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

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Abstract

Given the heterogeneity of HIV rates and risk in different provinces, province-specific estimates and projections of HIV/AIDS might be crucial for a better understanding of the epidemic in China. 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, based on available serological data and on the 2000 census data for China. The results of the present analysis provide supporting evidence for current informed assessments of the proportions of the HIV/AIDS in China. They also indicate, however, that strong assumptions on the future course of the epidemic at the sub-national level are needed to reproduce existing projections of HIV infections nationwide during this decade. By 2010, the cumulative number of HIV infections might be within the range of 4 to 6 million, rather than 10-20 million as estimated by UNAIDS and other international agencies.

1. 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), according to the latest estimates of the Chinese government and other international organizations there are between one and six million people currently infected with HIV (*Xinhua News Agency*, November 20, 2002; UNAIDS 2002a; WHO 2002a, 2002b; National Intelligence Council 2002; *New York Times*, June 28, 2002; Human Rights Watch 2003). More serious is the fact that several factors—such as the growing HIV epidemics among injecting drug users and sex workers, a highly mobile population, and the increase in sexually transmitted infections—indicate that HIV/AIDS might soon unfold through sexual transmission to the general public. In a generalized epidemic[1], HIV will spread among individuals who do not belong to any specific risk group, nor engage in any specific high risk behavior (UNAIDS 2002a: 70).

Because of the potential severity of the HIV/AIDS epidemic in China, there have been several initiatives aimed at projecting its future course (e.g. UNAIDS 2002a; National Intelligence Council 2002; WHO 2002a, 2002b). The major challenge faced by these attempts is the lack of national scientifically valid data on HIV infections and AIDS cases in China (UNAIDS 2002a; China CDC/U.S. CDC 2002; Morrison and Gill 2003). These national projections of HIV/AIDS have therefore been based on either consensus estimates suggested by experts (National Intelligence Council 2002) or educated guesses

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[1] 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.

on the size of each risk-group applied to the available seroprevalence data (Stover and Staneki 2001: 4).[2] These projections concur that China might become, after India, the highest HIV-infected country in the world within the next five to ten years (Gill 2002), with between 10 and 20 million of HIV infections by 2010 unless effective measures are implemented (National Intelligence Council 2002).

All these estimates and projections have been based on national average rates of HIV infection in China, and are therefore limited in at least two main respects. First, they do not account for the heterogeneity of HIV rates and risk in different provinces. This might problematic, because both China's health and mortality profile (Banister 1987; Hao, Arriaga and Banister 1988; Hao 2000; Wolf et al. 2003) and the characteristics of the HIV/AIDS epidemic (National Center for HIV, STD and TB Prevention, CDC, and U.S. Department of Health 2001; UNAIDS 2002a) vary greatly by province. Second, average rates of HIV infection based on educated guesses on the size of high-risk groups at the national level introduce large margin of errors in the estimates (UNAIDS/WHO 2003). Province-specific estimates and projections might therefore be crucial for a better understanding of the HIV/AIDS epidemic in China, and might be necessary for more focused policy interventions at the sub-national level. 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,

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[2] In concentrated epidemics, HIV prevalence in the 15-49 year old population is generally obtained by summing estimates of HIV prevalence in each risk-group. This, in turn, is calculated as the estimated HIV prevalence rate from surveillance data multiplied by the estimated size of the risk group (WHO 2002a).

Table 1). However, separate estimates of the future demographic impact of HIV/AIDS for individual Chinese provinces have not yet been made.[3]

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 Thailand and Myanmar—is the "birth place" of the HIV/AIDS epidemic in China (Sun et al. 1994) and today one of the worst-affected provinces, which accounted for about half of China's HIV-infected population at the end of 2000 (National HIV Sentinel Surveillance Group 2001). Yunnan represents 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, whereas in all other Chinese provinces the epidemic remains still concentrated among the high-risk population (Xiaobo et al. 2002; Hesketh et al. 2003; US Census Bureau 2003). Yunnan therefore permits tracing the possible evolution of HIV/AIDS in other provinces, as well as nationwide, if HIV spreads from high-risk groups to the general population.

2. Patterns and Trends of HIV/AIDS in China

The lack of scientifically valid data has introduced a large margin of error in current estimates of the HIV/AIDS epidemic in China. Although an official figure indicates that

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[3] UNAIDS, as part of its regular work, does not make 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).

there were about 30,000 reported HIV infections in China at the end of 2001, according to the latest estimates of the Chinese government one million people might currently be infected with HIV (*Xinhua News Agency*, November 20, 2002). UNAIDS and other international organizations calculate that between 800,000 and 1.5 million people are infected, but warn that these might be extremely conservative estimates (UNAIDS 2002a; WHO 2002; Human Rights Watch 2003). Indeed, the U.S. intelligence estimates that China had between one and two million HIV carriers in 2001 (National Intelligence Council 2002). And in June 2002, an unnamed UN official told the New York Times that there could have been as many as 6 million HIV cases in China at the end of 2001 (*New York Times*, June 28, 2002).

These national averages conceal, however, large differences in the estimated size of the HIV/AIDS epidemic between Chinese provinces. Concomitantly, there is a low prevalence nationally but a high-level prevalence in specific populations and certain regions (Ministry of Health/UNAIDS 2003: 2). This is the case in every country, but it might be particularly so within a huge and populous nation such as China, whose health and mortality profile varies greatly by province (Banister 1987; Hao, Arriaga and Banister 1988; Hao 2000; Wolf et al. 2003).

[Table 1 about here]

Table 1 presents the distribution of average HIV prevalence among selected high-risk, urban populations in Chinese provinces in 2000 (comparable data for rural populations are not available). Average HIV prevalence among intravenous drug users (IDUs) varies between 0.1 percent in Qinghai province to 60.2 percent in Xinjiang province. Signs of

heterosexually transmitted HIV epidemics by prostitutes can be found in at least nine provinces, with average HIV rates reaching 6.2 percent in Guangxi province. There are also large variations within provinces. For example, the HIV prevalence among IVUs was found to range from 35 percent to 79 percent in selected communities in Xinjiang province.

The differential impact of HIV/AIDS at the sub-national level is due to the fact that three distinct epidemics have been occurring in China: first, an epidemic among IDUs, concentrated, until recently, in western and southern China and related to the sharing of needles and syringes; second, 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; third, an epidemic in provinces in east-central China related to exposure of paid plasma donors to HIV-contaminated blood during the donation process (Ministry of Health/UNAIDS 1997; National Center for HIV, STD and TB Prevention, CDC, and U.S. Department of Health 2001; UNAIDS 2002a). The first epidemic originated in Yunnan province in the late 1980s, the "birth place" of the HIV/AIDS epidemic in China (Sun et al. 1994). HIV entered Yunnan from women who had returned from Thailand after working as commercial sex workers there. Research on the genetics of HIV has shown that HIV then spread along the main drug routes from Yunnan through Sichuan and Gansu to Xinjiang, as well as from Yunnan eastwards to Guangdong province (for a review of this research, *see* Yang et al. 2002).

The future evolution of each epidemic depends on the extent to which HIV will spread among high-risk groups, and from high-risk groups to the general population. 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). Surveillance data clearly show the discrepancy of HIV prevalence between the two (*see* Table 1). In all provinces, the HIV infection rate ranges from 0.1 percent to 7 percent among sex workers, but it is as high as 50-70 percent in drug users. 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 200b: 42).

However, several studies have shown that there might be at least[4] one emerging generalized epidemic in Yunnan province.[5] Sentinel surveillance detected a HIV epidemic among pregnant women in Yunnan as early as 1991 (US Census Bureau 2003). Between 1991 and 1997 average HIV prevalence among ANC women remained below 0.2 percent. In 1998, a prevalence of 0.4-0.5 percent was recorded in two sites and in 1999 Dali prefecture recorded a prevalence of 1.63 percent. By 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: 21). In 2001, the HIV prevalence in pregnant women was still, on average, 0.2 percent, but reached 2.2 percent in Longchuang county of Dehong prefecture and was rapidly increasing in other two counties in the same prefecture, Chuxiong and Lijiang (Xiaobo et al. 2002). A pilot study of about 10,000 people

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[4] As it will be discussed in the next section, the sentinel surveillance system does not target pregnant women in all provinces.

[5] Sample surveys and the surveillance system have, as of 2001, failed to identify positive HIV infection rates among pregnant women in the other three provinces that have been hit hardest by the epidemic, namely, Sichuan, Guangdong, and Guangxi (US Census Bureau 2003). 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.

attending the mandatory premarital examination at four selected sites in Yunnan province revealed a HIV prevalence of 0.75 percent in 2002 (Hesketh et al. 2003). A study in 2001 also revealed that the HIV prevalence in unlinked sample of high-level epidemic region had already passed the 1 percent mark (Xiaobo et al. 2002).

The emerging generalized epidemic in Yunnan province provides a unique opportunity to evaluate the spread of HIV/AIDS at the sub-national level in China. It allows the estimation and projection of HIV/AIDS on the tenable assumption of heterosexual epidemics, thus greatly diminishing the error related to estimating the size of high-risk groups.[6] In addition, it permits tracing the possible evolution of the HIV/AIDS epidemic in other provinces, as well as nationwide, if HIV unfolds from high-risk groups to the general population.

3. Data and methods

3.1 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. The second step involved using a simple epidemiological program developed by UNAIDS (EPP, Epidemic Projection Package[7]) to determine—on the basis of the prevalence estimates—

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[6] The assumption of heterosexual epidemic has been incorporated also in national projections (e.g. Eberstadt 2002; Wolf et al. 2003). At the national level, however, this assumption is not very plausible, because existing evidence is insufficient to show that HIV has spread among the general population.
[7] The Epidemic Projection Package (EPP) replaces EPIMODEL, which was developed by the Global Programme on AIDS at a time when very little surveillance data was available. The new EPP model is

the epidemic curve that best described the spread of HIV in the province. The final step relied on another computer program developed by UNAIDS (Spectrum) to read the prevalence projections produced by EPP and compute, on the basis of population estimates from the 2000 census, estimates of HIV incidence and AIDS-related mortality between 2000 and 2010 (Figure 1). The specific procedures followed in each step and the data used for the present analysis are described in the next sections.

[Figure 1 about here]

3.2 Constructing time series of HIV prevalence

The sources of information that can be used to estimate the number of people living with HIV/AIDS depend on the type and pattern of the epidemic, the coverage of the surveillance system, and the quality of the surveillance data.

Assumptions on the type and pattern of the epidemic. First, some basic presumptions about the nature of the HIV/AIDS epidemics in Yunnan province had to be made. These particular assumptions affect all subsequent calculations—but the only truly critical one considered in the present analysis was that in Yunnan the epidemic would be essentially heterosexual in nature. As it has been discussed earlier in this paper, this assumption is consistent with the available evidence.

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designed to take advantage of the much larger number of sites and years for which surveillance data is now available in many countries (UNAIDS Reference Group on Estimates, Models and Projections 2002). Despite its limitations, EPP, as EPIMODEL, continues to provide an attractive option because it requires more easily obtainable data than bio-behavioral models and presents a more satisfactory modeling alternative to other simple models (Heuveline 2003: 219).

The sentinel surveillance system. 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, reduces the reliability of information on HIV/AIDS-attributable mortality.[8] Sentinel surveillance systems, on the other hand, have emerged in all Chinese provinces, starting with Yunnan in 1991 (Hehe 2000). China's comprehensive HIV sentinel surveillance then begun in 1995. The system currently exist both at the national level within the National Center for AIDS Prevention and Control (NCAPC), an agency within the Chinese Academy of Preventive Medicine, 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. 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, CDC, and U.S. Department of Health 2001). Data on serosurveillance of HIV/AIDS in China is distributed to the public by the U.S. Census

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[8] For a detailed review of China's HIV/AIDS reporting systems, *see*: China CDC/U.S. CDC 2002: 13-19.

Bureau in its HIV/AIDS Surveillance Database, which is the data source used for the present analysis (Table 2).[9]

[Table 2 about here]

Coverage of the surveillance system. The major challenge in estimating HIV/AIDS at the sub-national level in China is represented by the availability and quality of the necessary data, which vary widely among the different provinces. 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 CDC/US CDC 2002: 8). At the sub-national level, however, the sentinel surveillance program exhibited large differences in geographic coverage, and in regards to the population sub-groups included in the surveys (Figure 2 and Table 3). Yunnan province had 47 of the 158 surveillance sites in the country, and the most comprehensive program that included IDUs, STI clinic attendees, sex workers and their clients, antenatal women, and hospital patients (National Center for HIV, STD and TB Prevention, CDC, and U.S. Department of Health 2001). Yunnan was also the only province with surveillance sites in rural areas as well as large and middle cities.

[Figure 2 and Table 3 about here]

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[9] 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.

Data quality. Not only the coverage, but also the quality of work done by the sentinel stations differs between provinces (China CDC/US CDC 2002). An assessment of the HIV surveillance systems in Guangdong, Jiangsu, and Shandong Provinces (China CDC/US CDC 2002) has found that although sites, in principle, implement a standard national HIV sentinel surveillance protocol, in reality, survey methods outlined in the protocol are not being implemented consistently or uniformly. Furthermore, oversight of the sentinel survey operations by national and provincial level staff is limited due primarily to the lack of human and financial resources at the national level. When funds are limited, confirmatory WB testing may not be done, and such cases lacking WB tests are not counted or reported. Since the CDC evaluation did not target Yunnan province, it is not possible to asses to which extent these problems affect its sentinel surveillance system. However, it can be noted that Yunnan's government has been extremely aggressive towards the problem. Over the past 10 years, the province has received assistance funds totaling approximately 100 million yuan (US$12 million) from the United Nations Children's Fund, the Joint UN Program on HIV/AIDS, the Asian Development Bank and non-governmental organizations in Australia, Britain and other countries. These funds are three times those generally allocated by provincial governments for HIV prevention and control in other provinces (US Embassy Beijing 2000d). With these funds, the province has launched prevention and treatment of HIV and AIDS programs in more than 20 cities and counties. Particularly, Yunnan has established an HIV/AIDS monitoring system which consists of a provincial-level AIDS and venereal diseases prevention and treatment center, 36 preliminary test labs, 49 AIDS

monitoring   stations   and   29   venereal   disease   monitoring   stations
(http://www.china.org.cn/english/China/50324.htm, accessed on October 10, 2003).

3.3 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-1 at the province level (the methodology behind this approach
is described in detail in: UNAIDS Reference Group on Estimates, Models and
Projections 2002: 38-48).

The model requires six demographic parameters to fit the surveillance data[10]: 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 2000 census data, and are summarized in Table 4.

[Table 4 about here]

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

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[10] 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).

starts later. To improve fitting of the epidemic curve, I have tried a range of beginning years of the epidemic between 1991 (the year when the epidemic among pregnant women in Yunnan province was first identified) and 1997. Resulting estimates of HIV prevalence in 2010 ranged between 1.5 and 5.3 percent and between 0.4 and 11.4 percent in 2020. I therefore identified three scenarios for the disease, which I termed "severe", "intermediate", and "mild" (Figure 3). In the first scenario, mean adult HIV prevalence exhibits an increasing trend until it peaks in 2020 at 11.4 percent; in the second scenario, HIV prevalence peaks in 2015, reaching 3.7 percent; and in the last scenario, the epidemic curve peaks early in 2010, at 1.5 percent. It will be discussed later how these different scenarios fall within the current expectations of informed independent observers about the future course of the epidemic at the national level.

[Figure 3 about here]

3.4 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 produces 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 I therefore computed population projections for the period from 2000 to 2020 on the basis of the 2000 census data under one set of mortality assumptions (in the absence of AIDS) and three scenarios of fertility assumptions, as described in Appendix. Since estimates and

projections of HIV/AIDS in Yunnan differ only marginally in the three cases, the results are presented only for the intermediate fertility scenario.

4. Results and discussion

4.1 HIV/AIDS estimates for Yunnan province, 2000

According to the EPP estimates, in 2000 HIV prevalence among the general population in Yunnan province was 0.5 percent (*see* Figure 3), which translated into 120,000 HIV infections (Table 5a). Since the epidemic was not yet generalized in 2000 and infections among high-risk groups accounted for 80 percent of all infections (Yang et al. 2002), the HIV-infected population of Yunnan province might have been around 600,000 people at the end of 2000. Sentinel surveillance shows that Yunnan accounted for 40 percent of all HIV cases nationwide at the end of 2000 (National HIV Sentinel Surveillance Group 2001). The estimates presented in this paper therefore imply that the total number of HIV infections at the national level might have been as high as 1.5 million. If the proportion of national HIV infections in Yunnan is allowed to range between 20 and 60 percent[11], the estimates presented in this paper imply a nationwide total between one and three million of HIV infections. All these figures are well within the range of informed assessments today (*Xinhua News Agency*, November 20, 2002; UNAIDS 2002a; WHO 2002; National Intelligence Council 2002; *New York Times*, June 28, 2002; Human Rights Watch 2003), as it has been discussed earlier.

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[11] 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 2000c).

4.2 HIV/AIDS projections for Yunnan province, 2000-2020

The projections presented in this paper indicate that HIV prevalence among the general population might pass the 1 percent mark as early as 2003 in the most pessimistic scenario, and reach 4 to 11 percent in case of a mild and severe epidemic, respectively.[12] Yunnan province alone could therefore have between one and two million of HIV infections by 2010—the estimated number of infections nationwide in China today—and a total of 1.4 to 8 million by 2020 (Table 5a and 5b). The corresponding death toll ranges from 80,000 to 350,000 deaths by 2020 (Table 5c).

[Table 5a, 5b and 5c about here]

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 most pessimistic scenario considered in the present analysis posits an eventual adult HIV prevalence rate in Yunnan province alone as high as those in the so-called "low scenario" modeled by the U.S. Census to describe possible future HIV paths for urban Africa (US Census Bureau 1999, Table B-1). The 11 percent adult HIV prevalence rate that the severe epidemic scenario ascribes to Yunnan in year 2020 can be further compared against UNAIDS' estimate of a sub-Saharan-wide prevalence rate of 8.8 percent for year-end 2002, and particularly with Cameroon's HIV prevalence of 11.8 percent, which has doubled since 1998 because of the explosive surge of the epidemic among young women (UNAIDS 2002b).

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[12] These projections do not indicate how the trend in HIV infection among high-risk groups will parallel that of infections in the general population before the epidemic becomes generalized, but it can be reasonably assumed that, after that moment, the HIV prevalence presented here capture both groups.

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 2002b). In Cambodia, an explosive epidemic during the early 1990s drove HIV prevalence among pregnant women to peak at 3.2 percent in 1996. Thanks to sustained prevention efforts focused on sex workers, HIV prevalence then steadily declined to 2.8 percent in 2000. HIV prevalence among ANC tested in Myanmar's cities of Yangon and Mandalay increased from no evidence of infection in 1992 and 1993 to 0.8 percent in 1995. HIV prevalence among ANC in urban areas remained about 2 percent in 1998, 1999 and 2000, but outside the major urban areas, it reached up to 5 percent in 2000.

In the mild epidemic 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 ANC peaked at slightly over 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.

4.3 Implications for estimates and projections of HIV/AIDS in other Chinese provinces

The epidemic curve estimated for Yunnan province can be used as a model for the trajectory of HIV/AIDS in other Chinese provinces (as the infection spreads from high-risk groups to the general populations), depending on the year at the onset of the epidemic but especially on the specific fertility and mortality conditions in the absence of AIDS.

In order to illustrate this point, let us consider Xinjiang province. Sentinel surveillance detected an emerging generalized epidemic among pregnant women in 1998, at about the same time as in Yunnan province. HIV prevalence in ANC peaked at 1.5 percent at the end of 1999 (US Census Bureau 2003).[13] In 2000, 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 Figure 4 and 5. Assuming the same epidemic curve of Yunnan province, in all three scenarios considered 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.

[Figure 5 and 6 about here]

This example highlights the heterogeneity of mortality risks due to AIDS across Chinese provinces, and the importance of provincial estimates and projections of HIV/AIDS for a better understanding of the epidemic at the national level.

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[13] See footnote 5.

<u>4.4 Implications for nationwide projections of HIV/AIDS</u>

What inferences can be made from the results of the present analysis about the course of the national HIV/AIDS epidemic in China? The answer to this question crucially depends on assumptions about the proportion of HIV infections in Yunnan province as percentage of the national total.

[Table 6 about here]

Let us consider the four situations presented in Table 6 for illustrative purposes. In a conservative scenario ("intermediate" epidemic), the cumulative number of HIV infections nationwide in 2010 ranges between about 4 million and 7.5 million, depending on whether the proportion of infections in Yunnan province remains at the same level as in 2000 (40 percent) or becomes cut in half by 2010 (20 percent). In a more extreme scenario ("severe" epidemic), the corresponding number of HIV infections nationwide ranges between 5 and 10 million.

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 4 to 6 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 (Gill 2002).

4.5 Limitations of the analysis

The major problem with estimates of HIV prevalence based on surveillance data is their high 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.[14]

The first set of issues relates to the use of sentinel surveillance data collected predominantly in urban areas. In fact, there may be systematic differences in urban and rural areas, and this difference is not being fully captured by the seroprevalence data used for the analysis in this paper. To eliminate this problem, surveillance sites would need to provide the same coverage of both urban and rural areas in each province. A related 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 (at least five years ahead all other Chinese provinces) and targeted pregnant women attending antenatal clinics (ANC) 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. Policy reforms are needed to improve the ability to collect

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[14] A detailed discussion of the general limitations of estimates and models of HIV and AIDS based on the EPP model can be found in Schwatlander et al. 1999.

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 in this paper 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. Although several studies have shown that this is generally the case in Sub-Saharan Africa (for a review, *see*: Zaba et al. 2000a, 2000b), this assumption has not been validated for Asian populations. This, however, might be an important source of bias particularly in China, where fertility is low and therefore 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.

5. Conclusions

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.

The estimates presented in this paper indicate that the HIV-infected population of Yunnan province might have been around 600,000 people at the end of 2000. These results provide supporting evidence for current informed assessments of the proportions of the HIV/AIDS in China, which indicate a nationwide total between one and three million of HIV infections. The corresponding projections indicate that HIV prevalence among the general population might pass the 1 percent mark as early as 2003 in the most pessimistic scenario, and reach 4 to 11 percent in case of a mild and severe epidemic, respectively. Yunnan province alone could therefore have between one and two million of HIV infections by 2010—the estimated number of infections nationwide in China today—and a total of 1.4 to 8 million by 2020. The major implication of the estimates and projections presented in this paper is that 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 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 4 to 6 million of infections by 2010.

There are, however, shortcomings with the current system of monitoring the epidemic in Yunnan province, and improvements in the surveillance system are needed especially to ensure equal coverage of urban and rural areas. In addition, further research is needed

to validate for Asian populations 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. This will permit increased precision of future estimates.

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Appendix

The prevalence projection created with EPP can be used to estimate the numbers of people infected, new infections and AIDS deaths. These estimates are made using the Spectrum program. Spectrum is a policy modeling system, which contains modules for a number of reproductive health areas. For the purposes of making a national HIV estimate two Spectrum modules are used: DemProj for the demographic projection and AIM for the epidemiological projection. This Appendix describes the underlying assumptions used to compute population projections in absence of HIV/AIDS mortality with DemProj/Spectrum.

Population projections in DemProj/Spectrum require assumptions on the base year distribution, on future trends in fertility and mortality at the province level, and on migration between provinces. Assumptions regarding the most appropriate life tables for fertility and mortality are also required. Projections of Yunnan's population have been prepared for 2000-2020 on the basis of the 2000 census age structure under one set of mortality assumptions and three scenarios of fertility assumptions, as described below.

Assumption on the base year age distribution. The age distribution of Yunnan province is given in Table A1. These are the original 2000 census data, as tabulated, without adjustments.

Assumptions on future trends in fertility. Assumptions on future trends in fertility are made for Yunnan on the basis of extrapolation of the past trends in the available values of the total fertility rates (TFR) between 1975 and 2000 (Table A2). Fertility has fallen rapidly in Yunnan since 1975, with the TFR dropping from 5.3 to 1.8 in 2000. The largest decrease in TFR (from about 5 to 3 children per woman) happened in the late 1970s and then continued with large fluctuations

until the late 1980s. The potential for fertility decline created by the socioeconomic changes of 1970-80s tended to be exhausted by the 1990s, leading to a slow decrease in TFR around replacement level. Three kinds of fertility assumptions are provided in light of this trend of fertility change in Yunnan province. First, a somewhat loose one, envisaging the TFR remains constant at the 2000 level (1.8) throughout the projection period. Second, an assumption of an increasingly reduced rate of decline, positing a linear decrease until the floor value of 1.5 in 2020. Fertility might slow down to decline because of the recent emphasis of the central government to relax the implementation of the one-child policy during the next decade. The third set of assumptions on fertility is similar to those of the above except that the floor values for the TFR in Yunnan were assumed to be 1.5 rather than 1.0. It was assumed that the fertility levels would not decline below 1.0 based on the current experience of lowest fertility levels achieved in developing and developed countries.

Assumptions on future trends in mortality. The life expectancy at birth in Yunnan Province reached 65.86 years for females and 68.77 years for males in year 2000 (Table A3). Base on empirical patterns of mortality transition, improvements in life expectancy becomes increasingly slower after reaching a certain level. According to United Nations estimates, when life expectancy at birth reaches 67.5-70 years, its quinquennial gains stand at 0.75 years for males and 1.80 years for females. In this paper, the male and female life expectancies of Yunnan Province for the projection period 2000-2020 are calculated based on these empirical values, taking the 200 census life expectancy as the starting point (this pattern of mortality is approximately the same as that obtained by extrapolating the past trends in life expectancy at birth available between 1973 and 2000 fitting a logarithmic trend). For any given expectation of

life the age patterns of mortality indicated in the Coale-Demeny North Model Life Tables were assumed for the purposes of projection.

Assumptions regarding migration. It was assumed, in the absence of any specific data, that there would be no large-scale inter-province migration in China during the projection period of 10 years. Although this is a serious assumption given the increasing importance of migration within Mainland China, the lack of scientific nationally valid data did not permit the estimation of inter-province migration.

Table A1. *First year population: Yunnan province, 2000*

Age group	Males	Females
0-4	1796329	1590751
5-9	1873762	1657488
10-14	2129164	1949207
15-19	1875938	1678772
20-24	2098870	1870514
25-29	2420027	2097044
30-34	2268156	1976418
35-39	1850079	1644808
40-44	1171928	1064320
45-49	1186850	1108967
50-54	903466	837478
55-59	731630	694421
60-64	668425	634984
65-69	526338	521305
70-74	374677	399789
75-79	197003	243959
80+	121701	195521

Source: My calculations from Population Census Office, 2002 (CD-ROM), various tables.

Table A2. *Total fertility rate (TFR): Yunnan province, 1975-2020*

Year	TFR
1975	5.3
1980	3.2
1985	3.0
1990	2.2
2000	1.8
2020	*1.8 / 1.5 / 1.0*

Note: Figures in *italics* are projected values.

Sources: The data series 1975-1985 is from: Li (1990), Table 1.1 and Table 1.2; the data series 1986-1992 is from: Jiang (1995), Table 2-3; data for year 2000 are the original census data, as tabulated, without adjustments.

Table A3. *Life expectancy at birth* (e_0)*: Yunnan province, 1973-2020*

Year	e_0 Males	e_0 Females
1973-75	59.80	61.35
1990	62.08	64.98
2000	65.86	68.77
2005	*66.61*	*70.57*
2010	*67.36*	*72.37*
2015	*68.11*	*74.17*
2020	*75.30*	*72.32*

Note: Figures in *italics* are projected values.

Sources: Values for 1973-75 are from Banister (1987), Table 4.9, p. 95; values for 1990 are from Hao (2000), Table 4.10, p.43; values for 2000 are calculated from original census 2000 data, unadjusted.

Tables

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

Data sources: US Census Bureau HIV/AIDS Surveillance Database (2003); National HIV Sentinel Surveillance Group (2001).

Table 2. *Surveillance data on seroprevalence of HIV-1 (percent) among pregnant women attending antenatal clinics in Yunnan Province, 1991-2000 (sample sizes in parentheses)*

Surveillance sites	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Dali								0.00 (191)	1.63 (123)	
Kaiyuan								0.47 (638)	0.14 (717)	
Kunming								0.11 (874)	0.42 (480)	
Longchuan								0.39 (768)	0.14 (729)	
Yingjiang								0.12 (800)	0.12 (800)	
Baoshan								0.00 (308)	0.54 (368)	
Other	0.20 (492)	0.00(1234)	0.04(2387)	0.10[a]	0.10[a]	0.20[b]	0.10[c]	0.20[d]	0.22(6417)	0.20[e]

Data source: US Census Bureau (2003).

[a] Average of 5 surveillance sites. [b] Average of 6 surveillance sites. [c] Average of 7 surveillance sites. [d] Average of 10 surveillance sites. [e] Average of various surveillance sites.

Table 3. *Distribution of populations assessed by HIV sentinel surveillance in China, 2002*

	STD Patients	Female Sex Workers	Injecting Drug Users	Long-Distance Truck Drivers	Pregnant Women	Men/Sex with Men	Other	Total
National	63 (40%)	34 (22%)	38 (24%)	9 (6%)	13 (8%)	1 (0.6%)	---	158
Provincial	147 (37%)	57 (14%)	92 (23%)	23 (6%)	45 (11%)	---	47 (12%)	411

Source: China CDC / U.S. CDC (2002), Table 1, p.8.

Table 4*. Parameters used for EPP estimation, 2000*

Total 15+ population	31,363,388
Proportion male	52.28 %
Birth rate for adults 15+	22.29 ‰
Survival to age 15	99.44 ‰
Mortality for adults 15+	7.88 ‰
15+ population growth rate	14.41 ‰

Note. The values presented in the table are unadjusted for census undercount, age misreporting, and underregistration of births and/or deaths.

Source: My calculations from Population Census Office, 2002 (CD-ROM), various tables.

Table 5a. Estimated number of HIV infections in the general population (thousands): Yunnan Province, 2000-2020

Year	Mild epidemic	Intermediate epidemic	Severe epidemic
2000	120	120	120
2005	351	440	490
2010	441	950	1,520
2015	302	1080	2,830
2020	145	750	3,030
Total 2000-2010	921	1,510	2,130
Total 2000-2020	1,359	3,340	7,990

Table 5b. Estimated number of new AIDS cases in the general population: Yunnan Province, 2000-2020

Year	Mild epidemic	Intermediate epidemic	Severe epidemic
2000	810	560	410
2005	5,580	5,960	5,590
2010	23,110	33,790	41,890
2015	31,680	71,470	122,920
2020	17,540	77,820	219,670
Total 2000-2010	29,500	40,310	47,890
Total 2000-2020	78,720	189,600	390,480

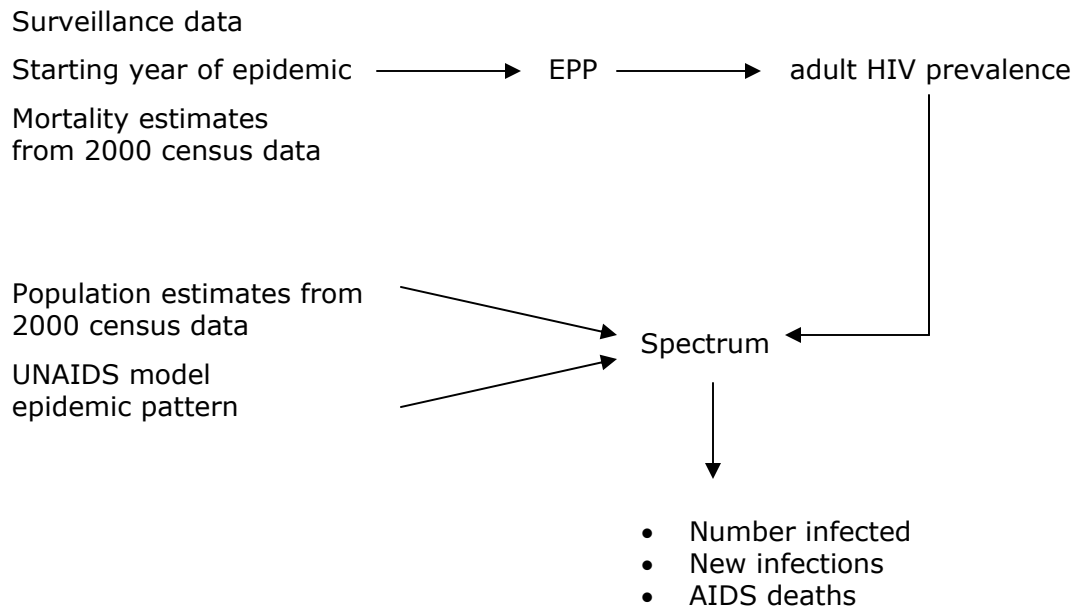*Table 5c. Estimated number of AIDS deaths in the general population: Yunnan Province, 2000-2020*

Year	Mild epidemic	Intermediate epidemic	Severe epidemic
2000	670	470	360
2005	3,910	4,000	3,950
2010	18,970	26,230	31,440
2015	31,960	64,730	102,240
2020	21,540	80,960	204,970
Total 2000-2010	23,550	30,700	35,750
Total 2000-2020	77,050	176,390	342,960

Table 6. *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%	25%	20%
Severe epidemic	5,325	7,100	8,520	10,650
Intermediate epidemic	3,775	5,033	6,040	7,550
Mild epidemic	2,303	3,070	3,684	4,605

Figures

Figure 1. *Method to estimate HIV prevalence and AIDS-related mortality in Chinese provinces by using EPP and Spectrum*

Figure 2: Geographical distribution of national sentinel sites in China, 2002

☆ Men sex with men
● STI clinic attendee
■ Sex worker
▲ Drug user
◆ Long-distance truck driver
✳ Pregnant woman
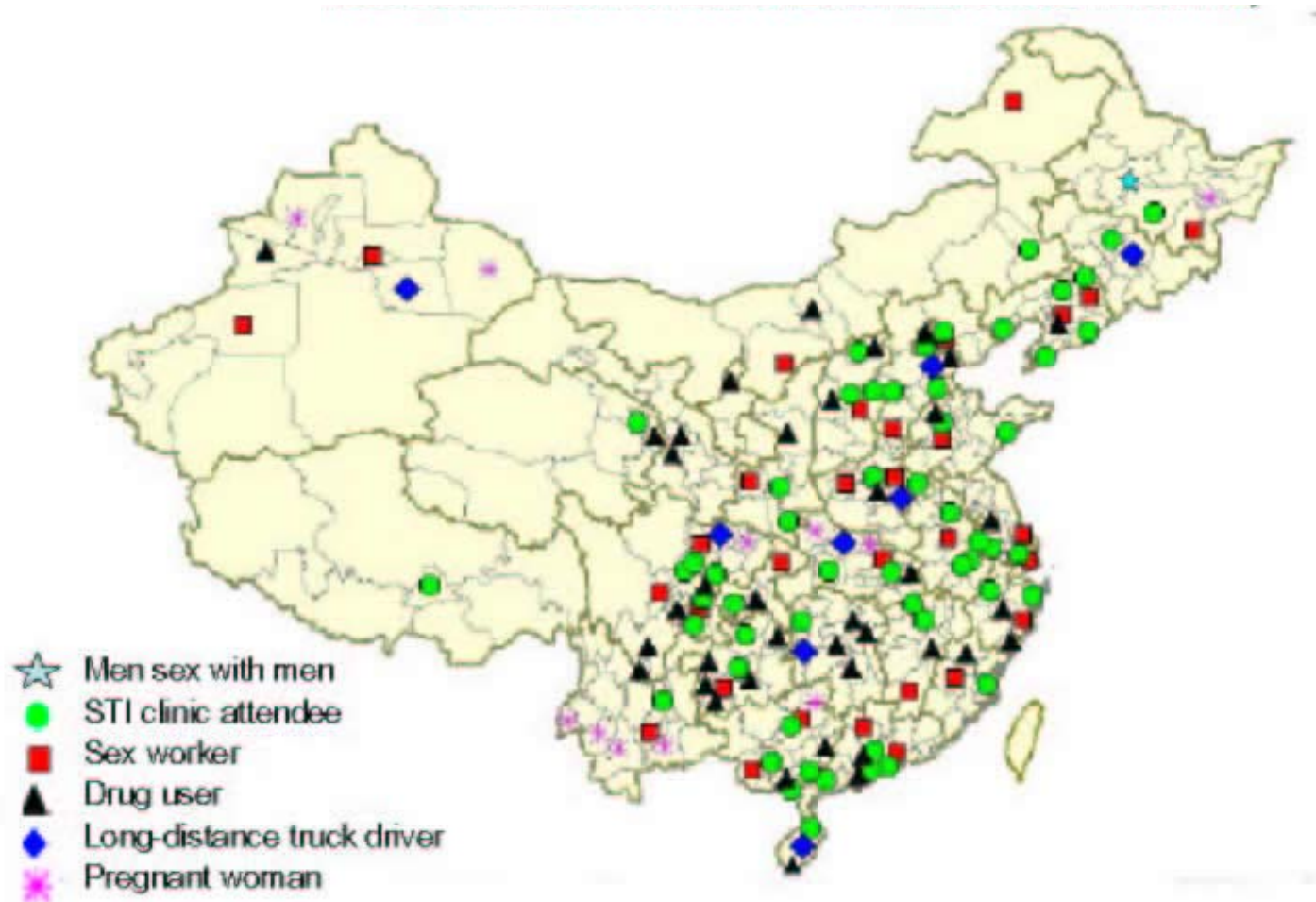
Source: US CDC/ China CDC (2002), Figure 2, p.9.

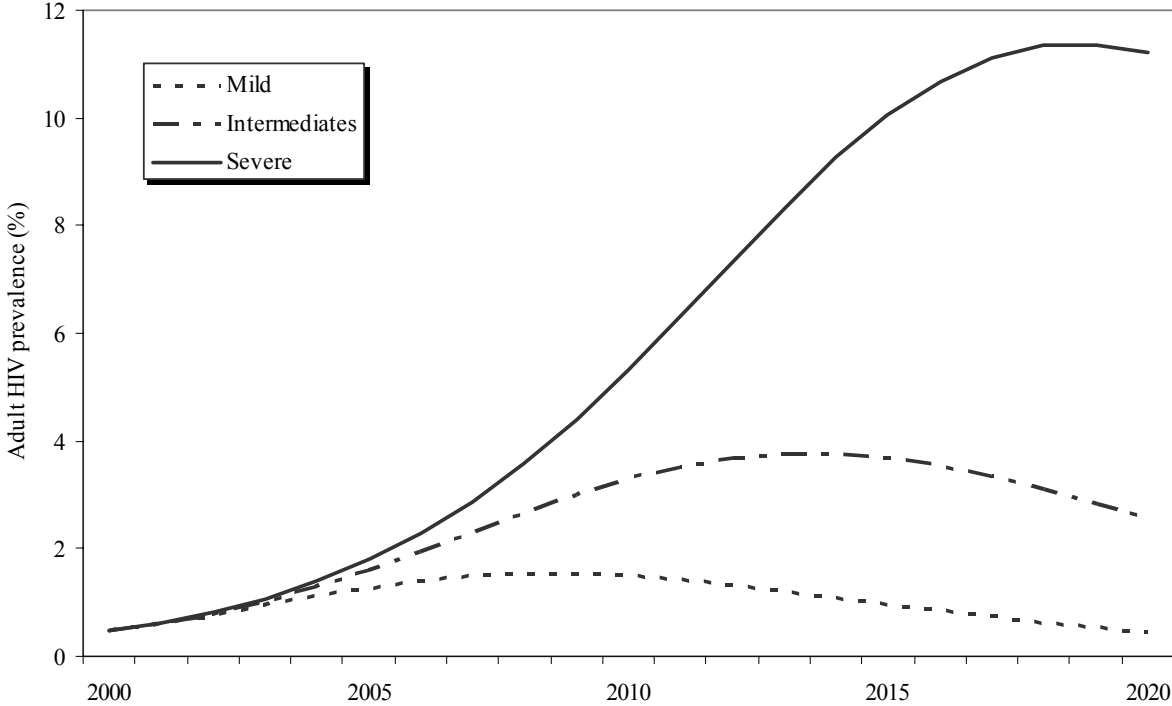***Figure 3***. *Yunnan adult HIV prevalence: three scenarios: 2000-2020*

Figure 4. *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*
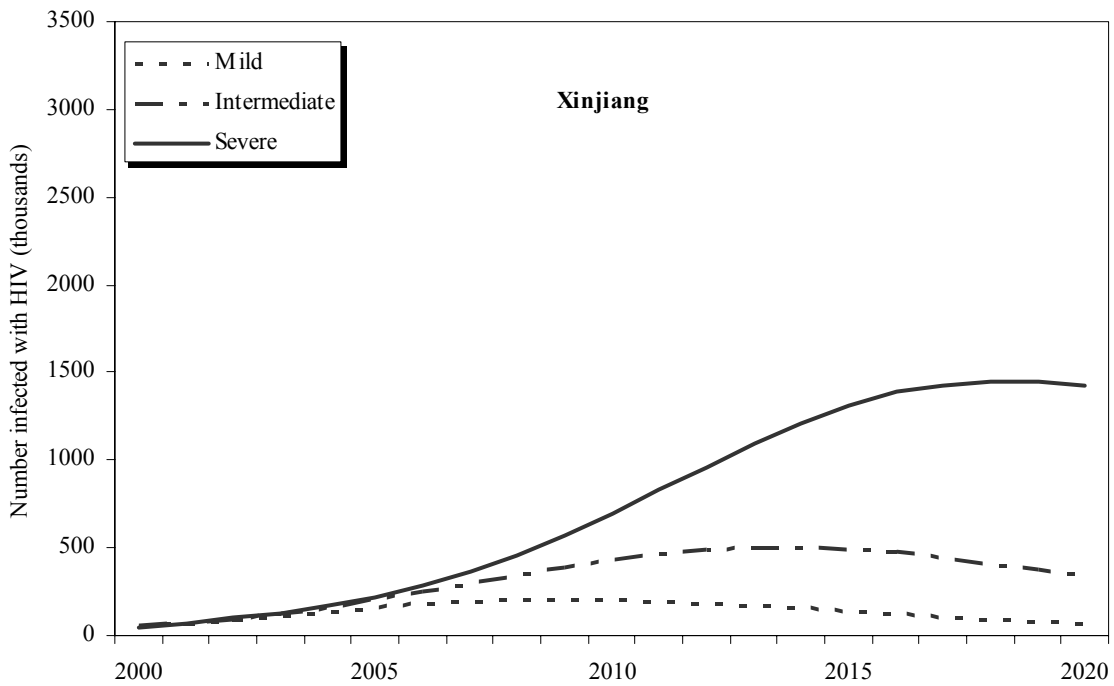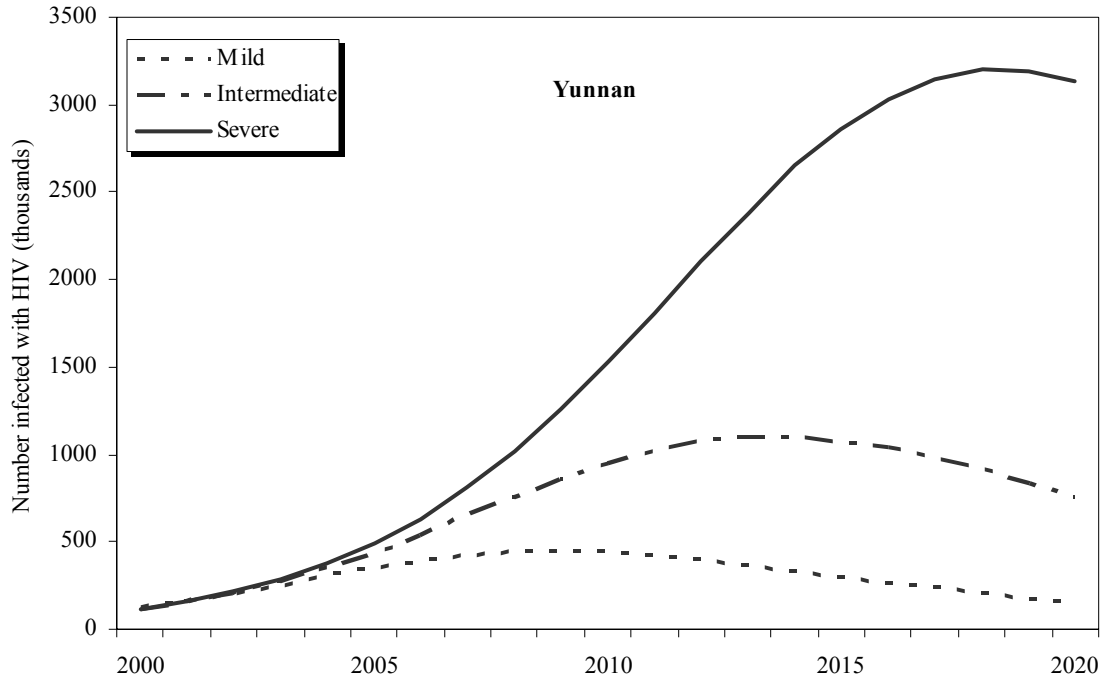
Figure 5. *Number of AIDS deaths in Yunnan and Xinjiang province, under the assumption of Yunnan's epidemic curve and the same onset of the epidemic, 2000-2020*