ORIGINAL CONTRIBUTION

Projecting the Minimum Size of HIV Infection and AIDS Epidemic in China

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At present, intravenous drug users (IVDUs) comprise the largest risk group to develop acquired immunodeficiency syndrome (AIDS) in China, and their sex partners seem the second largest risk group. It is necessary to understand long-term trends in the spread of human immunodeficiency virus (HIV) among IVDUs and their sex partners and the trends about AIDS cases development for disease prevention and control. The compartment model was used to project the number of HIV infectious individuals and the number of AIDS patients for the next 10 years. The model assumes that transmission is concentrated among IVDUs and their sex partners according to the current situation. The model estimates that by the year 2002, the number of HIV positives will reach 2,891, AIDS cumulative cases to 1,124, out of which 776 will have died of the disease; if we include oral drug users who also have experienced intravenous drug use, HIV positives will be 3,304, AIDS cases 1,285, death 887; if unsurveyed IVDUs are included, HIV positives can be estimated to be 4,129, AIDS cases 1,606, death 1,109; with increasing knowledge about AIDS, if persons at risk stop their risk behaviour are doubled, HIV positives will be 2,496, AIDS cases 1,024, death 714. These conclusions indicate that prevention efforts among male IVDUs and their female sex partners must be appropriately directed.

The first AIDS case was recognized in the United States in 198119), and the etiological agent, the HIV was discovered in 198319). In China, serological screening of HIV antibody was begun in 198419), and AIDS surveillance was begun in 198519). The first indigenous HIV seropositive person was detected in 1986, who had had an experience of using foreign blood product19). The first AIDS case was diagnosed on January 198719). At present, 80% of HIV positive persons in China are concentrated in Yunnan Province, the border area between China and Myanmar19). According to the investigation conducted by Yunnan Provincial Health and Anti-epidemic Center of China, by the end of 1990, a total of 17,021 people had been surveyed and 429 HIV positives were detected (include 2 AIDS cases). 347 out of 1,292 HIV positives are IVDUs (27%), and 2 out of 68 are their sex partners(3%). 48 out of 4,088 HIV carriers are oral drug users who admitted to an intravenous drug use habit after further confirmation. 331 of 372 indigenous HIV positives belong to IVDUs and their sex partners19). Projecting the size of HIV infection and AIDS epidemic are of major importance for future health care prevention and disease control. Based on the fact that IVDUs and their sex partners are the main high risk group for contraction of AIDS in China, a compartment model was designed to project HIV positives and AIDS cases in IVDUs and their sex partners for the next 10 year. In this study, we take no account of the type of HIV, because there has been almost no report of HIV-2 epidemics in Asian countries, and because serological data in China were those of HIV-119).

METHODS

Several authors have used compartment models for projecting the HIV/AIDS epidemics in different population and situations8-11). This compartment model is aimed at the assumption that intravenous drug abuse is the main source of HIV transmission in China (Table...
Table 1. Surveillance of HIV/AIDS among different groups in Yunnan Province of P.R. China.

| Groups             | 1986-1988 T* | 1989 P* | %   | 1990-1992 T* | 1993-1995 P* | %   | 1996-1998 T* | 1999-2001 P* | %   | Total T* | 1999-2001 P* | %   |
|--------------------|--------------|---------|-----|--------------|--------------|-----|--------------|--------------|-----|----------|--------------|-----|
| ODUs               | 888          | 15      | 1.69| 3198         | 33           | 1.03| 4086         | 48           | 1.17|          |              |     |
| IVDUs              | 356          | 131     | 36.80| 936          | 216          | 23.08| 1292         | 347          | 26.86|          |              |     |
| HIPSs              | 15           |         |     | 52           | 2            | 3.77| 68           | 2            | 2.94|          |              |     |
| ODUSs              |              | 1       | 100.00| 1           | 1            | 100.00|          |              |     |
| Myanamarers        | 46           | 2       | 4.35| 349          | 28           | 8.02| 395          | 30           | 9.59|          |              |     |
| Foreigners         | 18           | 1       | 5.56| 9            |              |     | 7            |              |     | 34        |              | 2.94|
| Prostitutes        | 174          |         |     | 145          |              |     | 294          |              |     | 613       |              |     |
| HIPSs              | 8            |         |     | 362          |              |     | 370          |              |     |
| PSTD               | 27           |         |     | 144          |              |     | 171          |              |     |
| Homosexuals        |              | 3       |     |              |              |     | 3            |              |     |
| SAIDS              | 1            |         |     |              |              |     | 6            |              |     | 7         |              |     |
| TBPU's             | 35           |         |     | 2            |              |     | 28           |              |     | 65        |              |     |
| Prisoners          | 81           | 27      |     | 2778         |              |     | 2886         |              |     |
| BRs                | 502          |         |     | 248          |              |     | 2167         |              |     | 2917      |              |     |
| PGA                | 22           |         |     | 690          |              |     | 712          |              |     |
| PRA                | 373          |         |     | 82           |              |     | 458          |              |     |
| blood doners       | 123          |         |     | 762          |              |     | 885          |              |     |
| hospital staff     |              |         |     | 328          |              |     | 328          |              |     |
| RSPs               | 280          |         |     | 280          |              |     |              |              |     |
| SDWC               | 10           |         |     |              |              |     | 10           |              |     |
| Others             | 17           | 185     |     | 615          |              |     | 817          |              |     |
| RRPE               | 623          |         |     | 623          |              |     |              |              |     |

Total 1228 1 0.08 2077 148 7.13 13716 280 2.04 17021 429 2.52

Translated from reference7).
* T=number of tested persons; **P=number of HIV positive persons
ODUs=oral drug users; IVDUs=intravenous drug users;
HIPSs=HIV infected persons' spouses; ODUSs=oral drug users' spouses;
HPSs=habitual prostitute seekers;
PSTD=persons with sexually transmitted diseases;
SAIDS=suspected AIDI cases; TBPU's=transfusion or blood products users;
BRs=border residents;
PGA=persons going abroad; PRA=persons returning from abroad;
RSPs=persons returning from abroad;
SDWC=staff in drug-withdrawal clinic;
RRPE=recruits who receive physical examination.

Figure 1. Projecting model for male IVDUs and their sex partners. Flow of HIV. —— Flow of persons.

1. In addition, HIV transmission from male IVDUs to their female sex partners was also considered. These phenomena are illustrated by compartment model in which individuals are divided into infected and susceptible individuals at the beginning of year $t$ (Figure 1). The exact year that HIV was introduced into the IVDU population in China is unknown, but we will assume that it is 1988, for reasons presented in the discussion. This is an open compartment model because it allows for immigration and emigration.

1. The model
1.1. Estimation of susceptible and infected IVDUs
Susceptible individuals at risk in year $t$ are expressed as $S_t(t)$, which includes susceptible individuals from the year before $S_{t-1}(t-1)$ and people who became infected IVDUs this year ($n$s). In the year from $t-1$ to $t$, some susceptible males become HIV infected with the probability $r_1$ because of sharing needles with HIV infected IVDUs and leave the population as a result of detoxification, death or other reasons with the proba-
bility $dr$, so the expression will be:

$$S_1(t) = S_1(t-1) \times (1-r_1-dr) + ns$$

Infected individuals in year $t$ [$I_1(t)$] consist of infected individuals from the year before [$I_1(t-1)$] and newly infected individuals in the year between $t-1$ and $t$ who were susceptible the year before [$S_1(t-1)$] and become infected with the probability $r_1$. Furthermore, persons who developed AIDS symptoms $1$ year before [$a(t-1)$] are excluded. The expression is:

$$I_1(t) = I_1(t-1) + S_1(t-1) \times r_1 - a(t-1)$$

1.2. Estimation of susceptible and infected persons among sex partners of IVDUs.

We assumed that every IVDU has one sex partner, so newly susceptible females at risk in year $t$ [$S_2(t)$] are equal to male IVDUs who were HIV positives one year before [$I_1(t-1)$], that is:

$$S_2(t) = I_1(t-1)$$

Because of unprotected vaginal intercourse between year $t-1$ and year $t$, females get infected in year $t$ from male IVDUs who were HIV positives in year $t-1$ with the probability $r_2$. The expression is:

$$I_2(t) = r_2 I_1(t-1)$$

1.3. Estimation of AIDS incidence in year $t$ [$a(t)$]

Both male IVDUs and their female sex partners who get infected will develop AIDS gradually. Newly infected persons from year $t-1$ to year $t$ will develop AIDS according to the Weibull distribution with the scale parameter ($B_0$) and the shape parameter ($B_1$). Between year $1$ and year $n$, AIDS incidence in year $t$ [$a(t)$] can be expressed as:

$$a(t) = \sum_{i=1}^{t} f(t-i) \times [I_1(i) - I_1(i-1) + I_2(i) - I_2(i-1)]$$

where $f(t)$ is the Weibull incubation period distribution.

$$f(t) = F(t) - F(t-1); \quad t = 1, \ldots, n$$

$$F(t) = 1 - \exp(-B_0 \times t^{B_1}); \quad t = 0, \ldots, n$$

$F(t)$ indicates the cumulative distribution function for the time from HIV infection to the onset of AIDS.

1.4. Estimation of infected persons who are not AIDS [$b(t)$]

$$b(t) = \sum_{i=1}^{t} [1-f(t-i)] \times [I_1(i) - I_1(i-1) + I_2(i) - I_2(i-1)]$$

$$= I_1(t) + I_2(t) - a(t)$$

1.5. Estimation of the number of deaths due to AIDS

AIDS patients will die in first year after disease at a rate of $v_1$, in the second year $v_2$, ..., in the fifth year $v_5$. After the fifth year, the rates are neglected since they get smaller and more unstable. Death in year $t$ ($t=1$ to $n$) after onset $d(t)$ can be expressed as:

$$d(t) = \sum_{i=1}^{5} a(t-i) \times v_i$$

1.6. Initial conditions

We assume that HIV entered the male IVDU population in 1988. From then on, 350 males become IVDUs every year.

2. Parameters

Table 2 shows the parameters we have used to construct the model.

2.1. Newly susceptible individuals ($ns$)

No literature shows how many males will enter IVDU population and nor how many females will be their sex partner every year. However, considering the result of current surveillance\(^7\), we use 350 as the number of newly susceptible individuals ($ns$) among IVDUs every year and use the number of male IVDUs

| Parameters                                | Symbols | Values | References    |
|-------------------------------------------|---------|--------|---------------|
| Newly susceptible persons                 | $ns$    | 350    | assumed       |
| Probability that a male IVDU is HIV positive | $r_1$  | 0.2    | Zhao's result\(^7\) |
| Probability that a woman gets infected from infected man by sexual contact | $r_2$  | 0.19   | Fordyce EJ\(^2\) |
| Proportion of susceptible persons who exit before infection | $dr$   | 0.05   | assumed       |
| Shape parameter of Weibull distribution of incubation period | $B_0$  | 2.45   | Kuo JM\(^4\) |
| Scale parameter of Weibull distribution of incubation period | $B_1$  | 0.1008 | Kuo JM\(^4\) |
| Death probability for AIDS cases (by year) | $v_1$  | 0.484  | Lemp GE\(^1\) |
|                                            | $v_2$  | 0.324  | Lemp GE\(^1\) |
|                                            | $v_3$  | 0.115  | Lemp GE\(^1\) |
|                                            | $v_4$  | 0.037  | interpolated  |
|                                            | $v_5$  | 0.016  | Lemp GE\(^1\) |
who became infected the year before \(I_t(t-1)\) as the number of their female sex partners who are newly susceptible at year \(S_2(t)\).

2.2. Estimation of the probability that a male IVDU is HIV positive \(r_1\)

The exact probability is unknown. According to Zhao’s report\(^7\), seroprevalence of anti-HIV was 26.86% \(\left(347/1292\right)\) by the end of 1990. Furthermore, if we assume HIV entered the male IVDU population in 1988 and that 350 males become IVDUs every year, the probability 0.2 seems appropriate. With this probability, the projected number of HIV seropositives is approximately equal to that of Zhao’s report.

2.3. The probability of infection by male IVDUs to their sex partners \(r_2\)

Based on the method of Fordyce et al\(^{12}\), two kinds of formulae were used as follows. First: \(r_2 = \left[1-(1-p)N^N\right],\) where \(p\) is the risk of HIV infection, and \(N\) is the average number of sexual acts per year. The risk \((p)\) of HIV transmission by per unprotected vaginal intercourse for women is between 0.001 and 0.002. On the basis of these estimates of infectivity, the annual conditional probability of infection, \(r_2\), was found to be between 0.104 and 0.198 by using the exponent of the average number of unprotected acts of vaginal intercourse (110 per year). Here, we choose 0.19 as \(r_2\) which is near the upper bound.

2.4. Estimation of the proportion of susceptible individuals who leave the population before becoming infected \(d_r\)

This group consists of IVDUs who undergo detoxification (male), condom users (female), and individuals who die of non-AIDS causes (male, female), as well as those who migrate abroad. No study shows this proportion up to now, so we assume that 5% will exit before becoming infected for the time being.

2.5. Scale parameter of Weibull distribution of AIDS incubation period for AIDS \(B_0\)

Many authors have estimated the mean incubation period and/or incubation time distribution for AIDS\(^{13-18}\). Some authors express it directly as mean incubation period, while others use scale and shape parameters to express the incubation time period indirectly. Here, we choose Kuo JM’s parameters\(^{18}\). They used data from a cohort study of 177 homosexual or bisexual men enrolled in Los Angeles between 1982 and 1983 to estimate the incubation period distribution of AIDS. The estimates are \(B_0=0.0084\) (time : month) or \(B_0=0.1008\) (time : Year).

2.6. Shape parameter of Weibull distribution of AIDS incubation period \(B_1\)

According to Kuo JM, shape parameter is \(: B_1=2.45\). Together with the above parameters, the estimated proportion of individuals who develop AIDS within 4 years of infection is 10%, and that within 8 years of infection is 45%.

2.7. The death probability for patients with AIDS

According to the study conducted by Lemp GF et al\(^{19}\), the cumulative probabilities of survival in 4622 AIDS patients were 51.6% for 1 year, 20.2% for 2 years, 8.7% for 3 years and 3.4% for 5 years. Therefore, death probabilities for patients with AIDS are, 1st year, \(v_1=0.484\), 2nd year, \(v_2=0.324\), \(v_3=0.115\), \(v_4=0.037\), \(v_5=0.016\). The value of \(v_4\) is used as our interpolation.

| Table 3. Estimated numbers of HIV positives, AIDS cases, and deaths due to AIDS in male IVDUs and their sex partners. |
|---|---|---|---|
| Year | Male IVDUs | Female sex partners | Total |
| 1987 | 0 | 0 | 0 | 0 |
| 1988 | 70 | 0 | 70 | 0 |
| 1989 | 192 | 13 | 205 | 0 |
| 1990 | 354 | 37 | 391 | 2 |
| 1991 | 544 | 67 | 611 | 5 |
| 1992 | 752 | 103 | 855 | 12 |
| 1993 | 971 | 143 | 1114 | 22 |
| 1994 | 1191 | 184 | 1375 | 36 |
| 1995 | 1407 | 226 | 1633 | 54 |
| 1996 | 1612 | 267 | 1879 | 76 |
| 1997 | 1800 | 306 | 2106 | 99 |
| 1998 | 1969 | 342 | 2311 | 123 |
| 1999 | 2117 | 374 | 2491 | 146 |
| 2000 | 2244 | 402 | 2646 | 167 |
| 2001 | 2352 | 426 | 2778 | 184 |
| 2002 | 2444 | 447 | 2891 | 197 |
| Total | 1124 | 776 |

Figure 2. HIV prevalence and AIDS incidence in China calculated by the model. a : Model for IVDUs and their sex partners. b : Model including of oral drug users and their sex partners. c : Model including of IVDUs who were not surveyed. d : Model doubling susceptible individuals who give up risk behavior.
Table 4. Estimated numbers of HIV positives, AIDS cases, and deaths due to AIDS including oral drug users and their sex partners.

| Year | Prevalence of HIV (+) Male IVDUs | Female sex partners | Total | Incidence of AIDS | Deaths due to AIDS |
|------|-----------------------------------|---------------------|-------|------------------|-------------------|
| 1987 | 0                                 | 0                   | 0     | 0                | 0                 |
| 1988 | 80                                | 0                   | 80    | 0                | 0                 |
| 1989 | 220                               | 15                  | 235   | 0                | 0                 |
| 1990 | 405                               | 42                  | 447   | 2                | 0                 |
| 1991 | 622                               | 77                  | 699   | 6                | 1                 |
| 1992 | 860                               | 118                 | 978   | 13               | 3                 |
| 1993 | 1110                              | 163                 | 1273  | 25               | 9                 |
| 1994 | 1362                              | 211                 | 1573  | 41               | 17                |
| 1995 | 1608                              | 259                 | 1867  | 62               | 30                |
| 1996 | 1842                              | 306                 | 2148  | 87               | 47                |
| 1997 | 2057                              | 350                 | 2407  | 113              | 68                |
| 1998 | 2251                              | 391                 | 2642  | 141              | 92                |
| 1999 | 2420                              | 428                 | 2848  | 167              | 118               |
| 2000 | 2565                              | 460                 | 3025  | 191              | 144               |
| 2001 | 2688                              | 487                 | 3175  | 211              | 168               |
| 2002 | 2793                              | 511                 | 3304  | 225              | 190               |
| Total |                                  |                     |       |                  | 1285              |

Table 5. Estimated numbers of HIV positives, AIDS cases, and deaths due to AIDS including unsurveyed persons.

| Year | Prevalence of HIV (+) Male IVDUs | Female sex partners | Total | Incidence of AIDS | Deaths due to AIDS |
|------|-----------------------------------|---------------------|-------|------------------|-------------------|
| 1987 | 0                                 | 0                   | 0     | 0                | 0                 |
| 1988 | 100                               | 0                   | 100   | 0                | 0                 |
| 1989 | 275                               | 19                  | 294   | 0                | 0                 |
| 1990 | 506                               | 52                  | 558   | 2                | 0                 |
| 1991 | 777                               | 96                  | 873   | 7                | 1                 |
| 1992 | 1075                              | 148                 | 1223  | 17               | 4                 |
| 1993 | 1387                              | 204                 | 1591  | 31               | 11                |
| 1994 | 1702                              | 264                 | 1966  | 52               | 22                |
| 1995 | 2010                              | 323                 | 2333  | 78               | 38                |
| 1996 | 2302                              | 382                 | 2684  | 108              | 59                |
| 1997 | 2572                              | 437                 | 3009  | 142              | 85                |
| 1998 | 2813                              | 489                 | 3302  | 176              | 115               |
| 1999 | 3025                              | 535                 | 3560  | 209              | 147               |
| 2000 | 3206                              | 575                 | 3781  | 239              | 180               |
| 2001 | 3360                              | 609                 | 3969  | 363              | 211               |
| 2002 | 3491                              | 638                 | 4129  | 282              | 238               |
| Total |                                  |                     |       | 1606             | 1109              |

Table 6. Estimated number of HIV positives, AIDS cases and deaths due to AIDS if persons who stop risk behavior double.

| Year | Prevalence of HIV (+) Male IVDUs | Female sex partners | Total | Incidence of AIDS | Deaths due to AIDS |
|------|-----------------------------------|---------------------|-------|------------------|-------------------|
| 1987 | 0                                 | 0                   | 0     | 0                | 0                 |
| 1988 | 70                                | 0                   | 70    | 0                | 0                 |
| 1989 | 189                               | 13                  | 202   | 0                | 0                 |
| 1990 | 342                               | 36                  | 378   | 2                | 0                 |
| 1991 | 518                               | 65                  | 583   | 5                | 1                 |
| 1992 | 707                               | 98                  | 805   | 11               | 3                 |
| 1993 | 901                               | 134                 | 1035  | 21               | 7                 |
| 1994 | 1094                              | 171                 | 1265  | 35               | 15                |
| 1995 | 1280                              | 208                 | 1488  | 51               | 25                |
| 1996 | 1452                              | 243                 | 1695  | 71               | 39                |
| 1997 | 1608                              | 276                 | 1884  | 92               | 56                |
| 1998 | 1745                              | 305                 | 2050  | 113              | 75                |
| 1999 | 1862                              | 331                 | 2193  | 133              | 95                |
| 2000 | 1959                              | 354                 | 2313  | 151              | 115               |
| 2001 | 2041                              | 372                 | 2413  | 165              | 134               |
| 2002 | 2108                              | 388                 | 2496  | 174              | 149               |
| Total |                                  |                     |       | 1024             | 714               |

**RESULTS**

1. Male IVDUs and their sex partners

Table 3 presents the projected cumulative numbers of HIV positives in male IVDUs and their female sex partners, the incidence of AIDS cases, and deaths associated with AIDS up to the year 2002. We have assumed that HIV infection began in 1988, and that 350 males enter the IVDU population every year. By the year 2002, the number of male and female HIV positives will be 2,444 and 477 respectively, cumulative AIDS cases will be 1,124, and 776 of them will have died of AIDS (Figure 2, line a).

2. Inclusion of oral drug users and their sex partners

As mentioned above, a survey of 39 indigenous oral drug users out of 48 HIV positives revealed that almost all of them had experienced intravenous drug use at least once. In the border area between China and Myanmar, indigenous oral drug use seems rather popular. Yunnan Provincial Anti-epidemic Center examined 4,088 oral drug users in 1989 and 1990, 48 of them were HIV positives (1.17%). Up to now, no evidence shows that HIV can be transmitted orally, so we think it is reasonable to include this group in the IVDUs group. Thereby, we can assume that 400 individuals enter the IVDUs population every year. The result of the same model is, by the year 2002, the number of male and female HIV positives will be 2,793 and 511 respectively, cumulative AIDS cases will be 1,285, and 887 of them will have died of AIDS (Table 4 ; Figure 2, line b).

3. Inclusion of IVDUs who were not surveyed

The real numbers of this population is impossible to know. If we assume, however that 20% were missed in the survey, the newly susceptible IVDUs will reach 500 per annum. In this case, by the year 2002, the number...
of male and female HIV positives will be 3,491 and 638 respectively, cumulative AIDS cases will be 1,606, and 1,109 of them will have died of AIDS (Table 5; Figure 2, line c).

4. Doubling susceptible individuals who give up risk behavior

At first, we assume that 5% of the population at risk will exit before becoming infected for the time being. With the expanding general knowledge of AIDS, if we double the current number of people at risk who stop their risk behaviour \((d_r=0.1)\), by the year 2002, the number of male and female HIV positives will be 2,108 and 388 respectively, cumulative AIDS cases will be 1,024, and 714 of them will have died of AIDS (Table 6; Figure 2, Line d).

Because this estimation only considers HIV positives among IVDUs and their sex partners in Yunnan Province of China who represent about 80% of HIV positives throughout the country by the end of 1990, we consider our estimation to be the minimum size of HIV infection in China.

**DISCUSSION**

The exact year that HIV was transmitted to IVDUs in China is unknown. 1988 is assumed to be the first year that HIV entered IVDUs. 1989 is the first year that HIV positives were detected in male IVDUs\(^7\). Up to 1990, there were 347 known HIV positives but no AIDS case among IVDUs. With the knowledge of AIDS incubation period distribution, we believe that the phenomenon would occur only in the first 3 years, because the Weibull distribution indicates that after 3 years of HIV infection, the AIDS incidence rate will reach 3% (with an incubation period of 8 years). Although a few IVDUs may have been infected before the year 1988, it seems to have little effect on our projection result.

According to the survey in China\(^7\), there are 48 HIV positives among 4,086 oral drug users (1.17%). We did not include this population in our model independently. As further investigation of 39 out of these 48 HIV positives confirmed, most of them had experienced intravenous drug use. Thus, we considered them to be IVDUs in spite of their oral drug use habit which appears to have no relationship to HIV transmission.

The probability that a male IVDU is HIV positive \((r_1=0.2)\) is derived from the anti-HIV seropositive rate (26.86%) in 1990\(^3\). With this probability, the seropositive rate will rise from 20% at the beginning to 70% in the year 2002. Jarlais et al.\(^{20}\) reported HIV-1 infection among IVDUs in New York, USA, from 1977 through 1987. Anti-HIV-1 positive rate rose from 9% in 1978 to 57% in 1987. From 1984 through 1987, the seroprevalence rate stabilized to between 55% and 60%. Vlahov et al.\(^{21}\) reported 30.1% as HIV-1 seroprevalence among 2,616 IVDUs. Compared to this report, our estimated probability may bias the estimate upwards in long-term projection.

At present, homosexual action is not a problem in China, but heterosexual vaginal intercourse plays an important part in sexually transmitted diseases. For this reason, we assume that one male IVDU has one female sex partner. Anderson and May\(^{22}\) reviewed the reports of 16 authors, and the probability of transmission from male to female varied between 0.03 and 0.73, where transmission from male IVDUs to females was 0.35. The probability of HIV transmission from male IVDUs to their female sex partners used here \((r_2)\) is based on the risk of HIV transmission per unprotected vaginal intercourse \((p=0.002)\) and the average number of unprotected acts of vaginal intercourse per year \((N=110)\). No consideration has been given to how many sex partners one IVDU has, because \(N\) is determined. If one HIV positive person has 2 sex partners, the probability \(r_2\) will be reduced by half. In this case, the infectivity that one HIV positive person contributed is dependent on \(p\) and \(N\), but not on the number of sex partners. In an estimation of HIV transmission rate among female sex partners of male IVDUs in New York, USA, Fordyce et al.\(^{12}\) assumed that only 18,615 sexually active women in New York select a male IVDUs as a sex partner, nevertheless, the number of male IVDUs in same city is 169,400. This implied that most male IVDUs in New York are homosexual or abstinent, which is obviously different from the situation in China.

It is impossible to use parameters such as scale and shape from China since these parameters require long-term observation. The parameters we used are derived from studies conducted in the United States. Some parameters may not be suitable in China. For example, the death probability for patients with AIDS also appears to be too high. These factors do have an effect on our estimate.

The proportion of susceptible persons who leave the at risk population before getting infected \((d_r)\) may affect the development of disease from its original trend. In a survey on knowledge and attitudes towards AIDS among administrative and medical staff and policemen in Yunnan Province of China\(^{23}\), 208 persons were interviewed. Out of these subjects, 88.9% showed concern about an indigenous AIDS epidemic, but 56.7% did not know the difference between an HIV infected person and an AIDS patient. This indicates that it is necessary to inform local residents about
AIDS, to stop risk behavior and to increase the proportion of HIV susceptible individuals who leave the population at risk for contracting AIDS (dr).

If the Government takes strong action to forbid drug use or after proper publication make it well known how to avoid HIV transmission, such as giving up drug use and promotion of condom use and so on, the estimation we made could show a downward trend, nevertheless we are satisfied if this happens.

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