

Estimation of Population-Size Changes and HIV Prevalence among Female Sex Workers from 2006 to 2009 in Kaiyuan, Yunnan, China*

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Abstract

Objective This study is to estimate the population size and prevalence of HIV and herpes simplex virus type 2 (HSV-2) infections among female sex workers (FSWs) in Kaiyuan, Yunnan Province, China.

Methods Eight cross-sectional studies were conducted among FSWs in Kaiyuan from 2006 to 2009. Based on the data from two study time points each year, the total numbers of FSWs and HIV positive FSWs were estimated by using the capture-recapture technique (CR).

Results Estimated sizes of FSWs in Kaiyuan were 1 629, 1 672, 1 186, and 1 014 in the respective years from 2006 to 2009. Although the crude prevalence rates of HIV and HSV-2 varied over time, the adjusted prevalence among this population was relatively stable at 10%-12% and the adjusted HSV-2 prevalence ranged from 67% to 72%.

Conclusion The reason for the slight decrease of the size of the FSW population is unknown. The adjusted prevalence rates of HIV and HSV-2 among them were stable over the course of this study.

Key words: Population; HIV; FSWs; Capture-recapture

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INTRODUCTION

HIV transmission through commercial heterosexual behaviors is one of the main modes of HIV transmission in China^[1-4]. In 2007, it was estimated that more than 20% of HIV cases in this country were infected through commercial heterosexual behaviors^[2,5-6]. In commercial sex, clients are likely to serve as a bridge population to transmit HIV to the general population,

as female sex workers (FSWs) are believed to be a "core population". Since FSWs are often hidden from the general population, it is often difficult to estimate the magnitude and changes of this population^[7]. According to estimates by Wang et al., there are 1.8-3.8 million FSWs and 17.7-37.1 million clients in China^[5]. The prevalence of STIs, such as HSV-2, was reported to have significant correlation with the transmission of HIV among the FSW population^[8]. Additionally, infection of HSV-2 was

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reported to be one of the common STIs among this specific population in Yunnan^[8-10]. The size of the FSW population and the HIV prevalence among them are believed to be important factors in the shift of the HIV epidemic from FSWs to the general population. Surveillance surveys have provided some insight into the prevalence of HIV among FSWs in Kaiyuan, but these estimates are based on convenience samples from single data collection periods and may not be reflective of the true prevalence among the local FSWs. The capture-recapture (CR) method is another means to estimate the prevalence of HIV in the total population of FSWs in Kaiyuan^[11].

Kaiyuan is a county in Honghe Prefecture, Yunnan Province, China. Yunnan Province has the highest HIV prevalence in China^[2,6,12-13], and Honghe has the second highest HIV prevalence among all prefectures in Yunnan Province^[6,14]. In Honghe Prefecture, the HIV cases account for 14% of the total HIV cases in Yunnan Province, and Kaiyuan County is the place with the highest number of reported HIV cases in China^[6]. A report from the Kaiyuan Center for Disease Control (CDC) in 2009 indicated that there were nearly 3 000 surviving HIV/AIDS cases at the end of 2009, with an HIV prevalence of about 1% among the general population. According to surveillance estimates by the Kaiyuan CDC, there have been approximately 400 new cases of HIV/AIDS every year in Kaiyuan since 2006. Commercial sex has surpassed injection drug use (IDU) as the main mode of HIV transmission in Kaiyuan^[12,15].

However, little is known about the size of the FSW population in Kaiyuan and how this population changes over time. Moreover, the previously determined prevalence rates of HIV and HSV-2 may not be accurate since they were determined from community-based samples^[8,16]. It is important to know the prevalence of the diseases among the local FSW population and the size of this population in order to better understand the HIV epidemic in Kaiyuan.

The capture-recapture (CR) method was first used to estimate population sizes and trends of wildlife^[17-18]. The CR technique has also been used to estimate the size of hidden populations in public health^[19-21], such as HIV-infected population^[22-23], men who have sex with men (MSM)^[24], drug users^[25-27], and FSWs^[28-29]. Although previous studies have determined the risk factors for HIV infection among FSWs in Kaiyuan^[12,16,30-32], no analysis has been conducted to determine the trends

of the size of this population and its HIV prevalence. The current study uses cross-sectional data and a multi-staged CR technique to estimate the magnitude of the FSW population in Kaiyuan and the adjusted HIV prevalence in order to help develop prevention and control strategies and determine resource allocation.

METHODS

The Chinese Center for Disease Control and Prevention (CDC) with provincial and Kaiyuan CDC staff conducted eight cross-sectional studies among FSWs from 2006 to 2009. A survey was conducted in spring and fall of each year. The size of the local FSW population and the HIV and HSV-2 prevalence rates were estimated every year with the capture-recapture technique and by using data from the two study periods each year.

Study participants were recruited by local outreach workers and health officers, who directly approached FSWs in commercial sex establishments and on the street. Women were considered eligible for the study participation if they were at least 16 years of age, self-reported to have provided sexual services in exchange for money in the past 6 months, and agreed to be tested for HIV and other sexually transmitted infections (STIs) and for the use of illegal drugs. After providing informed consent, participants were asked questions about their demographics, basic medical histories and behavioral risk factors.

All laboratory specimens were collected by trained physicians. Blood samples were obtained to test for HIV infection and HSV-2. Specimens were screened for HIV antibodies by the enzyme-linked immunosorbent assay (ELISA: Organon Teknika, Boxtel, Co., Ltd., the Netherlands), and positive tests were confirmed by HIV-1/2 Western blot assay (HIV Blot 2.2 WBH; Genelabs Diagnostics, Singapore). Specimens were also tested for antibodies to herpes simplex virus (HSV-2) by ELISA (Herpe Select-2 ELISA IgG; Focus Technologies, Cypress, CA).

All study staff were trained as to the standardized methods of data collection. Subjects were compensated 50 RMB (\$7 USD) for participation in this study. Participants were scheduled for a follow-up visit in four to six weeks as of the date of the study visit for post-test counseling. Participants with STIs were referred to the Kaiyuan Dermatology Hospital, where participants were entitled to receive a 60% discount on STI treatment. Those who were tested HIV-positive were referred

to the Kaiyuan People’s Hospital, where antiretroviral therapy was offered through the support of the Clinton Foundation.

This study obtained ethics approval from both China CDC and Yunnan Province CDC institutional review boards. It is part of a series of cross-sectional studies analyzing factors contributing to FSWs’ transmission of HIV/STIs in Kaiyuan of Yunnan Province. Eight surveys were carried out from 2006 to 2009. The results obtained have been published in several journals and contributed significantly to the study of HIV/STD transmission and control among the FSW population in China. Recently, size-estimation of HIV/STI high-risk population has been supported by mega-projects of national science research under the 11th Five-Year Plan of China and conducted in some cities and counties of Yunnan Province. Results of this study would provide a scientific evidence for the size-estimation derived from the above program models.

Data from the questionnaires and laboratory tests were entered into EpiData software (Version 3.10, Odense, Denmark). Data were analyzed with SAS (Version 9.1, Cary, NC, USA) and Matlab 7.0 (Natick, MA, USA).

Capture-recapture assumes that two samples are independent of each other, that subsequent samples should be collected after an interval when participants have had the opportunity to mix thoroughly with the rest of the population^[33], and that the population is relatively stable over time^[34-35].

Another important consideration for capture-recapture studies is that data sources are representative of the target population^[19].

The equation used in the capture-recapture technique is:

$$N = (n_1 + 1)(n_2 + 1)/(m + 1) - 1 \tag{1}$$

$$Var(N) = (n_1 + 1)(n_2 + 1)(n_1 - n_2)(n_2 - m)/(m + 1)(m + 2) \tag{2}$$

$$95\%CI = N \pm 1.96\sqrt{Var(N)} \tag{3}$$

The equation used in estimating the prevalence of HIV and HSV-2 is (take equation of HIV for example, the one for HSV-2 is the same with the one for HIV):

$$P_{HIV} = \frac{N^{HIV}}{N^{FSW}} = [(n_1^{HIV} + 1)(n_2^{HIV} + 1)/(m^{HIV} + 1) - 1] / [(n_1^{FSW} + 1)(n_2^{FSW} + 1)/(m^{FSW} + 1) - 1] \tag{4}$$

Where N , N^{HIV} , and N^{FSW} are numbers of the total population sizes, n_1 , n_1^{HIV} , and n_1^{FSW} the numbers from the first survey, n_2 , n_2^{HIV} , and n_2^{FSW} the numbers from the second survey, and m , m^{HIV} , and m^{FSW} the numbers from both surveys.

RESULTS

Table 1 describes the estimation of the population sizes and the HIV prevalence rates. The estimated sizes of the FSWs population in Kaiyuan were 1629, 1672, 1186, and 1014 for the respective years from 2006 to 2009. The estimated HIV prevalence rates were 10.4%, 10.6%, 9.4%, and 11.7%

Table 1. Estimation of Population Size and STIs Prevalence in FSWs from 2006 to 2009 in Kaiyuan

Items	2006		2007		2008		2009		P
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	
Survey Number	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	—
Number Captured	741	748	705	440	587	558	548	548	—
Number Recaptured	—	341	—	185	—	277	—	297	—
Estimated Population Size	—	1 629	—	1 672	—	1 186	—	1 014	—
95% CI	—	±242	—	±1 524	—	±377	—	±126	—
Number of HIV Positive Cases Captured	76	89	92	50	66	68	88	85	—
Number of HIV Positive Cases Recaptured	—	40	—	26	—	40	—	63	—
Estimated Number of HIV Positive Cases	—	169	—	177	—	112	—	119	—
Study HIV Prevalence	10.24	11.87	13.05	11.36	11.21	12.19	16.21	15.51	0.0208
Estimated HIV Prevalence	—	10.37	—	10.59	—	9.44	—	11.74	0.6344
HSV-2 Positive Cases Captured	499	509	499	276	401	397	387	386	—
HSV-2 positive Cases Recaptured	—	233	—	137	—	219	—	235	—
Estimated Number of HSV-2 Positive Cases	—	1 089	—	1 003	—	726	—	635	—
Study HSV-2 Prevalence	67.25	67.87	70.78	62.72	68.08	71.15	71.27	70.44	0.0294
Estimated HSV-2 Prevalence	—	66.85	—	59.99	—	61.21	—	62.62	0.0709

respectively from 2006 to 2009 ($P=0.6$) and the estimated HSV-2 prevalence rates were 66.9%, 59.99%, 61.21%, and 62.62% ($P=0.6$), respectively. The prevalence rates of HIV and HSV-2 from the eight sampling time frames varied over time ($P=0.02$ and $P=0.03$, respectively).

Figure 1 illustrates the change of the estimated FSWs population size in Kaiyuan from 2006 to 2009. There was a slight decrease of the size of the population from 2006 to 2009. Figure 2 shows the difference in the estimated CR-adjusted HIV prevalence by CR technique, which was derived directly from the study samples. There was no significant difference in the HIV prevalence in the course of four years, as revealed by the CR-adjusted estimates ($P=0.6$), but there were significant differences over time, as shown by the crude prevalence rates of the eight surveys ($P=0.02$). Similar differences existed over time for HSV-2 infection. Figure 3 elucidates the difference in HSV-2 prevalence over time, with CR-adjusted estimates ($P=0.6$) and crude sampling ($P=0.03$).

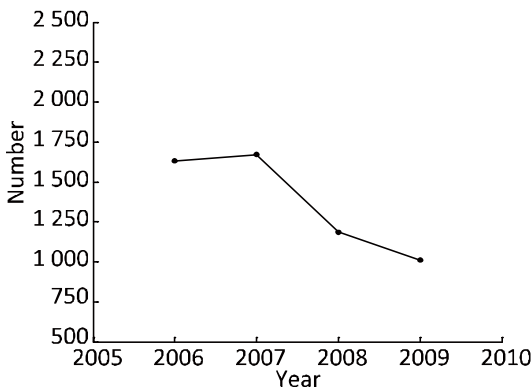


Figure 1. Estimated size of the FSW population in Kaiyuan from 2006 to 2009.

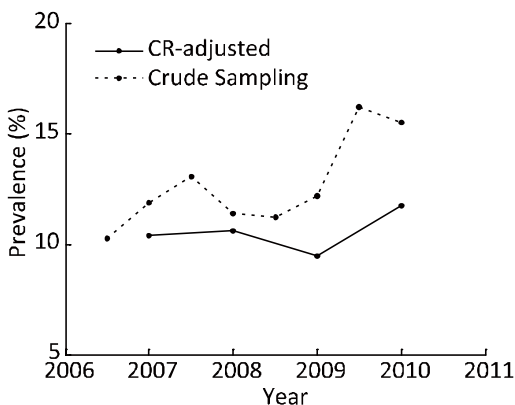


Figure 2. Difference in HIV prevalence between CR-adjusted estimates and crude sampling.

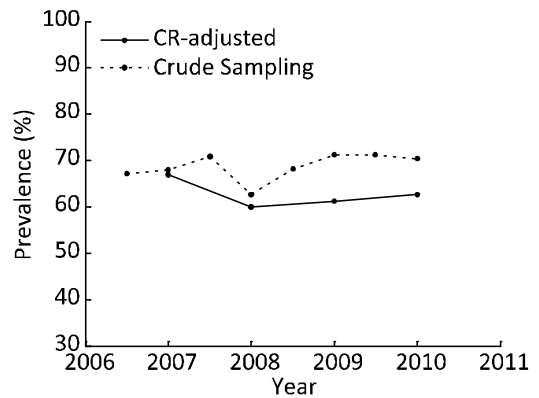


Figure 3. Difference in HSV-2 prevalence between CR-adjusted estimates and crude sampling.

DISCUSSION

It is important for public health officials to know the approximate magnitude of populations at high risks for HIV in order to allocate resources effectively for interventions. It is often difficult, however, to estimate the size of high risk population groups in China because they are often marginalized and hidden. The CR method is a relatively simple and inexpensive means of estimating the size of hidden populations. The current study estimated the population size of FSWs in Kaiyuan and analyzed how the population size changed from 2006 to 2009. The number of FSWs in Kaiyuan is estimated to have decreased by over 1000 in four years. There are approximately 146 000 females in Kaiyuan, so it can be inferred that approximately 0.7%-1.2% of all females in Kaiyuan are FSWs. Zhang et al. estimated that the percentage of FSWs in the urban adult female population was 3.4%-3.6% in 2003 based on the studies of two cities of Guizhou Province^[36]. Wang et al., estimated that there were 1.8-3.8 million FSWs throughout China in 2007^[5]. Figure 2 shows a slight decrease in the number of FSWs in 2008. The decline of the commercial sex industry in Kaiyuan may be related to the global economic crisis. According to reports from local residents, several mines were closed due to bankruptcy and some small private mining companies were forced to close down because of government safety concerns in 2008.

The CR technique was used to estimate the total number of cases and prevalence of HIV and HSV-2 among FSWs in Kaiyuan. From cross-sectional surveys, the sampling prevalence of HIV and HSV-2 could be determined, but these are only crude

estimates and may not be reflective of the overall population of FSWs in Kaiyuan. The prevalence rates of HIV and HSV-2 determined directly based on the study samples were higher than the CR-adjusted prevalence rates, but the two-stage CR technique approximates the actual disease prevalence rates better than convenience sampling from a single data collection period. The prevalence rates of HIV and HSV-2 were significantly different among studies, but they were not significantly different for each year. The prevalence of HIV among FSWs was 10%-12% and the HSV-2 prevalence among FSWs was 59%-67%. The HIV prevalence was much higher than that reported for the general population and FSWs in other regions in China, which may be due to the fairly common injection drug use (IDU) among FSWs in Kaiyuan^[12,16]. This study indicates that the CR-adjusted prevalence of HIV and HSV-2 among FSWs in Kaiyuan is relatively stable, which is consistent with reports from the Chinese National Center for AIDS/STD Control and Prevention (NCAIDS)^[2,6].

This study is subject to several limitations. The greatest possible bias is from high mobility of FSWs and the instability of this population. CR assumes a closed population; however, since FSWs may start and quit sex work at any time, this system shall not be considered as closed, which may result in an overestimation of the population size. Furthermore, the high mobility of FSWs may lead to an overestimation of their numbers. According to FSW self-report, the average amount of time spent working in the same location is 6 months; therefore, the period of recapture was selected to be 6 months. In the period of the 6 months, the population size was relatively stable and the captured FSWs could mix in the entire population of FSWs, giving every individual the same chance of being recaptured. FSWs were also recruited to participate through convenience sampling and might not have been representative of all FSWs living in Kaiyuan. Participants who took part in the first survey might have been familiar with the study staff and more likely to agree to participate in subsequent studies, which could lead to an underestimation of the true number of FSWs in Kaiyuan.

CONCLUSION

The number of FSWs in Kaiyuan is estimated to have declined slightly from 2006 to 2009. The reason for this decline is unknown, but may be related to

the global economic crisis and the closing of nearby mines. The prevalence rates of HIV and HSV-2 from the study samples and CR-adjusted estimates are different. The CR-adjusted disease prevalence rates tend to be stable over time. Future studies should estimate the impact of other variables influencing the changes of population size and HIV prevalence among FSWs, such as social, political, and economic factors, in order to better determine prevention and control of the diseases and relevant resource allocation.

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