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## Estimates and Projections of HIV/AIDS for Yunnan Province, China

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### Abstract

Existing national projections of HIV/AIDS in China do not account for the heterogeneity of HIV rates and risks across provinces. This paper takes a first step to better understand the contribution of provincial epidemics to the national epidemic by presenting a set of estimates and projections of HIV/AIDS for Yunnan Province from 2000 to 2020. Utilizing a standard modeling approach, HIV seroprevalence data and data from a 2000 census are used to estimate trends of HIV infections and AIDS deaths in Yunnan. These estimates and projections give important insights into the possible evolution of HIV/AIDS across Chinese provinces and nationwide. They cast doubt on the magnitude of the future impact of HIV/AIDS in China as currently suggested by UNAIDS and other international agencies.

### Keywords

AIDS projections, AIDS estimates, Yunnan province, China, seroprevalence data, HIV, epidemics

## Introduction

During the past decade, HIV/AIDS has emerged as one of the leading challenges for public health in China. Although the epidemic is still in an early phase and remains largely concentrated among few sub-population groups at highest risk (particularly injecting drug users and sex workers), the Chinese government and leading international organizations estimate that between one and six million people are currently infected with HIV (*Xinhua News Agency*, November 20, 2002; UNAIDS 2002a; WHO 2002a, 2002b; National Intelligence Council 2002; Rosenthal 2002; Human Rights Watch 2003; China Ministry of Health / UNAIDS 2003). It is feared that the epidemic will soon become generalized<sup>1</sup>, spreading through sexual transmission among individuals who neither belong to any specific risk group nor engage in any specific high-risk behavior (UNAIDS 2002a: 70; China Ministry of Health and UNAIDS 2003). Existing national projections indicate that, if the epidemic becomes generalized, China might become the second highest HIV-infected country in the world (after India), with between 10 and 20 million HIV infections by 2010 (National Intelligence Council 2002; Bates 2002). These figures have drawn the attention of international observers on “the immense, but mostly hidden HIV vulnerability conditions that underline this ‘Titanic threat’” (UNAIDS 2002a: 6).

The well-known limitation of these projections is that the baseline data on HIV prevalence and AIDS cases in China are lacking (UNAIDS 2002a; China Center for Disease Control / US Center for Disease Control 2002; Morrison and Bates 2003; China Ministry of Health / UNAIDS 2003). Less emphasized are serious shortcomings in the projection methodology that do not account for the heterogeneity of HIV rates and risk across provinces. This might be problematic, because both China's health and mortality profile and the characteristics of the HIV/AIDS epidemic vary greatly by province. Indeed, the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) recommend that for large countries with concentrated epidemics, such as China, estimates of prevalence should be done at a sub-national level (UNAIDS/WHO 2003, Table 1). However, separate estimates of the future demographic impact of HIV/AIDS for individual Chinese provinces have not yet been made.<sup>2</sup>

The differential impact of HIV/AIDS at the provincial level is due to three distinct epidemics that have been occurring in China: an epidemic among intravenous drug users (IDUs), concentrated, until recently, in western and southern China and related to the sharing of needles and syringes; a heterosexual epidemic, initially concentrated in provinces along the eastern coast of China, to a large extent related to HIV transmission between prostitutes and their clients; and an epidemic in provinces in east-central China, related to exposure of paid plasma donors to HIV-contaminated blood during the donation process (UNAIDS 1997; National Center for HIV, STD and TB prevention, US Center for Disease Control, US Department of Health and Human Services 2001; UNAIDS 2002a; China Ministry of Health / UNAIDS 2003). As a result of these three distinct epidemics, there is currently a low prevalence nationally but a high-level prevalence in specific populations and certain regions, as it can be seen in Table 1. The spatial heterogeneity of AIDS risk parallels geographic differentials in health and mortality across Chinese provinces. Low mortality levels characterize eastern coastal provinces, while the high-

mortality regions are the located in the northwest and southwest (Banister 1987; Hao 2000; Wolf et al. 2003).

Table 1. Average seroprevalence of HIV-1 (%) for selected high-risk urban populations, by province: Mainland China, 2000 (standard deviations in parentheses)

Province	Injecting Drug Users	Female Sex Workers	STD Patients
Anhui	N/A	0.25 (0.35)	0
Beijing	0	0.20 (0.28)	0.33 (0.15)
Chongqing	0.80 (0.57)	N/A	N/A
Fujian	0	0	0
Gansu	7.74 (4.21)	N/A	N/A
Guangdong	20.83 (1.29)	1.05 (1.09)	0.41 (0.30)
Guangxi	16.88 (2.27)	10.30 (0.57)	0.38 (0.12)
Guizhou	0.48 (0.84)	0.20 (0.28)	0
Hainan	N/A	0	0
Hebei	N/A	N/A	0
Heilongjiang	N/A	N/A	0
Henan	N/A	0	0.60 (0.28)
Hubei	0	0	0
Hunan	0.50 (0.36)	0.25 (0.35)	0
Inner Mongolia	0	0	0
Jiangsu	0.31 (0.43)	0	0.08 (0.15)
Jiangxi	5.89 (10.21)	0	0
Jiling	N/A	N/A	0
Laioning	0	0	0
Ningxia	0.62 (0.87)	N/A	N/A
Qinghai	0.14 (0.26)	N/A	0
Shaanxi	0	0	0
Shandong	0	0	0
Shanghai	N/A	0	0
Shanxi	0	0	0
Sichuan	2.44 (2.18)	0	0
Tianjin	N/A	0	0
Tibet	N/A	N/A	N/A
Xinjiang	60.21 (25.18)	0.75 (0.00)	N/A
Yunnan	N/A	3.10 (2.12)	0.55 (0.78)
Zhejiang	0	N/A	0

Source: US Census Bureau (2003).

This paper takes a first step towards a better understanding of the contribution of each provincial epidemic to the national epidemic, and about how this contribution might evolve

over time, by presenting a set of estimates and projections of HIV/AIDS from 2000 to 2020 in Yunnan province. Yunnan—which is located in the south-west of China, along the border with Myanmar, Laos and Vietnam—is the “birth place” of the HIV/AIDS epidemic in China (Sun et al. 1994) and is today one of the worst-affected provinces, accounting for about half of China's reported HIV-infected population at the end of 2000 (National HIV Sentinel Surveillance Group 2001). Yunnan is an interesting case study because the sexual transmission of HIV is already well established, and there is evidence of an emerging generalized epidemic among pregnant women attending antenatal clinics (Xiaobo 2002; US Census Bureau 2003; China Ministry of Health / UNAIDS 2003) that is well documented. On the basis of the available HIV seroprevalence data and of the 2000 census data, in this paper the most recent patterns and trends of HIV infection in Yunnan is estimated by means of a standard modeling approach. These are then used to derive annual and cumulative projections of AIDS cases and deaths in Yunnan, and to extrapolate the corresponding figures for China as a whole. The main thrust of this analysis is that the reasonably accurate knowledge available for the provincial epidemic of Yunnan might give important insights into the possible evolution of HIV/AIDS in other provinces as well as nationwide.

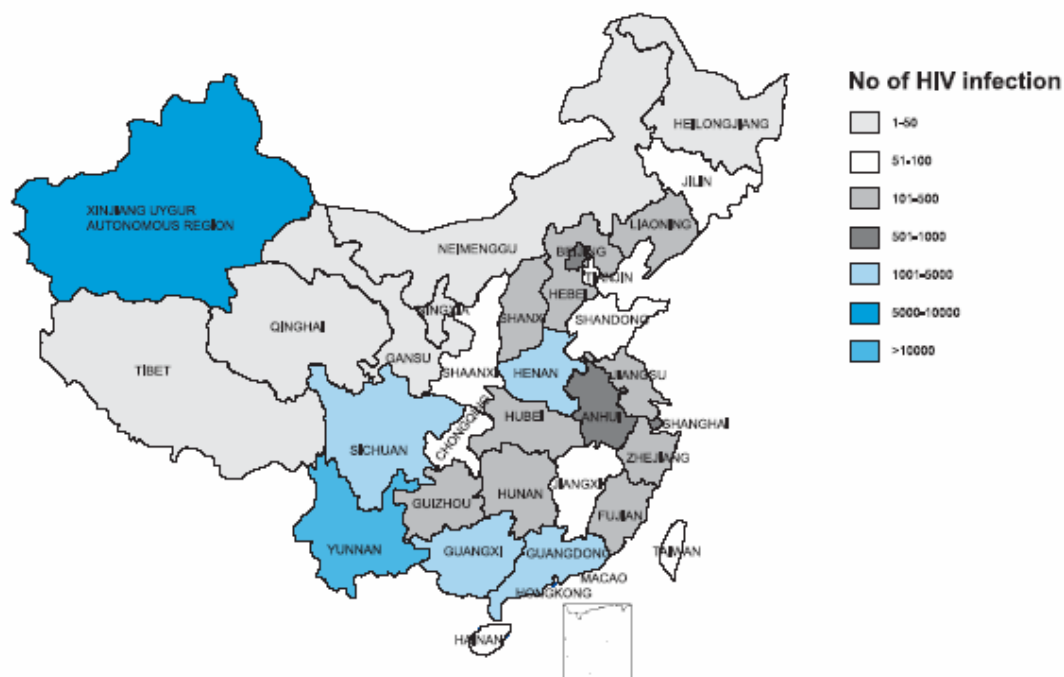
## Research Setting

Yunnan is one of China's largest but poorer provinces, with a GDP per capita of approximately US\$500 per year, and rural incomes per capita below US\$175 per year (World Bank 2003). The first HIV/AIDS epidemic in China originated in the late 1980s in Yunnan and then spread along the main drug routes through Sichuan and Gansu to Xinjiang province, and eastwards to Guangdong province (Yang et al. 2002).

The first AIDS case was detected in 1986 in Yunnan's Ruili County, on the Myanmar border. HIV entered Yunnan from commercial sex workers who had returned from Thailand. During the 1980s, HIV infections were sporadic and were mostly associated with people with international contacts until Yunnan reported the first HIV infection among IDUs in 1989 (China Ministry of Health / UNAIDS 2003). From then onwards, the epidemic among IDUs became more established and spread to other high-risk groups. As of 2000, Yunnan had 7,973 reported cases of HIV, which represented about 40 per cent of the HIV cases reported nationwide (China HIV/AIDS Socio-Economic Impact Study Team 2002; *see* Figure 1).

Yunnan's government has been aggressive towards the AIDS problem. In 1991 Yunnan was the first Chinese province to establish a sentinel surveillance system for HIV/AIDS, whereas China's national HIV sentinel surveillance began only in 1995. In 2001, Yunnan province had 47 of the 158 surveillance sites in the country and the most comprehensive program that included IDUs, attendees of clinics for sexually transmitted infections, sex workers and their clients, antenatal women, and hospital patients (National Center for HIV, STD and TB Prevention, US Center for Disease Control, US Department of Health and Human Services 2001).

Figure 1. The geographic distribution of reported HIV/AIDS cases in China



Source: China HIV/AIDS Case Report, December 2002.

Sentinel surveillance detected a HIV epidemic among pregnant women in Yunnan as early as 1991 (US Census Bureau 2003). In 2000, 6 out of 12 sentinel sites for pregnant women diagnosed HIV infections; prevalence reached 0.8 percent, although the average for the whole province among pregnant women remained 0.2 percent (UNAIDS 2002a). A study in 2001 then revealed that the HIV prevalence in a sample of pregnant women had passed the 1 percent mark (Xiaobo 2002).

The epidemic among pregnant women attending antenatal clinics in Yunnan is presently the only well-documented emerging generalized epidemic in China. Sample surveys and the surveillance system have failed to identify positive HIV infection rates among antenatal women in the other three provinces that have been hit hardest by the epidemic, namely, Sichuan, Guangdong, Guangxi and Henan (US Census Bureau 2003).<sup>3</sup> The emerging generalized epidemic in Yunnan province therefore provides a unique opportunity to evaluate the spread of HIV/AIDS in China. Because of its extensive monitoring, Yunnan is currently the province with the best available seroprevalence data in China. In addition, for Yunnan is possible to estimate and project HIV/AIDS on the tenable assumption of heterosexual epidemics, which greatly diminishes the error related to estimating the size of high-risk groups.<sup>4</sup>

## Data and Methods

### *Methods*

The provincial estimates and projections for Yunnan province required three basic steps. First, time series of point prevalence estimates were constructed by using available serological data for pregnant women attending antenatal clinics (ANCs). On the basis of the prevalence estimates, the epidemic curve that best described the spread of HIV in the province was then determined. Finally, on the basis of population estimates from the 2000 census and on the prevalence estimates, HIV incidence and AIDS-related mortality between 2000 and 2020 were estimated. For the second and third step, two computer programs developed by UNAIDS were used: EPP (Epidemic Projection Package) and SPECTRUM, respectively. The specific procedures followed in each step and the data used for the present analysis are described in the next sections.

### *Constructing time series of HIV prevalence*

Seroprevalence data are the most widely available epidemiological data on HIV/AIDS in China. HIV/AIDS notification data represent only a fraction of new cases and are subject to serious problems of misreporting and underreporting, which, in turn, reduce the reliability of information on HIV/AIDS-attributable mortality (China Center for Disease Control / US Center for Disease Control 2002). Sentinel surveillance systems, on the other hand, have emerged in all Chinese provinces, starting with Yunnan in 1991 (Hehe *et al.* 2000).

The system currently exist both at the national level within the National Center for AIDS Prevention and Control (NCAPC), an agency within the Ministry of Health, and at the provincial level within the respective Provincial Centers for AIDS Prevention and Control located within the provincial epidemic prevention stations (EPS). Based on a national protocol, the surveillance sites collect blood specimens, as well as demographic and limited behavioral data, for particular risk groups (such as commercial sex workers and IDUs) and pregnant women attending antenatal clinics. In December 2001, the national HIV sentinel surveillance program had 158 clinic-based or facility-based sentinel sites (including at least one in each of 31 provinces or autonomous areas), covering six population groups: injecting drug users, STI patients, truck drivers, sex workers, pregnant women, and men who have sex with men (China Center for Disease Control / US Center for Disease Control 2002). Specimens are tested at the provincial level using two ELISA screening tests and then demographic and test result data are electronically submitted to the NCAPC central office from the provincial EPS at the end of the survey period. Summary reports of findings are disseminated yearly to both the Ministry of Health and to officials in each province (National Center for HIV, STD and TB Prevention, US Center for Disease Control, US Department of Health and Human Services 2001).

Data on serosurveillance of HIV/AIDS in China is distributed to the public by the U.S. Census Bureau in its HIV/AIDS Surveillance Database, which is the data source used for the present analysis (US Census Bureau 2003).<sup>5</sup>

*Fitting an epidemic curve with EPP through point prevalence estimates*

The EPP model was used with the available surveillance data to estimate the time trend of adult prevalence of HIV at the province level. The methodology behind this approach is described in detail elsewhere (UNAIDS Reference Group on Estimates, Models and Projections 2002: 38-48), and its main features are described below.

EPP is a simple epidemiological model that (re)produces the basic epidemic curve found in most HIV epidemics. In the model, a population of size  $N$  is divided in three groups: those at risk of contracting AIDS ( $Z$ ), those not at risk of contracting AIDS ( $X$ ), and those already infected with AIDS ( $Y$ ). Three simultaneous equations then define the model:

$$\begin{aligned}\frac{dX}{dt} &= \left(1 - f\left(\frac{X}{N}\right)\right) E_t - \mu X \\ \frac{dY}{dt} &= f\left(\frac{X}{N}\right) E_t - \left(\mu + \frac{rY}{N} + \iota\right) Z \\ \frac{dZ}{dt} &= \left(\frac{rY}{N} + \iota\right) Z - \int_0^t \left(\frac{rY_x}{N_x} + \iota_x\right) Z_x g(t-x) dx\end{aligned}$$

where:  $E_t$  = new entrants to the population (i.e., children reaching the age of 15) at time  $t$

$\mu$  = mortality rate due to causes other than AIDS

$r$  = force of infection

$g$  = function describing the proportion of adults progressing to AIDS death

$\iota$  = 1 for the first year of the epidemic, and 0 for all other years

and where  $f(X/N)$  is fraction of new entrants who enter the population at-risk of contracting AIDS, which is given by:

$$\frac{\exp\left[\phi\left(\frac{X}{N} - (1 - f_0)\right)\right]}{\exp\left[\phi\left(\frac{X}{N} - (1 - f_0)\right)\right] + \frac{1}{f_0} - 1}$$

In order to apply the EPP model, some basic assumptions about the nature of the HIV/AIDS epidemics in Yunnan province have to be made. The critical assumption considered in the present analysis was that in Yunnan the epidemic would be essentially heterosexual in nature. As it has been discussed earlier, this is consistent with the available evidence.

The model then requires six demographic parameters to fit the surveillance data<sup>6</sup>: the fraction of the population aged 15 and above; the sex ratio for the population aged 15 and above; the birth rate per adult aged 15 and above; the proportion of number children who would survive to age 15 in the absence of any AIDS deaths; the proportion of adults aged 15 or above that dies each year due to causes other than AIDS; the estimated annual

growth rate of the adult population aged 15 or above. All these parameters were calculated on the basis of the published 2000 census data (China Population Census Office 2002).

The additional parameter required by the EPP model to fit the epidemiological data is the beginning year of the epidemic in Yunnan province. The start year of the HIV/AIDS epidemic is one of the parameters that determine the shape of epidemic curve: an earlier start year will cause the curve to rise earlier and a later start year will produce a curve that starts later. The fitting of the epidemic curve was improved by considering a range of beginning years of the epidemic, between 1992 (the year after the epidemic among pregnant women in Yunnan province was first identified) and 1996.

### *Baseline for population projections*

A baseline population structure is needed to describe the expected demographic trends in the absence of HIV/AIDS in each province considered. The U.S. Census Bureau and the United Nations Population Division routinely produce population projections for all countries in the world at the national level. They do not, however, produce projections at the province level for China. For the purposes of the present analysis, projections of Yunnan's population for 2000-2020 were computed on the basis of the published<sup>7</sup> 2000 census age structure (China Population Census Office 2002), under one set of mortality assumptions (quinquennial gains in life expectancy at birth after 2000 of 0.75 years for males and 1.80 years for females), three scenarios of fertility assumptions (constant fertility; fertility declining linearly with a floor value of TFR=1.5; fertility declining linearly with a floor value of TFR=1.0), and an assumption of no inter-province migration during the projection period. Since estimates and projections of HIV/AIDS in Yunnan differ marginally in the three cases, the results are presented only for the intermediate fertility scenario.

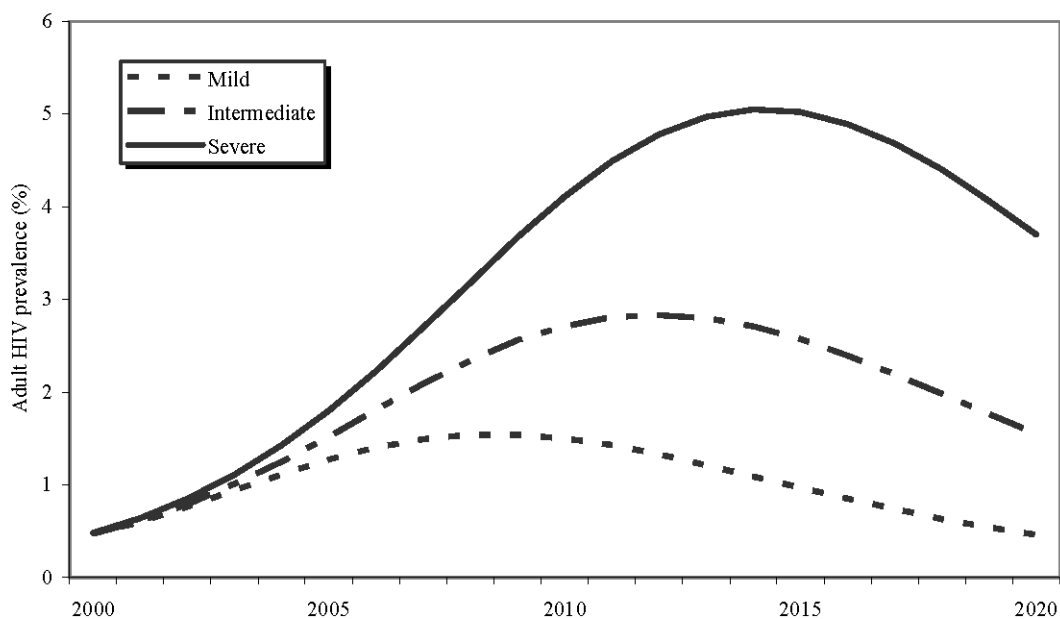
## **Results and Discussion**

### *Estimates and projections of HIV/AIDS in Yunnan province*

On the basis of the available seroprevalence data for pregnant women and assuming a heterosexual epidemic, in 2000 HIV prevalence among the general population in Yunnan province is estimated to be 0.5 percent, which translates into 120,000 HIV infections. Sentinel surveillance shows that Yunnan accounted for about 40 percent of all reported HIV cases nationwide at the end of 2000 (National HIV Sentinel Surveillance Group 2001), so that the implied number of cases nationwide would be 300,000 cases. This result provides supporting evidence to the conjecture that the reported number of HIV infections in Yunnan is highest because the greatest number of monitoring stations is located there.<sup>8</sup> If it is assumed, more reasonably, that Yunnan accounted for 10 per cent of HIV cases nationwide in 2000, the total number of infections implied by estimates for Yunnan province would be 1.2 million, which is well within the range of informed assessments about the Chinese epidemic today.



Figure 2. Yunnan adult HIV prevalence: three scenarios, 2000-2020



By combining the prevalence estimates with population estimates from the 2000 census, HIV incidence and AIDS-related mortality between 2000 and 2020 was also estimated. Three scenarios for the future course of HIV/AIDS in Yunnan were then identified (Fig. 2). In the ‘severe’ scenario, mean adult HIV prevalence exhibits an increasing trend until it peaks in 2014 at 5.1 percent; in the ‘intermediate’ scenario, HIV prevalence peaks in 2012, reaching 2.8 percent; and in the ‘mild’ scenario, the epidemic curve peaks early in 2008, at 1.5 percent. The projections of HIV/AIDS corresponding to these scenarios indicate that HIV prevalence among the general population might pass the 1 percent mark as early as 2003, and reach 3 to 5 percent in case of an intermediate and severe epidemic, respectively. Yunnan province alone could have between 500,000 and one million of HIV infections by 2010, the estimated number of infections nationwide in China today. The corresponding death toll ranges from 20,000 to 100,000 AIDS deaths by 2020 (Table 2).

Table 2. Estimated number of AIDS deaths in the general population: Yunnan Province, 2000-2020

Year	Mild epidemic	Intermediate epidemic	Severe epidemic
2000	670	520	400
2005	4,020	4,140	4,360
2010	19,320	24,940	31,140
2015	32,090	54,640	80,490
2020	21,630	57,850	109,960

One way of putting those hypothetical trajectories in perspective is to compare them with existing estimates of HIV prevalence for other countries or regions. The severe scenario posits an eventual adult HIV prevalence rate in Yunnan province that can be compared

against UNAIDS' prevalence estimate for sub-Saharan Africa, which was 8 percent for year-end 2002 (UNAIDS 2002b). The intermediate scenario posits a trajectory for adult HIV prevalence in Yunnan province similar to that estimated by UNAIDS for Cambodia and neighboring Myanmar, the two southeast Asian countries with the highest HIV prevalence as of 2002 (WHO 2002). In the mild scenario, the prevalence rates presumed for Yunnan's HIV epidemic reaches the levels estimated to characterize pregnant women in contemporary Thailand, where HIV prevalence among antenatal women peaked at slightly below 2 percent in the mid-1990s and has been slowly decreasing to about 1.5 percent in 2000.

Inescapably and necessarily, every one of these scenarios is speculative. The actual trajectory of Yunnan's HIV epidemic in the years ahead will be established by patterns and mechanisms of transmission, the prevalence of risky behaviors and practices among the general public, and the efficacy of the Chinese government's anti-AIDS strategies—quantities today unknown. However, each scenario considered in this paper can be seen to comport with HIV prevalence rates well within the contemporary historical experience of other societies, and especially within the historical experience of neighboring East Asian countries.

#### *Implications for the course of the HIV/AIDS epidemic in other Chinese provinces*

The epidemic curve estimated for Yunnan province can be used as a model to evaluate the trajectory of HIV/AIDS in other Chinese provinces as the infection spreads from high-risk groups to the general population.

As an example, let us consider Xinjiang province. Sentinel surveillance in Xinjiang detected an emerging generalized epidemic among pregnant women at about the same time as in Yunnan province, in 1998. HIV prevalence among women attending antenatal clinics then peaked at 1.5 percent at the end of 1999 (US Census Bureau 2003). According to the published 2000 census data (China Population Census Office 2002), Xinjiang had slightly lower fertility than Yunnan (the TFR was 1.5 and 1.8, respectively), but considerably lower baseline mortality (life expectancy at birth was 71.9 years for males and 74.4 years for females in Xinjiang, and 65.9 years and 68.7 years, respectively, in Yunnan). The impact of these differences for HIV infections and AIDS deaths can be seen in the figures (Fig. 3 and Fig. 4). Assuming the same epidemic curve of Yunnan province, in all three scenarios the underlying mortality conditions in the two provinces translate into a twice as high number of HIV infections and AIDS deaths in Yunnan as compared to Xinjiang.

This example highlights the strong impact for the future course of HIV/AIDS of the heterogeneity of mortality conditions across Chinese provinces, and stresses the importance of provincial estimates and projections of HIV/AIDS for a better understanding of the epidemic at the national level.

Figure 3. Number of HIV infections in Yunnan and Xinjiang province, under the assumption of Yunnan's epidemic curve and the same onset of the epidemic: 2000-2020

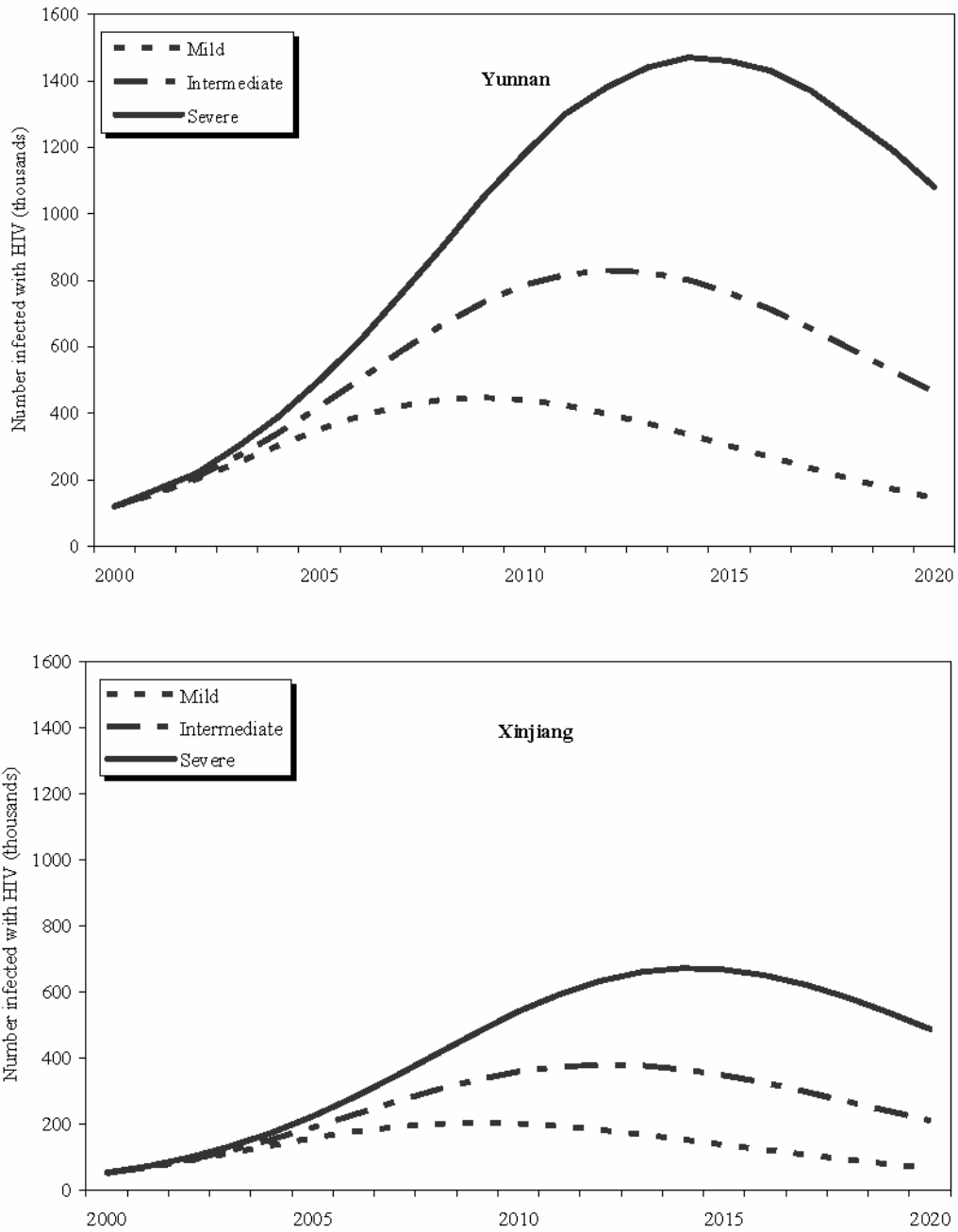
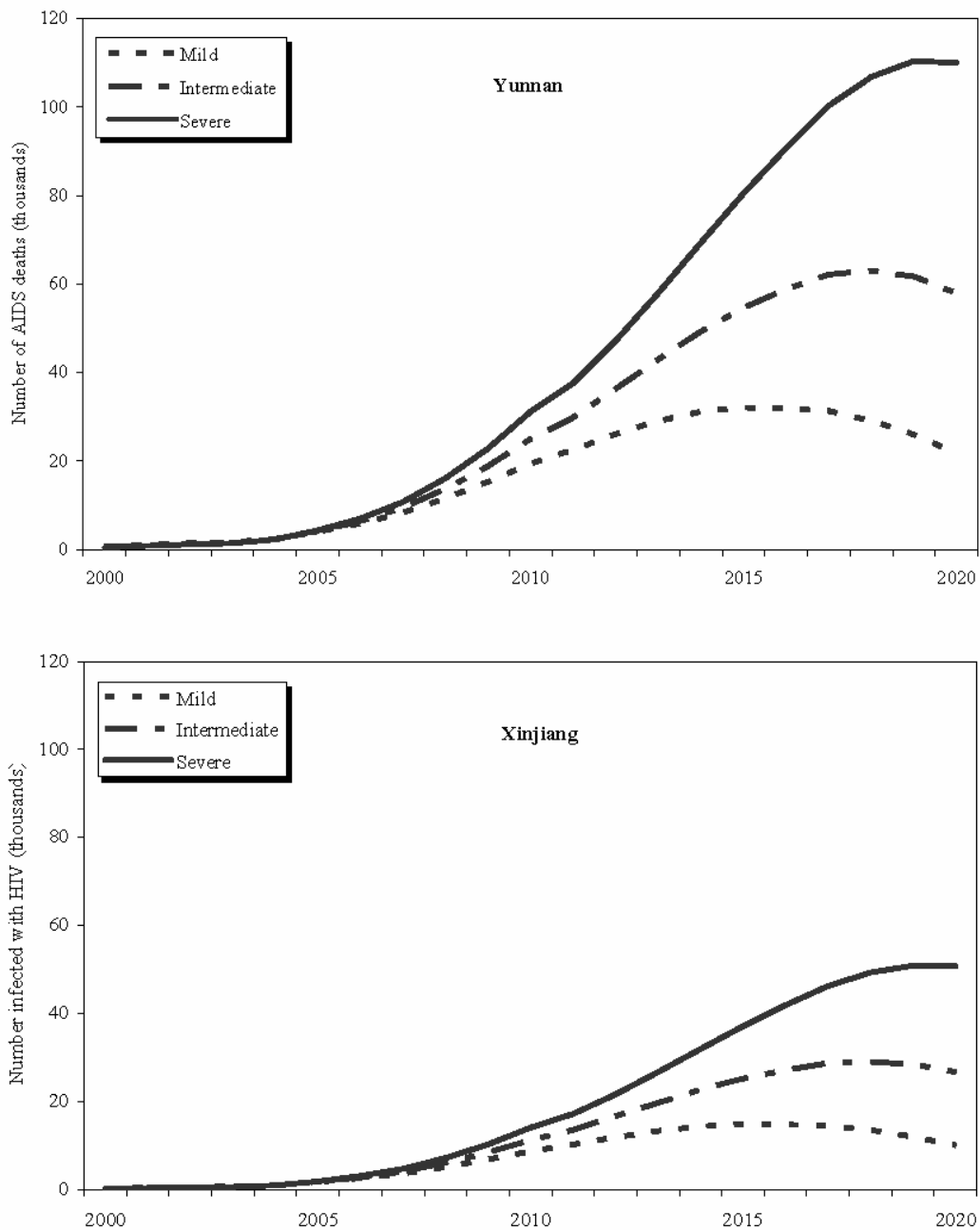


Figure 4. Number of AIDS deaths in Yunnan and Xinjiang province, under the assumption of Yunnan's epidemic curve and the same onset of the epidemic: 2000-2020



*Implications for the course of the HIV/AIDS epidemic at the national level*

Estimates and projections for Yunnan province permit making inferences about the course of the national HIV/AIDS epidemic in China. This can be achieved by making

assumptions about the proportion of HIV infections in Yunnan province as percentage of the national total.

Let us consider the four situations presented in Table 3 for illustrative purposes. In a conservative scenario (“intermediate” epidemic), the cumulative number of HIV infections nationwide in 2010 ranges between about 2 million and 8 million, depending on whether the proportion of infections in Yunnan province remains at 40 percent or at the more reasonable level of 10 percent. In a more extreme scenario (“severe” epidemic), the corresponding number of HIV infections nationwide ranges between 3 and 11 million.

Table 3. Projected number of HIV infections at the national level based on different assumptions about the proportion of infections in Yunnan Province (thousands): Mainland China, 2010

	40%	30%	20%	10%
Severe epidemic	2,950	3,933	5,900	11,800
Intermediate epidemic	1,968	2,623	3,935	7,870
Mild epidemic	1,105	1,473	2,210	4,420

In order to reproduce current estimates of UNAIDS and other international organizations (which range between 10 and 20 million of HIV infections by 2010), strong assumptions have therefore to be made about the future course of the HIV/AIDS epidemic in Yunnan and in the other Chinese provinces. According to the results of the present analysis, a cumulative number of 10 million of infections by 2010 at the national level is a “worst-case” scenario, rather than the lower bound of the projected size of the epidemic. It seems more likely that the cumulative number will be within the range of 3 to 8 million of infections by 2010. This is the same number of infections that can be obtained accepting Chinese estimates for 2000 of one million persons with HIV/AIDS nationwide and a relatively modest annual growth rate of 25 percent between 2000 and 2010 (Bates 2002).

#### *Limitations of the analysis*

The major problem with estimates of HIV prevalence based on surveillance data is their sensitivity to the coverage and appropriateness of the sentinel surveillance sites (UNAIDS/WHO 2003). Although HIV sentinel surveillance system in Yunnan province is rather extensive when compared with surveillance systems for other Chinese provinces, at least few issues related to how the data were used to produce estimates of the general population are open to question.

The first set of issues relates to the use of sentinel surveillance data collected predominantly in urban areas. Within countries, ANC-based sentinel surveillance systems generally show that infection levels are highest in urban areas (e.g., Gregson, *et al.* 2002; Fylkesnes, *et al.* 2001) and that HIV prevalence is generally lower in rural areas. This difference might not be fully captured by the seroprevalence data used for the analysis in this paper, as they have all been collected from urban surveillance sites, which would tend to overestimate HIV prevalence in Yunnan province. However, this is probably counter-balanced by the greater bias due to lower baseline fertility and mortality in urban

populations. As a result of these two effects, the estimates presented in this paper should approximate quite well those for the province as a whole.

A separate issue is the question of the overall representativeness of sentinel sites. Yunnan has long and good data series on HIV prevalence, since the sentinel surveillance program began in the early 1990s and targeted pregnant women attending antenatal clinics since its beginnings. However, as in most Chinese provinces, sentinel surveillance sites were initially chosen in areas believed to be of higher risk or showing higher prevalence, as an early warning system. This would tend to overestimate the prevalence in ways that are difficult to predict and incorporate in the analysis presented in this paper. Policy reforms are needed to improve the ability to collect unbiased, representative surveillance data, and will allow the government of China to respond to the HIV epidemic with more accurate and timely information on the true magnitude and diversity of the HIV epidemic.

An additional limitation of the estimates and projections presented here is that they rely on the crucial assumption that HIV prevalence in pregnant women can be used as a surrogate for HIV prevalence in the total 15-49 years old population. Previous studies in high-fertility populations in sub-Saharan Africa have established that data on pregnant women frequently provide under-estimates of female HIV prevalence (Zaba and Gregson 1998) but reasonable estimates of both-sex prevalence (UNAIDS 2000), as HIV levels are generally considerably lower in men than in women in established epidemics (Gregson and Garnett 2000). Studies in low-fertility populations in southern Africa have obtained more contradicting results, as they have found higher (Fontanet, *et al.* 1998), lower or the same (Gregson, *et al.* 2002) HIV prevalence in local ANC attendees than in the general female population. Due to the restrictions placed on fertility by the one-child policy, the assumption that prevalence among ANC women in China is representative of that in the general population needs to be validated, as women attending antenatal clinics might be an extremely biased sample of the general adult population. Improvements in our knowledge of the epidemic will allow refinement of the methodologies and increased precision of future estimates.

## Conclusion

Although accurate country-level estimates and the tracking of regional prevalence trends are essential components of advocacy for international HIV/AIDS efforts, accurate estimates at the sub-national level are equally important for national advocacy, planning, and evaluation purposes. At present, China's capacity to collect and undertake careful analysis of surveillance data for each of its provinces and put them into a consistent local modeling framework is limited. The estimates and projections presented in this paper are a first step in improving understanding of the spread of HIV at the sub-national level in China.

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## Notes

<sup>1</sup> In concentrated HIV/AIDS epidemic, HIV prevalence is consistently over 5 percent in at least one sub-population at highest risk, but it is below 1 percent in the general adult population. In generalized epidemics, HIV prevalence reaches 1 percent in the general adult population.

<sup>2</sup> UNAIDS, as part of its regular work, does not compute provincial estimates of adult infections, only national level estimates. The number of HIV infections and AIDS cases for individual Chinese provinces is generally calculated by distributing the national total according to the current HIV prevalence in each province (WHO 2002b: 45).

<sup>3</sup> An emerging epidemic among pregnant women started being registered in Xinjiang Province through the sentinel surveillance system in 1998, but the data are as yet too limited to permit more detailed analyses. In all other Chinese provinces, sentinel surveillance data indicate that bridging of the two primary risk populations, the drug users and the sex workers, has not occurred fully yet (Zhang and Ma 2002), as the discrepancy of HIV prevalence between the two groups well illustrates (*see* Table 1). In addition, according to the WHO, as of 2001 the number of HIV infections not associated with IDU in the provinces with higher prevalence rates among IDU still remained low, and that there were still no conclusive data to indicate that any extensive spread of HIV was occurring among the highest heterosexual risk groups in China (WHO 2002b).

<sup>4</sup> The assumption of heterosexual epidemic has been incorporated also in national projections (Eberstadt 2002; Wolf et al. 2003). At the national level, however, this assumption is not very plausible, because existing evidence is insignificant to show that HIV has spread among the general population.

<sup>5</sup> The U.S. Census Bureau HIV/AIDS Surveillance Database is a comprehensive compilation of HIV/AIDS prevalence data from country reports of HIV surveillance, as well as published journal articles, abstracts of conference presentations, and so on.

<sup>6</sup> This information is used together with model patterns prepared by the UNAIDS Reference Group that describe the progression from infection to death, the distribution of infection by age and sex, transmission from mother-to-child and the effect of HIV infection on fertility (UNAIDS Reference Group on Estimates, Models and Projections 2002).

<sup>7</sup> These are the original 2000 census data, as tabulated, without adjustments.

<sup>8</sup> In 2000, Yunnan had the most monitoring stations, so it is possible that its high HIV ranking was related to its relatively effective monitoring, in addition to the relative seriousness of the HIV problem (US Embassy Beijing 2000).

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