Nanning, to markets in Hong Kong. In the mid-1990s, the rapid growth in the HIV-positive population in Guangxi Province was likely related to high levels of intravenous drug use in towns along the transport route between Kunming and Nanning. HIV was also spread among cities in Guangxi province bordering Vietnam by intravenous drug users procuring heroin from Vietnam.

The northwestern province of Xinjiang also had a large HIV-positive population during this period. Studies using molecular epidemiology to trace the path of illegally trafficked heroin have found that heroin arriving in Kunming is also diverted north and west to Urumqi, a city in Xinjiang Autonomous Region, via Chengdu in western Sichuan province (Beyrer et al. 2000). Xinjiang Autonomous Region is close to the world's largest heroin producing region, the Golden Crescent, which includes Afghanistan, Iran, and Pakistan. As heroin production increases in this region, documented surges in the traffic of opiates from Afghanistan, Iran, and Pakistan to western China via Urumqi pose an even greater threat to HIV prevention and the public's health (Xinhuashe 2007). Not only is HIV spread among intravenous drug users via sharing infected needles, but drug users may also engage in high risk sexual behaviors. Such IVDU may transmit HIV infection or other STIs to their long term partners or commercial sex partners. (Li et al. 2003). Several studies have supported that a subset of drug users and those with increased sexual risk factors have higher prevalence of HIV infection (see Ruan et al. 2006, Lau et al. 2001).

The spread of HIV through central China in the 1990s was not primarily due to intravenous drug users, but was caused by unsafe blood collection and transfusion practices (Yang et al. 2005). In central China, impoverished farm workers in rural areas supplemented their income by donating blood plasma, and donors were frequently not tested for HIV infection. In areas such as Henan and Sichuan provinces, many individuals contracted HIV from these unsafe medical practices.

While these unsafe practices contributed to the spread of HIV, limited research suggests that blood donors and plasma donation recipients are not more likely than others to have unsafe sexual practices or multiple partners, limiting the spread of HIV from these individuals to others via sexual activity (Wu et al. 2001, Ji et al. 2006). In response to this problem, the government has improved collection and transfusion practices, routinely tests blood donors for HIV, and has shut down many unlicensed blood collection centers. As a result, HIV transmission due to blood transactions has been effectively halted in the central region. Unfortunately, as indicated on the map above, the estimated number of HIV-positive individuals in this region has been growing rapidly during the later 1990s and early years of this decade.

Table 1: HIV Infections in China by Transmission Source

Intravenous Drug Users	Sex Worker ¹	Infected Partner ²	Homosexual Sex ³	Commercial Blood ⁴	Mother to Child
44.3%	19.6%	16.7%	7.3%	10.7%	1.4%

Source: Ministry of Health, People's Republic of China (2006). (1) Sex Worker refers to prostitutes and their clients. (2) Infected Partner refers to those living with HIV who contracted it from their partner. (3) Homosexual sex refers to men who have sex with men. (4) Commercial blood refers to blood and plasma donors who were infected through donation or transfusion.

Currently, the number of HIV-positive individuals who contracted the disease through sexual contact is as large as the number who were infected through intravenous drug use, and HIV-infected individuals who contracted the virus from sexual activity represented 50% of all new cases in 2005. The HIV-positive population can be broken down into four groups (see Table 1). Intravenous drug users represent 44.3% of the total estimated HIV population, and those who were infected through sex represent 43.6% of HIV infections. Of those who were infected via sexual contact, 19.6% of cases were directly contracted from sex with a sex worker, 16.7% were from an infected partner, and 7.3% were attributed to men having sex with men. The third population, those who donated or received blood from commercial blood donors, represent 10.7% of the total estimated HIV population, and the remaining cases (representing 1.4% of the total HIV-positive population) are those infected via mother-to-child transmission. Because HIV infection is growing most rapidly among those who contract the disease from sexual contact, identifying the groups most at risk in this population is of crucial importance.

3 “Missing Girls” and Unmarried Men

Subsets of single, poor, young men in China may be able to afford a commercial sex worker, but not a wife. Compared to their rural married counterparts, such groups of single men may have increased risk for STI and HIV infection. As demographic trends in China lead to larger imbalances between numbers of men and women, increasing numbers of men will delay marriage and ultimately remain unmarried. For cohorts born between 1980 and 2000, there are 22 million more men than women. This phenomenon of missing girls implies that roughly 10.4% of the men in these cohorts can be expected to fail to ever marry.¹ Since many unmarried men may have higher rates of unprotected sex, it is important to predict the extent to which the unmarried male population in China will grow in the future.

¹ Percentage projected using data from China's 2000 Census.

Table 2: Marriage Rates in China

	Cohorts Born 1935-1945		Cohorts Born 1945-1955		Cohorts Born 1955-1965	
	Men	Women	Men	Women	Men	Women
Share Never Married	5.88%	0.18%	5.49%	0.29%	3.82%	0.38%
Share Illiterate, Ever Married Men	20.8%		7.7%		1.1%	
Share Illiterate, Never Married Men	48.6%		33.3%		12.7%	

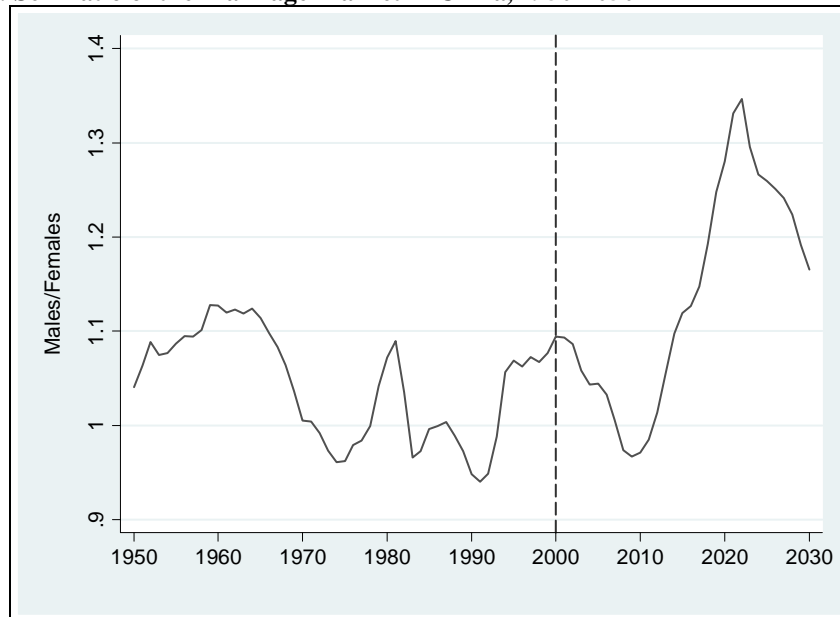
Source: Calculations derived from .1% 1982 Census, 1% 1990 Census, and .1% 2000 Census. Observed sex ratios are slightly higher than when the persons were of marrying age, since men have higher mortality than women during adulthood. Age at marriage is calculated using the 2000 census, and so the sample is restricted to those born in these cohorts still living at the time of the 2000 census.

The failure of men in China to marry due to a shortage of females is not an entirely new phenomenon. High sex ratios in China can be observed even in the 19th century, when missionaries reported that women interviewed indicated very high rates of female infant mortality (Coale and Banister 1994). Data on men born between 1935 and 1945 from China's 1982 census show that 5.9% of the men failed to marry, while only 0.18% of the women failed to marry (see Table 2). Marriage prospects for men born between 1945 and 1955 were only slightly better, with 5.5% of men failing to marry.² Given the stigma attached to those who remain single, it is unsurprising that in each cohort unmarried men have lower literacy rates than men who marry. Concern over the "bare branches" is partly due to the distributional consequences of this phenomenon, since the men who have the worst economic prospects will generally be forced to bear the burden of remaining single.

Relative to earlier cohorts, the situation improved for men born during China's baby boom of the 1950s and 1960s. Higher fertility rates were associated with less distorted sex ratios, since parents were able to have a son without resorting to sex selection. Men's marital prospects were improved by this population growth, which allowed them to select brides from a larger group of younger women. Data on these cohorts reflect the relative success of these men: for cohorts born between 1955 and 1965, the rate of failure to marry was only 3.8% for men and .3% for women. As a result, unmarried men from these cohorts represent an even more disadvantaged group. Among those who married, 1.1% of men were illiterate, but among those who failed to marry, roughly 13% were illiterate.

² One surprising finding is that the marriage rate was very high for cohorts of men born between 1935 and 1944 (almost 95%), in spite of the high sex ratio in these cohorts. As shown in Table 2, the ratio of men to women was roughly 1.14 to 1, so we might expect that more men would fail to find a spouse. One explanation for the high marriage rate among these men is that the sex ratios of cohorts entering the marriage market in the 1960s were falling. Many of the men from previous cohorts delayed marriage and married women from these younger cohorts. Intuitively, the observed increase in the age gap in spouses of a full year implies that on average men delayed marriage one year, and thus had an additional cohort of women to choose from (given that women do not generally marry men their age or younger men). Men's ability to marry women in younger cohorts has the potential to mitigate sex ratio distortions in any particular cohort. Such adaptation was also observed in England following World War I, and in other contexts where people feared a collapse in the marriage market and none ensued (Bhrolchain 2001).

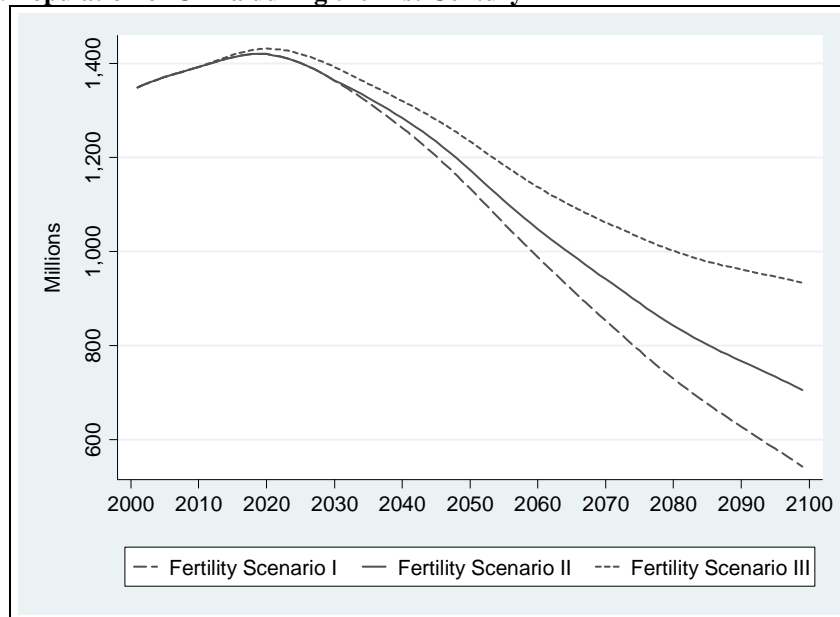
Figure 3: Sex Ratio of the Marriage Market in China, 1950-2050



Notes: The marriage market is defined as men ages 22-32 and women ages 20-30. The sex ratio for each year is calculated using data from the 2000 census, modeling population changes with age-sex-year specific mortality rates. The population is simulated forward from 2000 using baseline case fertility assumptions (explained in greater detail below) and a sex ratio at birth of 1.09 from 2005 and beyond. The vertical dotted line indicates the year 2000.

Unfortunately, China is on the cusp of a dramatic deterioration in the marital prospects for men. As shown in Figure 3, the sex imbalance between potential spouses is forecast to be at its worst by 2025, as the cohorts with the highest sex ratios born under the One Child Policy reach adulthood. What are plausible estimates of the number of unmarried men in China in the years to come? Such estimates depend on the sex ratios of future cohorts and the growth rate of the population. In the remainder of this section, we describe the derivation and results of population simulations which capture the anticipated effect of high sex ratios on the number of unmarried males over the course of the 21st century.

Figure 4: Population of China during the 21st Century



Notes: The simulations assume mortality rates documented in Hill and Banister (2004). The age-specific fertility rates for years 2000-2004 are determined from the published rates for 2004 (total fertility rate = 1.45). The scenarios vary by their assumptions for the predicted total fertility rate in China, and are described in the text.

Predicted declines in fertility may exacerbate the impact of the sex ratio imbalance on the marriage market, since future cohorts of men will be unable to find brides in younger and smaller cohorts, but current and predicted fertility rates in China are still a matter of scholarly debate.³ In Figure 4, we present three potential scenarios for the fertility rate in China during the next century. For the years 2000 to 2005, we assume a total fertility rate (TFR) of 1.45 based on China's National Bureau of Statistics estimate from 2004 survey data.⁴ The first scenario assumes that the TFR remains stable at 1.45 for the duration of the century, which leads to a massive population decline. The second scenario assumes a phased-in increase in the TFR, reaching the replacement rate of 2.1 in 2030. The third variant assumes that the One Child Policy is immediately abandoned and the TFR increases to the replacement rate in 2010. The intermediate scenario is used in the simulations as the baseline case throughout the paper.

The potential trajectories for the sex ratio at birth (SRB) in China from 2006 to 2100 are summarized by four scenarios. The first scenario assumes an immediate correction in the sex ratio at birth to 1.06, which is overly optimistic but represents a lower bound for our analysis. The second scenario assumes that the government's policy is effective at stabilizing the SRB at 1.09, a level identified as a government target (Li 2007). The third scenario assumes that the SRB in 2005 of 1.18 persists indefinitely, and the fourth scenario assumes a further deterioration of the situation and a SRB of 1.25.

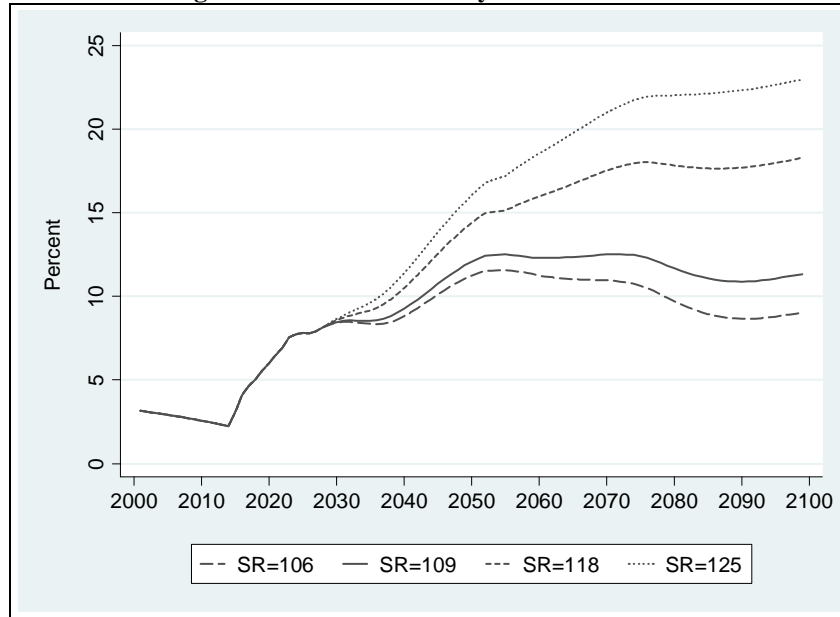
The simulations are executed using age-specific mortality rates reported by Banister and Hill (2004), and essentially assume no improvement in life expectancy from the year 2000 onward.

³ Data from the 2000 census indicate a total fertility rate of 1.22 children in the prior year, but some argue that a number of parents misled census officials out of a fear of punishment due to violations of the One Child Policy (Retherford et al. 2005). Retherford et al. estimate that the TFR in China in 2000 was roughly 1.5. The CIA Factbook estimate for 2007 is 1.75.

⁴ This is based on the Sample Survey on Population Changes (2004), and is available online at http://www.allcountries.org/china_statistics/.

The marriage rule assumes that men marry all available women who are in nearby birth cohorts, until the supply of females is exhausted and the remaining males fail to marry. The details of the algorithm generating the predictions are described in the technical appendix following the paper.

Figure 5: Share of Men Age 25+ Who Fail to Marry



Notes: The technical assumptions underlying marriage formation for the simulation are outlined in detail in the appendix to the paper. The shares of unmarried males are evaluated for 4 different possible trajectories for the sex ratio at birth, ranging from an immediate correction to 1.06 to a further deterioration to 1.25.

The results of the simulation are presented in Figure 5. Note that the fraction of men age 25 and older who fail to marry will exceed 5% by 2020. As the cohorts born in recent years enter the marriage market and some fraction inevitably fail to match, the size of the "bare branch" population will rise well beyond this level. In 2035 and beyond, the currently unborn cohorts of males will begin to enter the marriage market and contribute to the population of unmarried males. In the most optimistic scenario, where the sex ratio returns to normal immediately in 2006, the share of men who fail to marry in 2060 will stabilize just below 10%. In the second scenario, unmarried men will represent roughly 10%-12% of the men aged 25 and older. In the third and fourth scenarios, where the SRB persists at either 1.18 or 1.25, the share of men who fail to marry will peak above 15% and 20%, respectively.

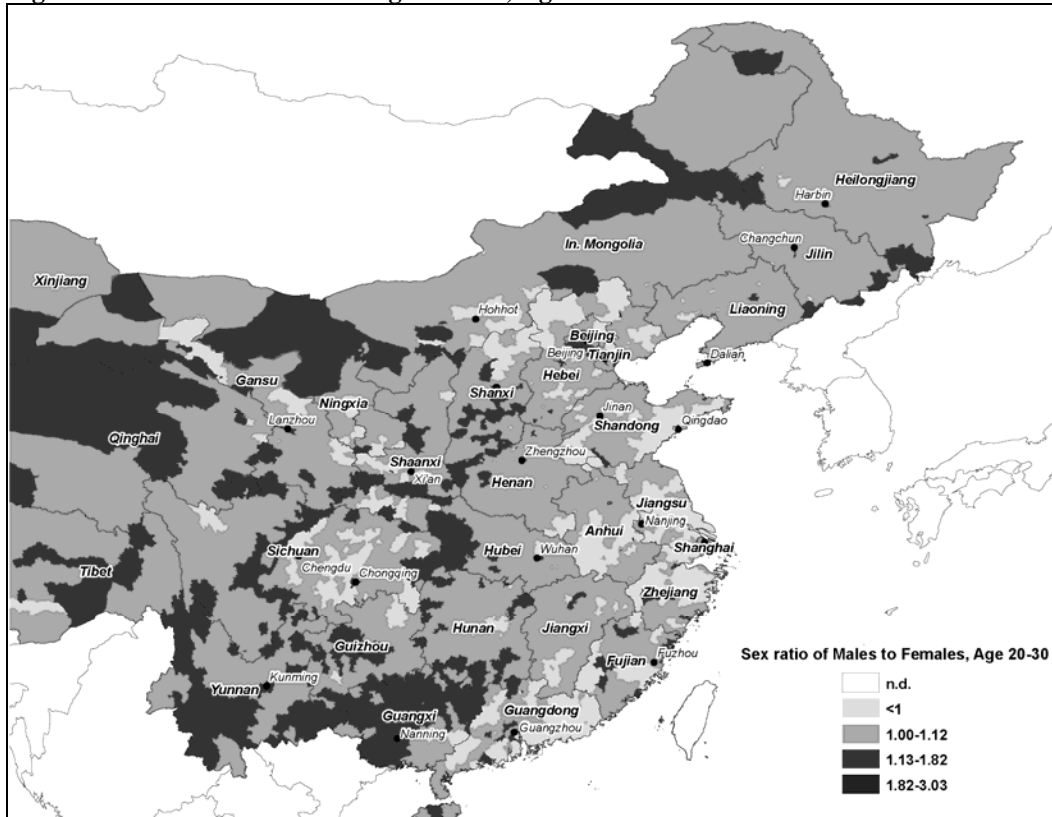
In light of the large number of men who are anticipated to become *guang gun*, we now focus on two issues that are particularly relevant to the impact of high sex ratios on HIV prevalence: STI/HIV risk and migration, and HIV transmission via commercial sex activity.

4 “Bare Branches” and Rural-Urban Migration

The potential for an increase in HIV infection rates fueled by unmarried males has attracted the attention of many researchers. Tucker et al. (2005) present compelling evidence that increasing rates of sexually transmitted infection (STI) in cities are due to the sexual practices of migrant workers, who are demographically similar to the men who are predicted to fail to marry: poor, uneducated, and single. Chen et al. (2007) analyze HIV rates among a sample of patients at clinics being treated for sexually transmitted infections and conclude that China’s imbalanced

sex ratios have created a population of young, poor, unmarried men of low education who appear to have increased risk of HIV infections.⁵ The authors perform a multivariate analysis of factors that affect HIV status, and report an odds ratio of 1.7 for single individuals relative to those who are married, and 1.4 for men versus women.

Figure 6: Sex Ratio of the Marriage Market, Age 20-30



Source: China 2000 Census.

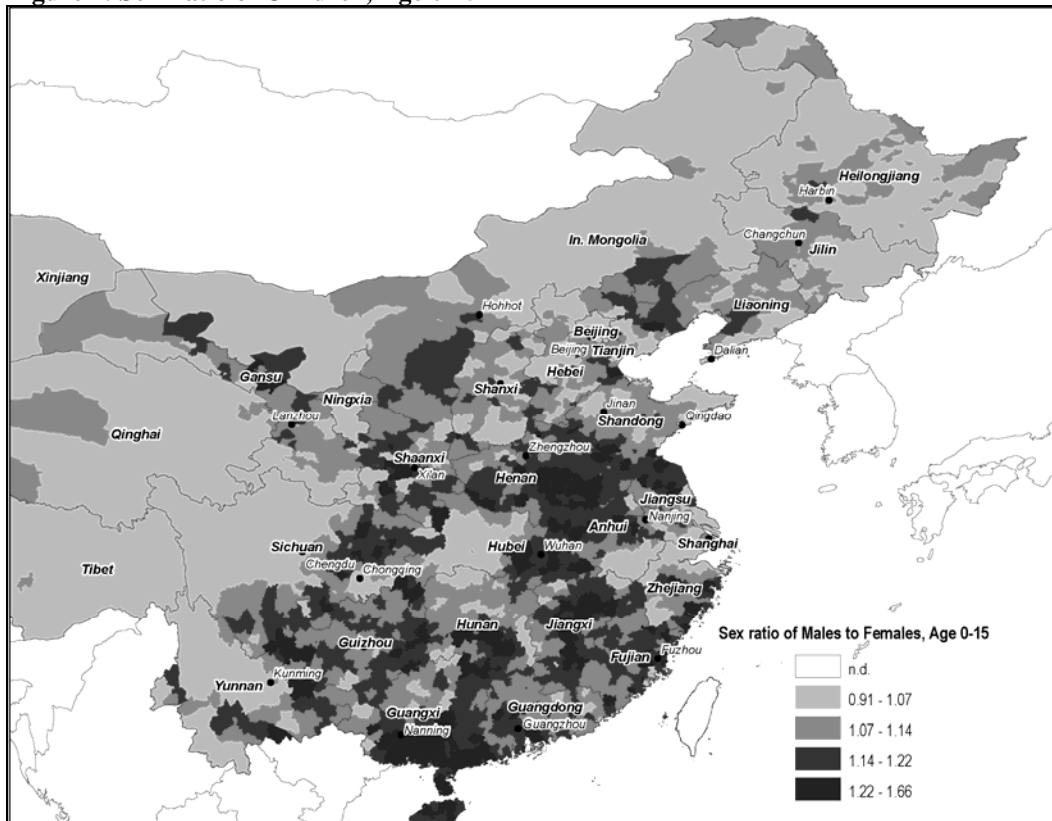
In order to determine how migration might affect HIV transmission, it is helpful to examine current and future expected migration patterns. Figure 6 displays the geographic distribution of sex ratios among 20-30 year olds in the year 2000, identifying counties where there exist large imbalances in marriage markets. The lack of women in the interior counties contributes to the migration of unmarried men to areas with more favorable sex ratios. Migration is currently occurring from areas with high sex ratios to areas with lower sex ratios, places where there are more favorable marriage markets and more economic opportunities. These locations, predominantly coastal cities, are also attractive to young men because of the available employment in industries with low barriers to entry, such as the construction sector. These cities have also attracted high numbers of female migrants of marrying age because of the recent explosive economic growth and ensuing competitive labor markets, further contributing to their more favorable sex ratios.

Unfortunately, these young men are migrating from poorer areas with higher rates of HIV infection. As shown in Figure 2, areas with high sex ratios among individuals of marrying age

⁵ This survey was conducted in Guangxi province at 14 clinics which provide screening and medical care for sexually transmitted infections.

tend also to have higher HIV prevalence, likely due to the higher incidence of intravenous drug use and unhygienic plasma donation practices. Moreover, it is unlikely that the supply of marriageable women in these areas will keep pace with demand from in-migrating men, which implies that a large number of these men may purchase sex. As young single adults migrate from the countryside to cities, they can either bring HIV with them, or be more likely to engage in risk taking behaviors that increase the likelihood of HIV transmission in urban settings. The migration process may thus exacerbate the spread of HIV from rural counties to urban areas and vice versa. Since migration in China encompasses hundreds of millions of individuals, it is impossible to predict *in toto* what the net effect of this human movement will be on HIV and STI epidemics.

Figure 7: Sex Ratio of Children, Age 0-15



Source: China 2000 Census.

This pull of young, single men from rural to urban areas will likely worsen over time. Figure 7 shows the geographic dispersion of sex ratios at birth, and identifies areas where the sex ratio at birth is highly skewed in favor of male offspring. Comparing this figure to Figure 6, it is clear that the regions with imbalanced marriage markets will experience worsening marriage markets and will have higher numbers of men unable to find marriage partners in the future. In this way, the continuing process of migration may contribute to epidemics of HIV in China's growing urban centers.

Further increase in the trafficking of women to supply sex to unmarried males is another potential consequence of the forecasted rise in migration. There are now an estimated 3 million sex workers in China, and a large number of these are thought to be migrants (Settle 2003). Traffickers are exploiting increasingly sophisticated networks that span international boundaries,

and China represents a potentially lucrative destination for these involuntary migrants (Hodge and Lietz 2007). China has experienced an increase in the trafficking of women for both prostitution and marriage, and some have linked this migration to the rising sex ratio (Zhao 2003). These trends indicate that the negative welfare consequences of high sex ratios can also be borne by women. Casual observers often predict an increase in the status of women in response to their scarcity, but this presumes that women have agency over their life circumstances. In many circumstances, the women who engage in sex work are illiterate, impoverished, and misled into participating in commercial sex (Hodge and Lietz 2007).

5 Unmarried Men and Sex Workers: Incidence and Projections

As outlined in the previous section, the increase in commercial sex activity and incidence of sexually transmitted infection is in part driven by economic reforms that have enabled workers to migrate more easily from economically depressed areas to growing areas. As cohorts of younger men fail to marry, these economic and demographic changes may fuel an increase in prostitution. The connection between marriage markets, prostitution rates, and HIV transmission is complex, but it is clear that these factors are all responsible for increasing HIV rates in China. This section models the relationship between these factors and estimates predictions for HIV infection rates in China in the years to come.

Considering the impending demographic pressures as heavily male birth cohorts enter adulthood and encounter shortages of marriageable women, relatively little is known about factors that influence the total number of sex workers in a population. In the 1980s and 1990s, sex workers represented a small share of the population. However, prostitution has expanded rapidly during the decades since 1980. At present, estimates range from 1 million women whose primary income comes from commercial sex up to as many as 10 million women engaging in paid sex of some kind (Fan 2007, China CDC 2004a). The data also indicate that young Chinese men are more likely to have visited a prostitute than older men: 12.6% of those aged 21-30 and 8.8% of those aged 31-40 have been to a prostitute.⁶ While evidence on HIV rates for this population are difficult to measure, the HIV prevalence rate among sex workers in Yunnan, Guangxi and Guangdong provinces was as high as 11 percent in 2000,⁷ and it seems reasonable to assume that the risky sexual practices of illegal sex workers place them at higher risk of exposure.⁸

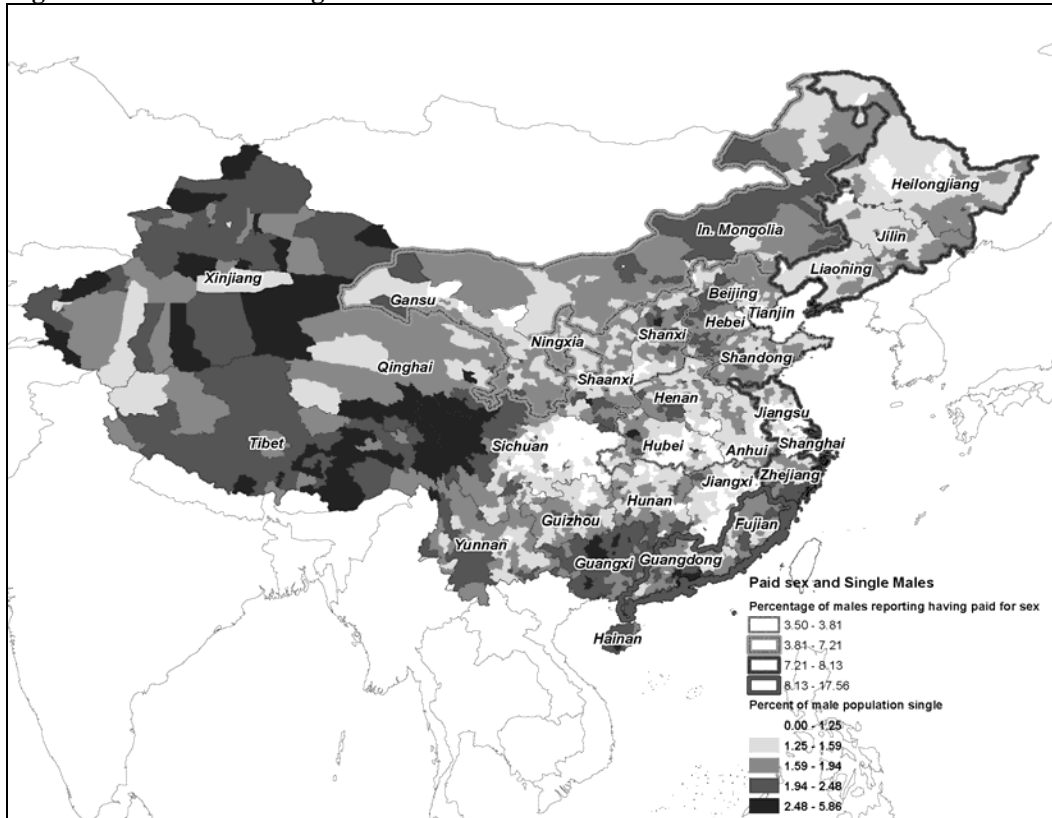
While not all single men will patronize sex workers, and married men will also pay for sex, documenting the relationship between failure to marry and commercial sex activity is important, as the population of single men will grow in the years to come. Moreover, identifying specific groups of men who are more prone to patronize sex workers is important, because of the need to target public health interventions at the groups who are most at risk. Construction workers represent a population of young, mobile men who are particularly likely to pay for services from low-cost female sex workers, and are less likely to be educated about sexually transmitted infections and condom use (China CDC 2004a).

⁶ Authors' calculation from CHFLS

⁷ This calculation is based on sex workers in detention centers, since prostitution is illegal in China (Settle 2003).

⁸ See Merli et al. (2006) for an epidemiological model of sexual transmission of HIV in China

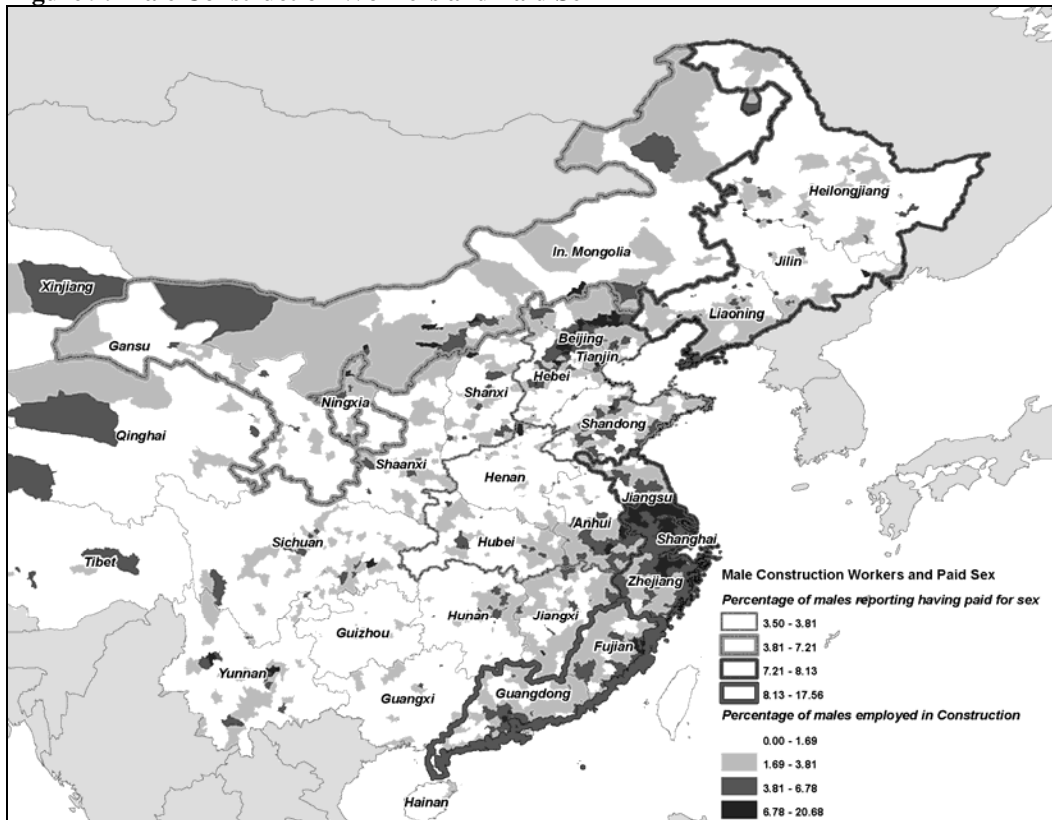
Figure 8: Paid Sex and Single Males



Source: CHFLS.

In order to analyze the relationship between percentages of men in at-risk groups and commercial sex activity, six regions are identified from the pooled responses to questions addressing paid sex in the China Health and Family Life Survey (CHFLS), and the prevalence of commercial sex activity is indicated by the borders in the figure above. Survey respondents were classified into groups by gender, marital status, and their response to the question of whether they had ever paid for sex. The results for all single males and for male construction workers, respectively, are displayed in Figure 8 and Figure 9. Paying for sex was most commonplace in the coastal southern region, encompassing the provinces of Guangdong and Fujian, followed by the coastal eastern region including Shanghai, Jiangsu, and Zhejiang provinces, and the far northeastern provinces bordering Korea and Russia. With the exception of Inner Mongolia, Tibet, and Xinjiang provinces (for which data on commercial sex activity are unavailable), the majority of counties with high percentages of single men tend to be located in regions where a high percentage of men report having paid for sex.

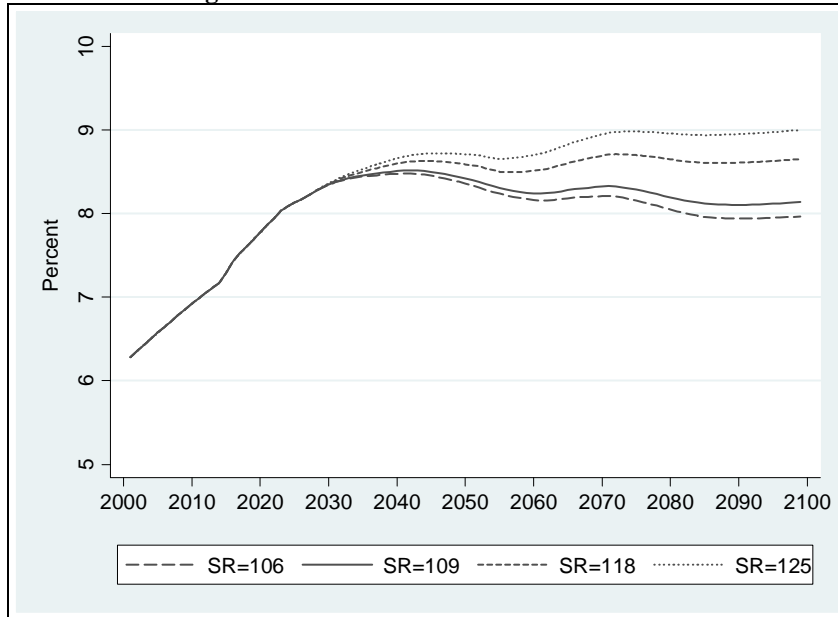
Figure 9: Male Construction Workers and Paid Sex



Source: CHFLS.

There exists a similar and more pronounced relationship between the percentage of men employed in the construction industry and the prevalence of commercial sex activity. The urban provinces of Guangdong, Fujian, Zhejiang, Shanghai and Jiangsu merit particular attention, as the percentage of males reporting having ever paid for sex exceeds 7 percent in these areas. These and other areas of dense concentration in the construction industry, such as northern Shandong province and the counties surrounding Beijing, merit particular attention as potential public health problems.

Figure 10: Share of Men Age 25+ Who Have Paid For Sex

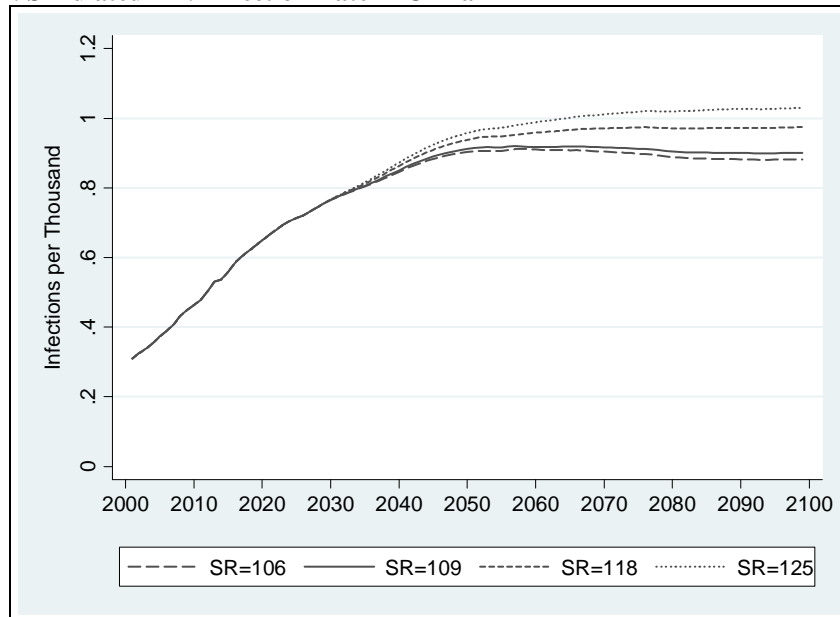


Notes: The simulations assume that the infection rate is determined by the age, sex, and marital status of the population. The rates of having paid for sex in these groups is imputed using the China Health and Family Life Survey (2000).

Given the correlation between percentages of unmarried men and commercial sex activity, how will the increase in sex ratios and the ensuing failure in marriage markets affect markets for sex? In order to model how the incidence of prostitution might evolve, we present the results of a simple simulation in Figure 10. The simulation projects the share of men who have paid for sex, assuming that the gender, marital status, and age specific rates of having paid for sex found in 2000 persist during the 21st century. Using the China Health and Family Life Survey, we observe that 14.7% of single men and 7.3% of married men admit to having paid for sex in 2000.⁹ We also observe the age profile of commercial sex activity and can calculate a hazard rate of the chance of attending a prostitute over the life cycle. While this calculation is admittedly imprecise, insofar as the current rates of having paid for sex represent a lower bound on the future prevalence of prostitution (due to increased levels of future migration and possible increases in human trafficking), we expect to see an increase in demand for sex work among Chinese men. The simulations indicate that almost immediately, demographic change will contribute to a rising share of men who have paid for sex, from roughly 6% to almost 9% in the next 30 years, or from 25 million men in 2005 to almost 37 million in 2035.

⁹ These percentages are derived from a regression of an indicator for having paid for sex on several demographic control variables, including marital status. The average fitted value for single men is 14.7% and for married men is 7.3%.

Figure 11: Simulated HIV Infection Rate in China



Notes: The simulations assume an HIV infection odds ratio of 1.4 between men and women and a 1.7 odds ratio between single and married individuals (Chen et al. 2007).

In Figure 11, we present results that attempt to assess how demographic change will affect China's HIV infection rate in the 21st century. We assume in these calculations that the unknown hazard rate for HIV infection by age and sex generates 650,000 cases when applied to the population age 22-40 in 2006. Then, the HIV-positive share is imputed to each cohort by sex, age, and marital status using the aforementioned odds ratios from Chen et al. (2007). Thus, these simulations attempt to model how HIV infection rates will change solely driven by changes in the demographic structure of China as cohorts with higher percentages of single males enter their sexually active years. The results indicate that the infected population will increase precipitously over the next 30 years, and stabilize at a higher rate of infection.

While these predictions for the spread of HIV do not incorporate any increases in the probability of contracting the disease (which might result as more people become infected), they also do not assume any changes in prevention behaviors. Since the Chinese government has launched many comprehensive HIV prevention and treatment initiatives, there is reason to hope that these predictions are overly pessimistic.

6 Government Response

The alarming increases in sex ratios at birth revealed in the 2000 census spurred the Chinese government to action to address one of the underlying demographic problems contributing to the spread of HIV (Li 2007). The government's response can be classified into two primary strategies: one on increasing the value of girls in the minds of parents, and the second focusing on decreasing the availability of sex selection technology. The "Care for Girls" campaign identified 24 counties with extremely high sex ratios, and provided incentives to reduce the female deficit, including free public education for female children. The preliminary indication is that these programs are having an effect. In a joint venture of the Ford Foundation and UNICEF, the "Chaohu Experimental Zone Improving Girl-Child Survival Environment" was established in

2000 and succeeded in decreasing the sex ratio at birth from 125 in 1999 to 114 in 2002. The government is currently attempting to expand the "Care for Girls" campaign to a national initiative. In 2004, President Hu Jintao declared that the campaign was a top national priority and the government would strongly attempt to stop the country's sex ratio at birth from increasing any further in 3 to 5 years (Li 2007).

The second strategy employed by Chinese officials is a concerted effort to crack down on sex-selective abortion. The government has passed several legislative initiatives aimed at curbing this practice and has vowed to punish offenders. In 2006, the New York Times reported the closure of several fertility clinics in violation of the policy.¹⁰ However, for all these efforts, the sex ratio at birth in China in 2005 was 1.18, near the all-time high, possibly related to more stringent enforcement of the One Child Policy in recent years. Public health officials have also acknowledged that the increasing prevalence of prostitution represents a risk factor for the spread of HIV from infected subpopulations to the overall population. The central government and local authorities show signs of recognizing the growing role of sex workers in HIV transmission, and several pilot projects promoting safer sex (practices such as condom use) are in place in Hubei, Yunnan, Jiangsu, Fujian, and Beijing.

Unfortunately, such programs face relatively low rates of condom usage by Chinese men. As reported in the Chinese Health and Family Life Survey, Chinese men are more likely than American men to report ever having paid for sex, and are less likely to use condoms during sex. As a result, unsafe sex practices have grown from accounting for just 10% of Chinese HIV infections in the 1990s to as many as 30% of infections in the years since 2000 (Xinhuashe 2005).

Table 3: Comparative Statistics Regarding Condom Usage and Prostitution

	China		United States	
	Always or Usually	Never or Rarely	Always or Usually	Never or Rarely
Respondents use condoms during sexual intercourse	26.02%	73.98%	35.09%	64.91%
Respondents admit having paid for sex	12.13%		8.99%	

Notes: Samples restricted to men between the ages of twenty and thirty. Chinese statistics are calculated from the China Health and Family Life Survey (CHFLS), and United States statistics are calculated from the Chicago Health and Social Life Survey (CHSLS). The Chinese survey asks questions regarding condom usage in long-term-, short-term-, and paid-sex relationships, while the American survey asks questions regarding condom usage with a respondent's two most recent sex partners. Though it is expected that recent sex partners of the CHSLS respondents are primarily long-term or monogamous partners, comparability between the China and United States statistics is maintained by the fact that short-term and paid-sex relationships make up only a small fraction of the CHFLS responses.

In light of this threat, the Chinese government has launched a widespread campaign to promote condom use and safe sex practices in the last several years. Spending by the government on combating HIV rose by a factor of 8 between 2001 and 2003, and spending on prevention efforts have reached almost 900 million yuan annually (UN 2007). The government is also treating more cases of HIV, with efforts such as the China Comprehensive AIDS Response (CARES) campaign. This program, initiated in 2003, aims to supply free domestically-manufactured anti-retroviral AIDS medication to those who contracted the disease through contaminated blood plasma transfusions. The effectiveness of such efforts will be critical to containing the virus, as the sex ratio rises and the percentage married falls among the sexually active population.

¹⁰ <<http://www.nytimes.com/2006/06/01/world/asia/01briefs-brief-003.ready.html?pagewanted=print>>

7 Conclusion

The Chinese government's recent actions to provide contraception and care to those infected with HIV are promising developments, but future actions to contain the spread of the disease must focus on the large and growing number of unmarried men who may be at increased risk for STI/HIV. The future course of Chinese policy is yet to be determined, and discussions on revising the policy have begun (Wang 2005). The results presented here outline some of the potential negative welfare consequences to having large numbers of males who fail to marry. Many scholars have identified clear linkages between the One Child Policy and the high sex ratio at birth during the last 20 years (Johansson and Nygren 1991, Ebenstein 2007), and so an associated benefit of allowing higher fertility could be a mitigation of the costs of high sex ratios presented here.

China's legacy of missing girls will have a dramatic effect on several aspects of Chinese society in the 21st century, and increased migration and an increase in the demand for commercial sex seems highly probable. It is unlikely that government action can effectively reduce the prevalence of commercial sex activities, and so policy must be directed to making this activity less risky. Policy efforts in this area should be directed towards increasing awareness of the risk of contracting HIV, and the availability of condoms, with a particular focus on geographic regions that attract unmarried men. Although China's HIV rates are still low, failure to act soon may prove costly, and the spread of HIV may be difficult to contain once these single young men referred to as bare branches are felled.

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8 Technical Appendix

The simulation model used in this paper is based on a one per 1,000 sample of the national population census of China (Long File) in the year 2000. Age-specific mortality rates from Banister and Hill (2004) are attributed to the population, and applied to reduce the population at the start of each simulation year. After applying mortality rates, a cut-off age of 110 years old is applied to remove the residual population above age 109. Age-specific fertility rates (ASFRs) are attributed to the population based on published data from the Sample Survey on Population Changes (2004), resulting in a Total Fertility Rate of 1.45. The ASFRs used in the present study do not vary over time or by marital status; thus, all women contribute to total fertility.

The true TFR in year 2000 is likely within the range of 1.45-1.8, and the simulation can be adjusted to allow the TFR to vary in specific years or to grow over time. The results presented in this paper use a starting TFR of 1.45 in year 2000 and a phased-in increase in ASFRs that reaches replacement-level TFR of 2.1 in 2030. The number of new births is calculated and the quantity of births by sex is determined by the input sex ratio at birth. For years prior to 2006, the known SRB of 1.18 boys to 1 girl is applied. Between 2006 and 2100, the simulation uses an input SRB (the paper contrasts four scenarios: 1.06, 1.09, 1.18 and 1.25) to divide the new births by sex. The fecund population used in the calculation of the General Fertility Rate is defined as all females 15-49. Crude birth rate is also calculated at this juncture.

The size of the labor force is calculated by adding the total population of males age 22-40 and 80% of the population of females age 22-40. LFP is defined as the labor force share of the total population. The Elderly Dependency Ratio is defined as the population age 65 and over per 1000 of the population of ages 15-64. Special EDRs are calculated for the population of elderly men by marital status.

Table 4: Example Marriage Model in 2001

Round	Males	Females	Round	Males	Females	Round	Males	Females
1	25	22	2	25	23	7	25	28
1	26	23	2	26	24	7	26	29
1	27	24	2	27	25	7	27	30
...
1	109	106	2	109	107	7	106	109

Notes: The marriage rule is executed in a macro model where the males and females in each round are married to each other in the following manner until the number of available females reaches zero. The leftover males are recorded as those who fail to marry.

After generation of fertility and labor force indicators, the population of males 25 and older and females 22 and older are married according to a rule. The population counts are divided into married/unmarried categories, and as many unmarried men age 25 as exist unmarried women age 22 are moved from the counts of unmarried and added to the married counts. The women are also moved to married counts, indicating that they have been removed from the marriage market. The process is repeated for men age 26 and women age 23, until all men have been given the first opportunity to marry women three years younger than themselves. Because past fertility differentials across three years may have resulted in larger cohorts of women of marrying age than males, any remaining unmarried men aged 25 and over are then given the opportunity to marry any remaining unmarried women two years younger than themselves, and the process is iterated until single men have been married to any available women up to three years older than themselves. After year 2001, the marriage model is applied except apply only to men between

ages of 25 and 30 (and women 22-33). This marriage model, because it uses the ever married population, inherently assumes that widowed spouses and divorced couples do not remarry. The advantage of this interpretation is that the marital status indicator can be seen as a proxy for the population that is most likely to have borne children.

After the marriage model has been run, the sums of unmarried men age 25 and over as well as those age 65 and over are counted. Additionally, the percentage of adult males who did not find a marriage partner is recorded each year. These populations are indexed to the total mid-year population and the total population of the same age groups as appropriate. The population age 22-40 is used to calculate HIV+ incidence. Using a known population of 650,000 HIV+ cases in China in 2006 and odds ratios of 1.4 for men to women and 1.7 for married to single from Chen et al. (2005), four HIV+ populations are calculated: married males; married females; single males; and single females. The sum of these populations divided by the total adult population is defined as the HIV+ rate.

After calculating these variables, the population is aged by 1 year and the calendar year is advanced. A new population age 0 is added using the birth statistics calculated above.