

Prevalence, incidence, and persistence of syphilis infection in female sex workers in a Chinese province

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SUMMARY

The study's objectives were to investigate the prevalence, incidence, persistence, and associated risk factors of syphilis in female sex workers (FSWs) in Kaiyuan City, Yunnan, China. Three serial cross-sectional surveys were conducted and biological specimens were collected and tested for HIV, sexually transmitted infections, and drug use. The logistic Generalized Estimating Equation regression model was used to identify risk factors for prevalent syphilis. The prevalence of syphilis was 7·5%, 8·4% and 8·8%, respectively, in the three survey periods. Estimated syphilis incidence was 1·07 cases/100 person-years, and the persistence of syphilis per person at 6 months was 90·4%. In multivariate analysis, the factors associated with syphilis were age, lower education level, number of clients in a week, inconsistent condom use with clients, herpes simplex virus type 2 (HSV-2), and *Chlamydia trachomatis*. Persistent syphilis in this population of FSWs is a serious public health concern.

Key words: China, female sex workers (FSWs), sexually transmitted infections (STIs), syphilis.

INTRODUCTION

The re-emergence of China's syphilis epidemic in the past 20 years has highlighted the complex relationship between rapid economic development and public health [1, 2]. While rising prosperity and economic reforms may have improved health conditions for

some, the resulting inequality in income, internal migration and re-establishment of the commercial sex industry has greatly facilitated the spread of syphilis and other sexually transmitted infections (STIs). From the near eradication of syphilis during the Mao Zedong years [3, 4], the nationally documented primary and secondary syphilis incidence rate increased from 0·2 cases/100 000 in 1993 to 5·7/100 000 by 2005 [1].

As China's economic development continues and contributes to the growth of the commercial sex industry, syphilis in China's population of female sex

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workers (FSWs) presents a considerable public health challenge. By 2003, an estimated 4–10 million women were engaged in commercial sex in mainland China [5, 6]. Marginalized populations, like FSWs, are of particular concern because many may have compromised access to condoms, healthcare services and educational materials, making them particularly vulnerable to infection. Previous studies have found that FSW populations with high syphilis prevalence (7.5% in Yunnan, 11.0% in Sichuan, 14% in Guangdong) [7–10] also practice relatively low levels of condom use [11]. This may indicate limited access and poor knowledge, but also sheds light on the problem that syphilis may continue to spread with the continuation of these unsafe sexual practices.

As HIV prevalence rates reach new highs in high-risk populations such as FSWs, syphilis is also of particular concern for understanding the HIV epidemic. Previous research has found that syphilis plays a facilitative role in the transmission of HIV [12, 13], and tracking syphilis prevalence, incidence and the associated risk factors may help to understand the future of the HIV epidemic.

This study aims to assess the prevalence, incidence, and persistence of syphilis and to determine the risk factors for syphilis infection in FSWs in an area with prevalent commercial sex work. The analysis of three consecutive cross-sectional studies in FSWs in Kaiyuan City, Yunnan provides an important opportunity to understand syphilis prevalence trends, syphilis incidence, and can inform intervention methods to control STIs in FSW populations.

METHODS

Study subjects

From March 2006 to May 2007, we conducted three consecutive cross-sectional surveys of FSWs in Kaiyuan City, Yunnan Province at 6-month intervals. Outreach workers recruited potential study subjects at sex-work venues directly and through venue-owner outreach. The study site was conveniently located in central Kaiyuan. Outreach workers explained the study's purpose, procedures, and the risks and benefits of participation. All eligible FSWs were invited to participate in the study at the initiation of each cross-sectional survey, including newly recruited subjects and those who had participated in previous surveys. The inclusion criteria stipulated that all participants were aged ≥ 16 years (legal age of consent in China),

self-reported sex work within the last 3 months, were willing to have their blood and urine tested for HIV/STIs and opiate use, and were willing and able to give written informed consent. Those eligible for study participation were thoroughly informed of the study's purpose and procedure and informed consent was obtained. Study protocol secured approval from the institutional review boards of the China Center for Disease Control and Prevention (China CDC) and Yunnan CDC. All participants were compensated 50 Renminbi (RMB) upon the completion of each survey.

Data collection

Staff members from the National Center for AIDS/STD Control and Prevention and Yunnan CDC trained local staff members from Kaiyuan CDC in the protection of human subjects, obtaining informed consent, and safeguarding confidentiality.

After providing written informed consent, participants were asked a series of questions regarding their demographics, basic medical history, and sexual and drug-use behaviour. Blood, urine, and vaginal swab samples were collected. To protect confidentiality, all subjects, subject surveys and collected specimens were assigned a corresponding participant identity number. Subjects were scheduled for follow-up visits 4–6 weeks after the initial visit to receive test results and receive post-test counselling. Those who were infected with STIs were referred to Kaiyuan City Dermatology Hospital for evaluation and treatment, and those found HIV-positive were referred for treatment to Kaiyuan People's Hospital. Attempts were made to contact those who did not return for post-test counselling. All enrolled subjects were also encouraged to participate in subsequent surveys.

Laboratory testing

Sera specimens were tested for syphilis, HIV, and Herpes simplex virus type 2 (HSV-2) antibodies. Syphilis antibodies were tested for using the rapid plasma reagin (RPR) test (Xinjiang Xindi Company, China). Samples testing positive by RPR test were confirmed by the *Treponema pallidum* particle assay (TPPA) test (Serodia-P-PA-Fujirebio, Japan) and subjects positive by both RPR and TPPA tests were considered syphilis positive. Successful treatment for syphilis was defined as a fourfold decrease in a participant's RPR titre after at least 6 months. Subjects

who tested syphilis seropositive on at least two consecutive visits without a fourfold decrease in RPR titre were considered as having persistent syphilis infection. HIV-1 antibodies were tested for using enzyme-linked immunosorbent assay (ELISA) (Vironostika HIV Uni-Form plus O; bioMérieux, Holland) and positive HIV-1 results determined through ELISA were confirmed by Western blot (Diagnostics HIV Blot 2.2; Genelabs, USA). HSV-2 antibodies were tested for using HerpeSelect-2 ELISA IgG (Focus, USA). Endocervical and vaginal swabs were collected by physicians from Kaiyuan Dermatology Hospital in a private examination room on the research site. Endocervical swabs were collected and tested for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* by polymerase chain reaction (PCR; AMPLICOR, Roche, USA). Vaginal swabs were collected and wet mounts were prepared. Samples were classified as *Trichomonas vaginalis* (TV)-positive if motile organisms were observed. Urine was tested for opiate presence (MOP One Step Opiate Test Device, ACON Laboratories Inc., USA). Participants were classified as using illegal drugs if they tested urine-opiate positive or self-reported a history of illegal drug use.

Data analysis

Syphilis incidence density was calculated for subjects who were initially negative and completed at least two surveys. We estimated date of syphilis infection as the midpoint between the last syphilis seronegative test and the first syphilis seropositive test. Syphilis incidence density was calculated by dividing the number of events of syphilis seroconversion by the number of person-years of follow up. The follow-up time for each FSW was calculated as the time between her first negative syphilis test and the most recent negative syphilis test or incident syphilis infection if she seroconverted. Poisson 95% confidence intervals (CIs) were calculated for overall incidence density. Fisher's exact and χ^2 tests were used to compare demographic characteristics across survey periods.

The logistic Generalized Estimating Equation (GEE) regression model was used to analyse risk factors for syphilis infection. This technique allows for repeated within-subject measurement, and variation in the number of observations over the course of study. The model was adjusted across corresponding baseline measures for covariates to obtain adjusted odds ratios (aORs) to assess the effect of risk factors or confounders on dichotomous outcomes, by

including factors with $P < 0.2$ in univariate analyses and then by limiting final multivariate models to risk factors or confounders that were statistically significant ($P < 0.05$). A time period indicator was included in each model to capture any temporal effects that had not been taken into account, for example, the time effects of repeated surveys. Analyses were performed using SAS 9.1 software (SAS Institute Inc., USA).

RESULTS

Participant demographics and risk behaviours

A total of 1450 FSWs were approached to participate in the study. All of those approached were initially willing to participate and were enrolled in the study, but eight (0.6%) withdrew because they refused specimen collection and another 30 (2.1%) withdrew when sensitive questions were asked. Of the 1412 FSWs included in the final study population, 871 (61.7%) participated in one survey, 305 (21.6%) participated in two surveys and 236 (16.7%) completed all three surveys. A total of 53.3% (393/737) FSWs participated in post-test counselling from the first survey, 65.6% (490/747) from the second survey and 52.5% (370/705) from the third survey.

FSWs were primarily of Han ethnicity (69.0%) and were permanent residents of Yunnan Province. Table 1 outlines some of the differences between subjects in each survey period. Compared with subjects who participated in the second and third cross-sectional surveys, subjects in the first survey were, on the whole, younger and more likely to reside at their sex-work venue. Subject characteristics across the three surveys were statistically similar in regards to nationality, residence, education level, marital status and entertainment venue. Relatively high HIV and STI rates were identified in each survey period.

In all, 720 (51%) subjects reported having a regular partner (RP), which was defined as a male with whom the subject had regular sexual relations without compensation. Of these 720 participants, 597 (83%) said they did not routinely use condoms with their RP. Of the 56 syphilis-positive FSWs who reported having a RP, only six (10.7%) said they always used condoms with the RP in the previous week. The overall syphilis prevalence was significantly lower in those reporting consistent condom use with clients (6.4% for those with consistent condom use with clients vs. 14.5% for those with inconsistent condom use with clients, $P < 0.0001$).

Table 1. Demographic and behavioural characteristics of female sex workers in three consecutive cross-sectional surveys

Demographic characteristics	First survey (<i>N</i> = 737) <i>n</i> (%)	Second survey (<i>N</i> = 747) <i>n</i> (%)	Third survey (<i>N</i> = 705) <i>n</i> (%)	<i>P</i> value
Age (years)				< 0.01
16–20	225 (30.5)	171 (22.9)	202 (28.6)	
21–25	255 (34.6)	217 (29.0)	188 (26.7)	
26–52	257 (34.9)	359 (48.1)	315 (44.7)	
Ethnicity				0.22
Han	492 (66.8)	519 (69.5)	500 (70.9)	
Other	245 (33.2)	228 (30.5)	205 (29.1)	
Registered permanent residence				0.35
Kaiyuan City	159 (21.6)	151 (20.2)	173 (24.5)	
Other cities in Yunnan	433 (58.7)	443 (59.3)	403 (57.2)	
Outside Yunnan	145 (19.7)	153 (20.5)	129 (18.3)	
Education (years)				0.40
< 9	387 (52.5)	400 (53.5)	353 (50.1)	
≥ 9	350 (47.5)	347 (46.5)	352 (49.9)	
Marital status				0.06
Married or cohabiting	225 (30.5)	194 (26.0)	180 (25.5)	
Single, separated, divorced, or widowed	512 (69.5)	553 (74.0)	525 (74.5)	
Residence type				< 0.01
Apartment	491 (66.6)	509 (68.1)	485 (68.8)	
Family home	59 (8.0)	69 (9.2)	88 (12.5)	
Brothel or other working location	187 (25.4)	169 (22.6)	132 (18.7)	
Illegal drug use				< 0.01
No	617 (83.7)	606 (81.1)	534 (75.7)	
Yes	120 (16.3)	141 (18.9)	171 (24.3)	
Duration of commercial sex work (years)				< 0.01
< 2	426 (57.8)	391 (52.3)	343 (48.6)	
≥ 2	311 (42.2)	356 (47.7)	362 (51.4)	
Fee per sexual service				0.15
> 100 RMB*	458 (62.1)	479 (64.1)	417 (59.1)	
≤ 100 RMB	279 (37.9)	268 (35.9)	288 (40.9)	
Number of clients in previous week				0.17
1–5	572 (77.6)	549 (73.5)	526 (74.6)	
≥ 6	165 (22.4)	198 (26.5)	179 (25.4)	
Always used condom with clients in previous week				0.32
Yes	619 (84.0)	648 (86.8)	604 (85.7)	
No	118 (16.0)	99 (13.2)	101 (14.3)	
Syphilis positive				0.63
Yes	55 (7.5)	63 (8.4)	62 (8.8)	
No	682 (92.5)	684 (91.6)	643 (91.2)	
<i>N. gonorrhoeae</i> positive				0.06
Yes	61 (8.3)	43 (5.8)	39 (5.5)	
No	676 (91.7)	704 (94.2)	666 (94.5)	
<i>C. trachomatis</i> positive				< 0.01
Yes	191 (25.9)	147 (19.7)	126 (17.9)	
No	546 (74.1)	600 (80.3)	579 (82.1)	
<i>T. vaginalis</i> positive				0.24
Yes	78 (10.6)	66 (8.8)	57 (8.1)	
No	659 (89.4)	681 (91.2)	648 (91.9)	
HSV-2 positive				0.40
Yes	502 (68.1)	513 (68.7)	502 (71.2)	
No	235 (31.9)	234 (31.3)	203 (28.8)	
HIV positive				0.27
Yes	76 (10.3)	89 (11.9)	90 (13.1)	
No	661 (89.7)	658 (88.1)	613 (86.9)	

* RMB, Renminbi (100 RMB = 9 GBP).

Prevalence, incidence, and persistence of syphilis

Syphilis prevalence for this study sample was 7.5% (55/737), 8.4% (63/747) and 8.8% (62/705) in the three respective surveys. Of the 112 subjects who had ever been infected with syphilis, 58 (51.8%) FSWs only participated in one survey, 31 (27.7%) participated in two surveys, and 23 (20.5%) participated in three surveys. Only five subjects showed evidence of having received successful treatment (a fourfold decrease in RPR titre), and 47 had persistent syphilis (30 FSWs were syphilis-positive in two consecutive surveys and 17 FSWs were syphilis-positive in three consecutive surveys). The persistence of syphilis per person at 6 months was 90.4% (47/52). A total of 1305 (92.4%) participants were syphilis-negative at their first survey and of these 1305 participants, 492 (37.7%) FSWs returned for at least one follow-up visit. During the 375 person-years (p-yr) of follow-up over the course of the survey period, four subjects were newly infected with syphilis, yielding an overall incidence of 1.07/100 p-yr (95% CI 0.29–2.71).

Univariate analysis for syphilis-related risk factors (Table 2) showed that those who were older, who had ever been married, who charged <100 RMB per sexual service, who saw ≥ 6 clients per week, who reported inconsistent condom use with clients (defined as sometimes or never used condoms in recent week), and those who were infected with *C. trachomatis* or HSV-2 were more likely to be syphilis seropositive. On the other hand those with more years of schooling, those who lived at their sex-work venue (as opposed to a private residence), and those who reported alcohol use were less likely to have syphilis.

Table 3 shows the results from multivariate analysis. Multivariate analysis found that subjects who were HSV-2 positive had about 3.8 times the risk of syphilis infection than those who were HSV-2 negative; similarly, risks were nearly twice as high for FSWs infected with *C. trachomatis*. Having ≥ 6 clients per week and inconsistent condom use with clients in the previous week were also associated with greater risk of syphilis infection.

DISCUSSION

To our knowledge, this study is the first that characterizes the risk factors associated with syphilis and measures the incidence and persistence of syphilis in a population of FSWs in Kaiyuan City, Yunnan. Syphilis in this population of FSWs was found to be

significantly associated with HSV-2 co-infection, *C. trachomatis* co-infection, older age, fewer years of education, higher client volume, and inconsistent condom use with clients. Syphilis incidence was low (1.07/100 p-yr), but prevalence rates showed a slight increase from each survey period to the next. Syphilis prevalence found in this study (7.5–8.8%) was not as high as the rates in other cities such as Guangzhou (14%) [14] or Xichang (15.7%) [9], but is similar to the corresponding rates found in Guangxi Province (8.5%) and Shandong Province (7.4%) [15, 16]. The increasing trend in prevalence rates and other factors identified during this study, such as low reported condom use and high persistence of syphilis, make this population of particular concern because they could be indicators of a larger syphilis epidemic in Kaiyuan FSWs in the future.

In this study, the persistence of syphilis at 6 months was very high (90.4% of FSWs) and only five individuals exhibited successful treatment. This is of concern for several reasons. First, FSWs may not be seeking treatment after a syphilis-positive diagnosis or if seeking treatment, may not be successfully completing treatment. Second, if women are seeking and successfully completing treatment, they may experience a recurrence of syphilis because of failure to reduce risk behaviour after the first syphilis diagnosis. Previous research has shown that high-risk populations reduce their post-HIV-test risk behaviours regardless of the test result [17]. Because syphilis is a treatable infection, syphilis-positive FSWs may not fear subsequent syphilis-positive diagnoses or transmission to others. Previous research has identified syphilis as a biological risk factor for HIV [18–20], syphilis-positive FSWs increase their own and their partners' risk of HIV transmission.

Multivariate analysis revealed that being infected with HSV-2 and *C. trachomatis* were both risk factors for syphilis in this study population. Biological factors may help explain the association with HSV-2 and *C. trachomatis* infections. *C. trachomatis* can cause pelvic inflammatory disease, cervical inflammation and other chronic inflammation of the urogenital tract [21, 22] and chronic urogenital tract inflammation can contribute to the susceptibility of other microbial pathogens, including syphilis [23–25]. Our study finding that there were higher rates of syphilis in subjects with HSV-2 is in accord with previous studies [23–26]. HSV-2 is a reliable indicator of past risky sexual behaviour and such behaviours may also put individuals at risk for syphilis [27].

Table 2. *Results of univariate analysis: risk factors for syphilis infection in female sex workers in three consecutive cross-sectional surveys*

Variable, risk factor	Unadjusted OR (95% CI)
Age (years)	
16–20†	
21–25	1.9 (1.04–3.40)
26–52	2.7 (1.54–4.76)
Ethnicity	
Han†	
Other	1.2 (0.77–1.84)
Registered permanent residence	
Outside Yunnan†	
Kaiyuan City	0.9 (0.43–1.76)
Other cities in Yunnan	1.2 (0.67–2.03)
Education (years)	
<9†	
≥9	0.4 (0.26–0.61)
Marital status	
Single or cohabiting†	
Married, separated, divorced, or widowed	1.7 (1.14–2.60)
Residence type	
Apartment†	
Family home	0.9 (0.45–1.60)
Brothel or other working location	0.6 (0.35–0.96)
Illegal drug use	
No†	
Yes	1.3 (0.81–2.10)
Drink alcohol	
No†	
Yes	0.4 (0.30–0.64)
Duration of commercial sex work (years)	
<2†	
≥2	1.2 (0.85–1.70)
Has regular sexual partner	
No†	
Yes	0.99 (0.69–1.41)
Always used condom with regular partner in previous week	
Yes†	
No	1.2 (0.62–2.49)
Fee per service	
>100 RMB*	
≤100 RMB	1.7 (1.14–2.52)
Number of clients in previous week	
1–5†	
≥6	1.8 (1.24–2.65)
Always used condom with clients in previous week	
Yes†	
No	3.1 (2.03–4.74)
Condom split or fell off during sex with clients in previous week	
No†	
Yes	1.2 (0.63–2.19)
Vaginal douching	
No†	
Yes	0.7 (0.49–1.13)
HIV-1 positive	
No†	
Yes	1.1 (0.62–2.00)

Table 2 (cont.)

Variable, risk factor	Unadjusted OR (95% CI)
<i>N. gonorrhoeae</i> positive	
No†	
Yes	1.6 (0.89–2.72)
<i>C. trachomatis</i> positive	
No†	
Yes	1.7 (1.16–2.55)
<i>T. vaginalis</i> positive	
No†	
Yes	1.3 (0.70–2.29)
HSV-2 positive	
No†	
Yes	5.0 (2.49–9.93)

OR, Odds ratio; CI, confidence interval.

* RMB, Renminbi (100 RMB=9 GBP).

† Indicates reference group.

Table 3. Results of multivariate analysis: risk factors for syphilis in female sex workers in three consecutive cross-sectional surveys

Risk factors	Adjusted OR (95% CI)
Age (21–25 years vs. 16–20 years)	1.9 (1.04–3.53)
Age (26–52 years vs. 16–20 years)	2.1 (1.17–3.85)
Education level (≥ 9 years vs. < 9 years)	0.5 (0.31–0.75)
Number of clients in previous week (≥ 6 clients vs. < 6 clients)	1.5 (1.01–2.21)
Inconsistently used condoms with clients in previous week	2.1 (1.38–3.20)
HSV-2 positive	3.8 (1.86–7.67)
<i>C. trachomatis</i> positive	1.8 (1.21–2.71)

OR, Odds ratio; CI, confidence interval.

Additional consideration of the independently associated behavioural risk factors provides further insight into the nature of syphilis-related risk behaviors in Chinese FSWs. Inconsistent condom use and higher client volume were both significantly associated with syphilis in this study and have been identified as risk factors in previous research [14, 28, 29]. Low condom use and high client volume increase exposure to syphilis and other STIs which in turn increases the risk of transmission. Similarly, older age, which was found as a risk factor in this study, has also been identified as a syphilis risk factor in previous research on high-risk populations in China and other settings [30]. However, research that looks further into the relationship between syphilis and older age is needed. Older age could also be a proxy for other risks, such as client base, that were not

captured in this model. Lower education was also identified as a syphilis risk factor in the multivariate model. FSWs with poor education may have less access to information about STIs, their prevention methods, safe-sex practices and proper health-seeking behaviours. Although not statistically significant, the overall low reported condom use rates with RPs in this population were also a point of concern identified in this study. Only 17% of FSWs with RPs and 10.7% of syphilis-positive FSWs with RPs reported consistent condom use with those partners. FSWs may act as a bridge of infection of syphilis and other STIs or HIV to lower risk populations through unsafe sexual practices with their RPs. Health education programmes that address condom negotiation between different types of partners may help FSWs and their clients and FSWs and

their RPs to more effectively and successfully discuss condom use.

Despite significant findings, this study was subject to several limitations. First, in subjects who may have been in early or late stages of syphilis, false-negative results for both RPR and TPPA tests may result in an underestimation of syphilis in our study. Subjects who may have been in the early stages of syphilis infection may at least have been detected in subsequent follow-ups, thus reducing the effect of this bias. Syphilis-positive participants were referred for treatment to Kaiyuan City Dermatology Hospital, but information on the medical treatment or staging of syphilis was not collected; therefore, it is difficult to distinguish between persistent and recurrent syphilis. This is compounded by recall bias regarding medical treatment or staging of syphilis. Second, follow-up with this population was low and only 16.7% of participants completed all three surveys. Low follow-up may have impacted the calculated incidence, prevalence, treatment, and persistence rates. Previous research on commercial sex in China has suggested that most FSWs are highly mobile but within a limited area, suggesting that future studies might achieve better follow-up by working with not only local but also prefectural-level health departments to recruit and follow-up with participants. Key informants from the target population might also be recruited to consult on alternative methods for better maintenance of the study cohort. Finally, this study analysed a population of FSWs in Kaiyuan City, Yunnan and the results of this study may not be applicable to all FSWs in Kaiyuan or FSWs in other parts of China.

Significantly, this study found a high persistence of syphilis in this population of FSWs in Kaiyuan City, Yunnan. As discussed earlier, syphilis may be of particular concern because of its infectiousness and its ability to act as a co-factor in HIV transmission. Future research should investigate the issues that impact on recurrent and persistent syphilis in order to help inform effective interventions. There is an urgent need for a national campaign to carry out screening and treatment of syphilis, including education programmes and prevention efforts to address social drivers of this epidemic. In addition further research into the current treatment programme and factors associated with unsuccessful treatment and recurrent syphilis are important for control of this preventable and treatable STI.

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DECLARATION OF INTEREST

None.

REFERENCES

1. **Chen ZQ, et al.** Syphilis in China: results of a national surveillance programme. *Lancet* 2007; **369**: 132–138.
2. **Fisman DN.** Syphilis resurgent in China. *Lancet* 2007; **369**: 84–85.
3. **Sidel VW.** The barefoot doctors of the People's Republic of China. *New England Journal of Medicine* 1972; **286**: 1292–300.
4. **Grassly NC, Fraser C, Garnett GP.** Host immunity and synchronized epidemics of syphilis across the United States. *Nature* 2005; **433**: 417–421.
5. **Yang H, et al.** Heterosexual transmission of HIV in China: a systematic review of behavioral studies in the past two decades. *Sexually Transmitted Diseases* 2005; **32**: 270–280.
6. **Qian HZ, Vermund SH, Wang N.** Risk of HIV/AIDS in China: subpopulations of special importance. *Sexually Transmitted Infections* 2005; **81**: 442–447.
7. **Wang H, et al.** Application of cumulative odds logistic model on risk factors analysis for sexually transmitted infections among female sex workers in Kaiyuan city, Yunnan province, China. *Sexually Transmitted Infections* 2009; **85**: 290–295.
8. **Wang H, et al.** Prevalence and predictors of herpes simplex virus type 2 infection among female sex workers in Yunnan Province, China. *International Journal of STD AIDS* 2008; **19**: 635–639.
9. **Ruan Y, et al.** Syphilis among female sex workers in southwestern China: potential for HIV transmission. *Sexually Transmitted Diseases* 2006; **33**: 719–723.
10. **Ma S, et al.** Decreasing STD incidence and increasing condom use among Chinese sex workers following a short term intervention: a prospective cohort study. *Sexually Transmitted Infections* 2002; **78**: 110–114.
11. **Tian LG, et al.** Incidence rates of human immunodeficiency virus and syphilis as well as the rate of retention in a 6-month follow-up study of female sex workers in areas with heavy drug use in Xichang of Sichuan province, China. *Chinese Journal of Epidemiology* 2006; **27**: 939–942.

12. **Lee PM, Ho KM.** Risk factors associated with human immunodeficiency virus (HIV) infection among attendees of public sexually transmitted infection clinics in Hong Kong: implications for HIV prevention. *Hong Kong Medical Journal* 2008; **14**: 259–266.
13. **Huhn GD, et al.** Factors associated with newly diagnosed HIV among persons with concomitant sexually transmitted diseases. *Sexually Transmitted Diseases* 2008; **35**: 731–737.
14. **van den Hoek A, et al.** High prevalence of syphilis and other sexually transmitted diseases among sex workers in China: potential for fast spread of HIV. *AIDS* 2001; **15**: 753–759.
15. **Huang T, et al.** Seroprevalence of HCV among STD patients, sexual promiscuous groups and general population in Jinan. *Chinese Journal of STD/AIDS Prevention and Control* 1998; **4**: 28–30.
16. **Wang B, et al.** Vaginal douching, condom use, and sexually transmitted infections among Chinese female sex workers. *Sexually Transmitted Diseases* 2005; **32**: 696–702.
17. **Jin X, et al.** Association between testing for human immunodeficiency virus and changes in risk behaviors among injecting drug users in southern China. *Sexually Transmitted Diseases* 2009; **36**: 473–477.
18. **Cameron DW, et al.** Female to male transmission of human immunodeficiency virus type 1: risk factors for seroconversion in men. *Lancet* 1989; **2**: 403–407.
19. **Plummer FA, et al.** Cofactors in male-female sexual transmission of human immunodeficiency virus type 1. *Journal of Infectious Diseases* 1991; **163**: 233–239.
20. **Laga M, et al.** Non-ulcerative sexually transmitted diseases as risk factors for HIV-1 transmission in women: results from a cohort study. *AIDS* 1993; **7**: 95–102.
21. **De Muylder X, et al.** The role of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* in pelvic inflammatory disease and its sequelae in Zimbabwe. *Journal of Infectious Diseases* 1990; **162**: 501–505.
22. **Buchholz KR, Stephens RS.** The extracellular signal-regulated kinase/mitogen-activated protein kinase pathway induces the inflammatory factor interleukin-8 following *Chlamydia trachomatis* infection. *Infection and Immunity* 2007; **75**: 5924–5929.
23. **Msuya SE, et al.** Seroprevalence and correlates of herpes simplex virus type 2 among urban Tanzanian women. *Sexually Transmitted Diseases* 2003; **30**: 588–592.
24. **O'Farrell N, et al.** HSV-2 antibodies in female sex workers in Vietnam. *International Journal of STD AIDS* 2006; **17**: 755–758.
25. **Kaur R, et al.** Risk factors of herpes simplex virus type 2 among STD clinic attenders in Delhi, India. *Journal Community Diseases* 2006; **38**: 339–343.
26. **Mihret W, et al.** Herpes simplex virus type 2 seropositivity among urban adults in Africa: results from two cross-sectional surveys in Addis Ababa, Ethiopia. *Sexually Transmitted Diseases* 2002; **29**: 175–181.
27. **van de Laar MJ, et al.** Prevalence and correlates of herpes simplex virus type 2 infection: evaluation of behavioural risk factors. *International Journal of Epidemiology* 1998; **27**: 127–134.
28. **Mejia A, et al.** Syphilis infection among female sex workers in Colombia. *Journal of Immigrant and Minority Health* 2009; **11**: 92–98.
29. **Lu F, et al.** Prevalence of HIV infection and predictors for syphilis infection among female sex workers in southern China. *Southeast Asian Journal of Tropical Medicine and Public Health* 2009; **40**: 263–272.
30. **Ruan Y, et al.** Risk factors for syphilis and prevalence of HIV, hepatitis B and C among men who have sex with men in Beijing, China: implications for HIV prevention. *AIDS and Behavior* 2009; **13**: 663–670.