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Original Article

Seroprevalence of hepatitis B surface antigen and hepatitis B e antigen among childbearing-age women in Mianyang, China

Min Wang[1], Hong Li[2], Yulin Ji[3], Yuanji Ma[4], Liping Wang[5], Tao Ren[6], Fengsu Hou[1], Ping Yuan[1]

[1] *Department of Epidemiology and Statistics, West China School of Public Health, Sichuan University, Chengdu, Sichuan, China*
[2] *Department of Urology, West China Hospital, Sichuan University, Chengdu, Sichuan, China*
[3] *Department of Respiratory Medicine, West China Hospital, Sichuan University, Chengdu, Sichuan, China*
[4] *Department of Infectious Disease, West China Hospital, Sichuan University, Chengdu, Sichuan, China*
[5] *Jiangyou County Center for Disease Control and Prevention, Mianyang, Sichuan, China*
[6] *Fucheng District Center for Disease Control and Prevention, Mianyang, Sichuan, China*

Abstract

Introduction: Few studies have focused on hepatitis B virus (HBV) infection among childbearing-age women. This study explored hepatitis B surface antigen (HBsAg) seroprevalence and hepatitis B e antigen (HBeAg) seroprevalence and their associated factors among childbearing-age women.

Methodology: A cross-sectional, population-based study was conducted between June 2013 and October 2013 in Mianyang; women 15–49 years of age were enrolled using a multistage cluster sampling design. Participants completed questionnaires about demographic characteristics and potential factors associated with HBV infection, and provided blood samples for screening HBsAg and HBeAg. The analysis methods included descriptive statistics, Chi-square test, and multivariate logistic regression.

Results: Among 62,007 childbearing-age women, 5.66% were HBsAg positive. The HBsAg seroprevalence rates were 7.28% in women 40–44 years of age, 7.0% in Fucheng women, 5.70% in Han women, 6.59% in married women, and 6.60% in agriculture workers. Multivariate models identified having HBsAg-positive family members, and having no self-reported immunization history to be positively associated with HBsAg positivity; being a healthcare worker was negatively associated with HBsAg positivity. Among 3,499 HBsAg-positive childbearing-age women, 9.97% were HBeAg positive. The HBeAg seroprevalence rates were 46.54% in women 15–19 years of age, 10.82% in Fucheng women, 38.51% in single women, and 42.86% in students. Multivariate models identified living in Fucheng and younger age to be positively associated with HBeAg positivity.

Conclusions: These findings could provide scientific evidence for the Chinese government to plan efficient health care services and prevention initiatives, and to allocate health resources reasonably for this population.

Key words: childbearing-age women; hepatitis B surface antigen; hepatitis B e antigen; seroprevalence; China.

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Introduction

HBV infection remains a challenging global health problem, affecting more than two billion people worldwide [1]. There are still more than 350 million chronic HBV infection carriers worldwide, who face a lethal risk of developing hepatic decompensation, cirrhosis, and hepatocellular carcinoma (HCC) [2]. In China, the improvements in socioeconomic status and hygienic conditions, the introduction of general vaccination, as well as complete sterilization of medical instruments, have led to a decline in the prevalence of HBV infection [3]. However, it still remains as high as 7.18%, and 300,000 people die from HBV-related diseases annually, accounting for 40%–50% of HBV-related deaths worldwide [1,3]. It was estimated that even for residents with health insurance, the direct cost caused by HBV infection exceeded 40% of resident's disposable household income in China [4].

HBV infection is not just a risk for childbearing-age women; women with HBV infection can transmit the HBV to their newborns, to children or other household members, and to sexual partners or spouses by vertical, horizontal, or sexual transmission [5]. Vertical transmission is the predominant transmission mode in China [5] and China still accounts for the largest annual number of perinatal HBV infections, estimated to be 84,121 in the World Health

Organization (WHO) Western Pacific Region [6]. Horizontal transmission is an important transmission mode during early childhood [7]. Children, especially those 0–3 years of age, usually stay with their mothers and thus face a higher risk of being infected by their infectious mothers. Almost 80%–90%, 20%–30%, and less than 5% of individuals who are infected during the perinatal period, early childhood, and adulthood will become chronic carriers, respectively [8]. A systematic review also shows that HBV infection at an early age is not only a known risk factor for chronic HBV infection, but also increases the risk of developing liver cirrhosis and HCC [9]. In China, chronic HBV infection is the dominant risk factor for HCC [10]. Thus, for childbearing-age women, measures should be taken to protect them from being infected, and to cut off vertical transmission and early childhood horizontal transmission prospectively.

Mothers with HBV infection can transmit the HBV to their newborns vertically. For these newborns, post-exposure prophylaxis with hepatitis B vaccine and hepatitis B immune globulin (HBIG) within 24 hours of birth have been recommended to tremendously reduce the prevalence of HBV infection [3]. However, the incidence of immunoprophylaxis failure still remains [11]. Both HBsAg-positive and HBeAg-positive mothers more easily transmit the viruses to their newborns than do mothers who are only HBsAg positive [12,13]. This emphasizes again that measures focusing on childbearing-age women should be taken to cut off vertical transmission efficiently and prospectively.

Although HBsAg seroprevalence and its risk factors have already been investigated in various groups (general population [14], blood donors [15], healthcare workers [16], and pregnant women [17]), few studies have focused on HBsAg seroprevalence and its associated factors among childbearing-age women. Furthermore, HBeAg seroprevalence and its associated factors among HBsAg-positive childbearing-age women in China remains largely unknown, and efficient strategies to control HBV infection among childbearing-age women are lacking. Thus, for purposes of planning efficient healthcare services and prevention initiatives, as well as allocating health resources reasonably for childbearing-age women, it is necessary to investigate the prevalence of HBV infection among this population.

We conducted this study to explore HBsAg seroprevalence and its associated factors among childbearing-age women, and further explored HBeAg seroprevalence and its associated factors among HBsAg-positive childbearing-age women in Mianyang, China.

Methodology

Between June 2013 and October 2013, a cross-sectional, large population-based study was conducted. The study included women between 15 and 49 years of age residing in Mianyang city, which is located in the northwest region of Sichuan Province, China. Of note, a city in China most often is a region that can include multiple counties/districts (equivalent to counties), towns/sub-districts (equivalent to towns), and villages/residential communities (equivalent to villages). Mianyang city is not a major, highly modern urban area like Sichuan’s capital, Chengdu City. In 2010, its per capita gross domestic product (GDP) of 20,053 yuan (approximately 3,303 US dollars) was the sixth in Sichuan Province [18].

Study population and sampling strategy

All participants who were enrolled in this study were permanent residents of Mianyang city and had provided informed consent. Target study populations were selected from a list of residents, using a random multistage cluster sampling approach. First, two counties/districts were selected from nine counties/districts in Mianyang city: Fucheng district and Jiangyou county. Second, towns/sub-districts in selected counties/districts were divided into three different levels based on economic status, which was defined according to the current year’s GDP obtained from the data published by the local Bureau of Statistics. In each of the three levels, seven towns/sub-districts were randomly selected. Third, within each town/sub-district, all villages or residential communities were selected. Finally, proportional random sampling was used to select 60% of permanent residents in each village or residential community as the study populations.

Procedure, questionnaire, serological testing, and quality control

After providing informed consent, each participant completed a face-to-face interview and had blood drawn. The face-to-face structured interviews were conducted by interviewers who were a members of the field research team. The interviewers were trained and qualified for this study. After completing the face-to-face interview, each participant provided a 5 mL blood sample for serological testing. Participants received some compensation for their time after completing the entire study.

A questionnaire was used to collect information about demographic characteristics and potential factors associated with HBV infection. The demographic characteristics included age, residence region, ethnic group, marital status, and occupational status. The potential factors associated with HBV infection included the following: history of surgery, history of trauma, history of transfusion, having HBsAg-positive family members, and self-reported immunization history.

The trained phlebotomist drew a 5 mL venous blood sample from each participant using strict hygiene and safety guidelines. The participant's demographic information was recorded. The blood samples were centrifuged and tested immediately, or were stored in a cold container for no more than 24 hours before testing. Qualitative enzyme-linked immunosorbent assay (ELISA) kits (Xinhaiwan Company, Chengdu, China) were used to assess HBsAg status. If a blood sample was HBsAg positive, qualitative ELISA kits were used to assess HBeAg status. A signal to cut-off (S/CO) ratio ≥ 1 was considered to be HBsAg or HBeAg positive. Verification of test results for positive specimens was carried out by retesting twice on the same sample using the same kits. Only samples that were positive on both tests were considered to be HBsAg or HBeAg positive.

Data collection

A scanner was used to scan the completed questionnaires into pictures, and then optical character recognition (OCR) technology was used to convert the pictures into digital data, storing it in a special software. Then, the biochemical data from the biochemical analyzer database was exported directly and was also stored in the special software. Finally, all the data stored in the special software was exported into a Microsoft Excel database directly. The special software was developed by the technicians from the College of Computer Science, Sichuan University.

Statistical analysis

SPSS statistical software (version 17.0) was used to manage and analyze the data. First, participants' demographic information was described, and then descriptive statistics were used to calculate HBsAg seroprevalence or HBeAg seroprevalence by age groups (15–19 years, 20–24 years, 25–29 years, 30–34 years, 35–39 years, 40–44 years, or 45–49 years), residence regions (Fucheng district or Jiangyou county), ethnic groups (Han, or other ethnic minorities), marital status (single, married, or widowed/divorced), occupational status (agriculture worker, non-agriculture worker, student, healthcare worker, or unemployed), and all associated factors among childbearing-age women or HBsAg-positive childbearing-age women. Next, the Pearson's Chi-square test and Fisher's exact test were used to carry out univariate comparisons between categorical variables. The Cochran–Armitage trend test was used to identify the trend across ordered groups such as age groups among HBsAg-positive childbearing-age women. Finally, demographic characteristics or associated factors were included in the univariate analyses at a significance level of $p < 0.10$ into an unconditional multivariate logistic regression model, which was constructed using the enter method. Odds ratios (ORs) were calculated with the corresponding 95% confidence intervals (CIs) to explore the strength of the relationship. All statistical tests were two-sided, and $p < 0.05$ was used to indicate statistical significance.

Ethical considerations

This study was approved by the ethics committee of West China Hospital, Sichuan University, and it conformed to the provisions of the Declaration of Helsinki. Each participant signed an informed consent form before enrollment.

Results

Characteristics of the study participants

Of 62,555 individuals chosen randomly as the study populations, 62,007 individuals were included for final analysis. Before completing questionnaires, providing blood samples, or conclusive serological results, 548 individuals were excluded. The mean age of participants was 34.6 ± 11.4 years. About 51.53% of participants were living in Jiangyou county, while 48.47% of them were living in Fucheng district. The majority of participants were Han (98.60%). The percentages of married, single, and widowed/divorced women were 77.34%, 22.05%, and 0.61%, respectively. Occupational status included agricultural workers (50.97%), non-agricultural workers (17.63%), students (18.31%), healthcare workers (1.86%), and unemployed (11.23%) (Table 1).

HBsAg seroprevalence and its associated factors – univariate analyses and multivariate logistic regression

Of 62,007 childbearing-age women in this study, 3,508 (5.66%) were positive for HBsAg. On univariate analyses (Table 2), HBsAg seroprevalence was high in the 40–44, 30–34, 45–49, and 35–39 year age groups (7.28%, 6.61%, 6.59%, and 6.46%, respectively), and lowest in the 15–19 year age group (1.84%, $p < 0.001$). Women living in Fucheng district had a higher HBsAg seroprevalence than those living in Jiangyou county (7.00% *vs*. 4.40%; $p < 0.001$). Han women had a higher HBsAg seroprevalence than women of other ethnic minorities (5.70% *vs*. 2.76%; $p < 0.001$). The HBsAg seroprevalence was 9.02%, 6.57%, and 2.27% in divorced/widowed, married, and single women, respectively ($p < 0.001$). The HBsAg seroprevalence differed among occupational status ($p < 0.001$). Unemployed women had the highest HBsAg seroprevalence (7.45%), and students had the lowest (1.86%).

On univariate analyses (Table 2), several significant factors associated with HBsAg positivity were also revealed. Having a history of surgery and having HBsAg-positive family members were significantly positively associated with HBsAg positivity among childbearing-age women ($p < 0.001$). Women who had no self-reported immunization history had a higher HBsAg seroprevalence than did those with self-reported immunization history ($p < 0.001$).

In the multivariate model (Table 2), older women, especially those in the 40–44 year age group, were more likely to be HBsAg-positive than those in the 15–19 year age group (OR, 2.65; 95% CI, 1.78–3.94). Women living in Fucheng district had a higher HBsAg seroprevalence than did those living in Jiangyou county (OR, 1.62; 95% CI, 1.51–1.75). Han women had a higher HBsAg seroprevalence than did those of other ethnic minorities (OR, 1.59; 95% CI, 1.05–2.39). Agriculture workers had a higher HBsAg seroprevalence (OR, 1.13; 95% CI, 1.03–1.24), and healthcare workers had a lower HBsAg seroprevalence (OR, 0.43; 95% CI, 0.28–0.66) compared with non-agriculture workers. Women who had HBsAg-positive family members were more than four times as likely to be HBsAg positive (OR, 4.52; 95% CI, 1.29–3.88). The lack of self-reported immunization history was positively associated with HBsAg positivity (OR, 1.51; 95% CI, 1.36–1.68).

Table 1. Characteristics of the study participants

Characteristics	Frequency	Percentage
Age groups (in years)		
15~	11,848	19.11
20~	3,219	5.19
25~	4,836	7.80
30~	4,658	7.51
35~	9,289	14.98
40~	13,881	22.39
45~49	14,276	23.02
Residence regions		
Fucheng	30,054	48.47
Jiangyou	31,953	51.53
Ethnic groups		
Han	61,138	98.60
Others	869	1.40
Marital status		
Single	13,672	22.05
Married	47,958	77.34
Widowed/divorced	377	0.61
Occupational status		
Agriculture worker	31,607	50.97
Non-agriculture worker	10,931	17.63
Student	11,351	18.31
Healthcare worker	1,154	1.86
Unemployed	6,964	11.23
Total	62,007	100.00

Table 2. HBsAg seroprevalence and its associated factors among childbearing-age women

Variables	Frequency	HBsAg+ frequency	Seroprevalence % (95% CI)	X^2	p*	Multivariate** OR (95% CI)	Multivariate** p
Demographic characteristics							
Age groups (Years)							
15~	11,848	218	1.84 (1.60-2.08)			1	-
20~	3,219	171	5.31 (4.54-6.08)			2.14 (1.48-3.09)	0.001
25~	4,836	259	5.36 (4.72-5.98)			2.02 (1.35-3.02)	<0.001
30~	4,658	308	6.61 (5.90-7.32)	436.272	<0.001	2.50 (1.67-3.78)	<0.001
35~	9,289	600	6.46 (5.96-6.96)			2.37 (1.59-3.53)	<0.001
40~	13,881	1,011	7.28 (6.85-7.71)			2.65 (1.78-3.94)	<0.001
45~49	14,276	941	6.59 (6.18-7.00)			2.32 (1.56-3.44)	<0.001
Residence regions							
Fucheng	30,054	2,103	7.00 (6.71-7.29)	196.201	<0.001	1.62 (1.51-1.75)	<0.001
Jiangyou	31,953	1,405	4.40 (4.17-4.63)			1	-
Ethnic groups							
Han	61,138	3,484	5.70 (5.52-5.88)	13.846	<0.001	1.59 (1.05-2.39)	0.03
Others	869	24	2.76 (1.67-3.85)			1	-
Marital status							
Single	13,672	311	2.27 (2.02-2.52)			1	-
Married	47,958	3,163	6.60 (6.37-6.81)	380.137	<0.001	0.97 (0.75-1.25)	0.81
Widowed/divorced	377	34	9.02 (6.13-11.91)			1.39 (0.90-2.15)	0.14
Occupational status							
Agriculture worker	31,607	2,087	6.60 (6.33-6.87)			1.13 (1.03-1.24)	0.01
Non-agriculture worker	10,931	668	6.11 (5.66-6.56)			1	-
Student	11,351	211	1.86 (1.61-2.11)	434.103	<0.001	0.67 (0.60-1.24)	0.41
Healthcare worker	1,154	23	1.99 (1.17-2.87)			0.43 (0.28-0.66)	<0.001
Unemployed	6,964	519	7.45 (6.83-8.07)			1.13 (1.00-1.27)	0.06
Behavior factors							
History of surgery							
Yes	13,997	906	6.47	22.519	<0.001	0.99 (0.91-1.07)	0.08
No	48,010	2,602	5.42			1	-
History of trauma★							
Yes	825	56	6.79	2.002	0.16		
No	61,182	3,452	5.64				
History of transfusion★							
Yes	620	42	6.77	1.463	0.23		
No	61387	3,466	5.65				
HBsAg-positive family members							
Yes	880	191	21.70	430.901	<0.001	4.53 (3.83-5.36)	<0.001
No	60,067	3,256	5.42			1	-
Unknown	1,060	61	5.75			1.75 (1.34-2.30)	<0.001
Immunization history							
Yes	18,175	598	3.29	270.760	<0.001	1	-
No	35,164	2,352	6.69			1.51 (1.36-1.68)	<0.001
Unknown	8,668	558	6.44			1.33 (1.17-1.51)	<0.001
Total	**62,007**	**3,508**	**5.66**				

*Pearson's Chi-square; **multivariate logistic regression analysis; ★These demographic characteristics or factors ($p \geq 0.10$) were not included in multivariate logistic regression; OR: odds ratio; CI: confidence interval.

Table 3. HBeAg seroprevalence and its associated factors among HBsAg-positive childbearing-age women

Variables	HBsAg+ frequency	HBeAg+ frequency	Seroprevalence %(95% CI)	X^2	p	Multivariate****	
						OR (95% CI)	**p**
Demographic characteristics							
Age groups (Years)							
15~	217	101	46.54 (39.90-53.18)	44.784*	<0.001	20.95 (9.01-48.71)	<0.001
20~	171	38	22.22 (15.99-28.45)			6.52 (3.73-11.42)	<0.001
25~	259	42	16.22 (11.73-20.71)			4.65 (2.88-7.50)	<0.001
30~	308	34	11.04 (7.54-14.54)			3.03 (1.85-4.97)	<0.001
35~	598	47	7.86 (5.70-10.02)			2.12 (1.35-3.32)	0.001
40~	1,008	51	5.06 (3.71-6.41)			1.33 (0.86-2.06)	0.20
45~49	938	36	3.84 (2.61-5.07)			1	-
Residence regions							
Fucheng	2,098	227	10.82 (9.49-12.15)	4.172**	0.04	1.40 (1.08-1.82)	0.01
Jiangyou	1401	122	8.71 (7.23-10.19)			1	-
Ethnic groups★							
Han	3,475	347	9.99 (8.99-10.99)	-***	0.57		
Others	24	2	8.33 (-)				
Marital status							
Single	309	119	38.51 (33.08-43.94)	308.082**	<0.001	1	-
Married	3,156	229	7.26 (6.53-8.17)			0.89 (0.47-1.70)	0.73
Widowed/divorced	34	1	2.94 (-)			0.35 (0.04-2.84)	0.32
Occupational status							
Agriculture worker	2,081	150	7.21 (6.10-8.32)	271.880**	<0.001	1.08 (0.77-1.51)	0.67
Non-agriculture worker	666	59	8.86 (6.70-11.02)			1	-
Student	210	90	42.86 (36.71-49.55)			0.90 (0.45-1.79)	0.76
Health care worker	23	2	8.70 (-)			0.71 (0.16-3.28)	0.67
Unemployed	519	48	9.25 (6.76-11.74)			1.04 (0.68-1.59)	0.85
Behavior factors							
History of surgery★							
Yes	906	78	8.61	2.537**	0.11		
No	2,593	271	10.45				
History of trauma★							
Yes	56	4	7.14	0.508**	0.48		
No	3,443	345	10.02				
History of transfusion							
Yes	42	1	2.38	0.120**	0.07	0.43 (0.06-3.16)	0.41
No	3,457	348	10.07			1	-
Have HBsAg-positive family members							
Yes	191	22	11.52	27.186**	<0.001	1.00 (0.61-1.65)	1.00
No	3,247	309	9.52			1	-
Unknown	61	18	29.51			2.46 (1.26-4.81)	0.01
Immunization history							
Yes	597	121	20.27	88.595**	<0.001	1	-
No	2,344	172	7.34			0.93 (0.67-1.29)	0.65
Unknown	558	56	10.04			0.96 (0.64-1.44)	0.83
Total	**3,499**	**349**	**9.97**				

*Cochran–Armitage trend test; **Pearson's Chi-square; ***Fisher's exact test; ****multivariate logistic regression analysis; ★ These demographic characteristics or factors ($p \geq 0.10$) were not included in multivariate logistic regression; OR: odds ratio; CI: confidence interval

HBeAg seroprevalence and its associated factors – univariate analyses and multivariate logistic regression

Of 3,499 HBsAg-positive childbearing-age women, 349 (9.97%) were positive for HBeAg. On the univariate analyses (Table 3), HBeAg seroprevalence showed a statistically significant decreasing trend with increasing age ($p < 0.001$); it was highest in the 15–19 year age group (46.54%) and lowest in the 45–49 year age group (3.84%). Women living in Fucheng district had a higher HBeAg seroprevalence than did those living in Jiangyou county (10.82% *vs*. 8.71%; $p = 0.04$). The HBeAg seroprevalence was 2.94%, 7.26%, and 38.51% in divorced/widowed, married, and single women, respectively ($p < 0.001$). The HBeAg seroprevalence differed among occupational status ($p < 0.001$). Students had the highest HBeAg seroprevalence (42.86%), and agriculture workers had the lowest (7.21%).

On univariate analyses (Table 3), another significant factor associated with HBeAg positivity was also revealed. Women who had no self-reported immunization history had a lower HBeAg seroprevalence than did those with self-reported immunization history ($p < 0.001$).

In the multivariate model (Table 3), younger women, especially those 15–19 years of age, were more likely to be HBeAg positive than those 44–49 years of age (OR, 20.95; 95% CI, 9.01–48.71). Women living in Fucheng district had a higher HBeAg seroprevalence than those living in Jiangyou county (OR, 1.40; 95% CI, 1.08–1.82).

Discussion

The HBsAg seroprevalence among childbearing-age women was 5.66% in this study, lower than 9.51% reported in Hainan province [19], and higher than 3.77% and 4.53% reported in Henan and Shangdong provinces, respectively [20,21]. HBV infection is not just a risk for childbearing-age women; women with HBV infection can transmit the HBV to their newborns, children or other household members, and sexual partners or spouses by vertical, horizontal, and sexual transmission. Vertical transmission contributes significantly to the persistence of plentiful chronic HBV infections [7] and cannot be totally blocked by immunoprophylaxis for newborns [11]. The Chinese government has formulated some strategies to reduce HBV infections, including screening for HBsAg during pregnancy, immunizing high-risk populations, managing blood products, encouraging condom use, and following standard medical practices [22-24]. However, the prevalence of HBV infection still remains as high as 7.18% [3]. Special protective strategies for childbearing-age women are lacking, with the exception of premarital medical examination for HBV [22]. The utilization rate of premarital medical examination, which is voluntary, is as low as 48.4%; most of the HBV-infected women cannot, therefore, be diagnosed and treated through this method [25]. Thus, the high HBsAg seroprevalence highlights that further efforts are needed to protect childbearing-age women from being infected, and to cut off vertical, horizontal, and sexual transmission of HBV prospectively.

This study showed that older women had a higher HBsAg seroprevalence compared with women 15–19 years of age. The HBsAg seroprevalence was high in the 40–44, 30–34, 45–49, and 35–39 year age groups, and lowest in the 15–19 group, which further confirmed the former epidemiological discovery by Luo *et al*. [26] and Chen *et al*. [27]. There are four reasons that can explain why HBsAg seroprevalence was lowest in the 15–19 year age group. First, hepatitis B immunization was recommended for all Chinese infants in 1992. Second, all children under 15 years of age who were never or incompletely immunized with hepatitis B vaccine were revaccinated from 2009 to 2011 [22]. Third, the women in this group live in a better environment, with lower prevalence of HBV infection, compared with women in the older age groups. Last, the women in the 15–19 year age group have fewer opportunities to be infected by sexual transmission. There may be another reason explaining why the older women had a higher HBsAg seroprevalence: HBsAg seroprevalence can accumulate with increasing age, since HBsAg can persist for many years with chronic HBV infection [28]. This study also showed that the HBsAg seroprevalence was more than 5% among women 20–29 years of age, who were at the peak period of pregnancy; they may more easily transmit the HBV to their newborns vertically. Thus, government programs should target women 30–49 years of age and/or women 20–29 years of age for HBV-related education, screening, therapy, and vaccination.

This study showed that childbearing-age women living in Fucheng district had a higher HBsAg seroprevalence than those living in Jiangyou county. However, reasons causing differences in HBsAg seroprevalence among residence regions have remained unknown. We suggest that Fucheng district is the political, economical, and cultural center of Mianyang city, with convenient transportation and numerous floating populations, and thus may accelerate the spread of HBV infection. The floating populations with HBV infection might easily transmit the HBV to others, because most of them have not been registered for management and are always in poor health condition [29].

This study indicated that agriculture workers had a higher HBsAg seroprevalence, and healthcare workers had a lower HBsAg seroprevalence than did non-agriculture workers. The low HBsAg seroprevalence in healthcare workers was consistent with Liang *et al*.'s study [30] and can be attributed to two reasons. First, hepatitis B immunization funded by local governments or medical facilities has been recommended for high-risk populations, including healthcare workers in China [31]. Second, healthcare workers with more professional medical knowledge can protect themselves more efficiently from becoming infected. The high HBsAg seroprevalence in agriculture workers was consistent with Moezzi *et al*.'s study [32] and can be also attributed to two reasons. First, agriculture workers have the lowest vaccination rate of all occupations [33]. Second, most of them have low education levels and little knowledge about healthcare. Thus, protective programs or strategies, especially health education for agriculture workers, should be developed and implemented.

This study showed that histories of surgery, blood transfusion, and trauma were not associated with HBsAg positivity among childbearing-age women. This was not consistent with Gheorghe *et al*.'s study, which reported that surgical operation and blood transfusion were relevant with HBV [34]. We suggest that good surgery and nursing care environments in the local areas could explain these differences, because the Chinese government has formulated some strategies about standard medical practices to reduce infections from medical operations [22]. Having HBsAg-positive family members was a common associated factor observed in many previous studies [35,36]. Our results also indicated that no self-reported immunization history was positively associated with HBsAg positivity, which was consistent with Zenebe *et al*.'s study [17]. Furthermore, the rate of self-reported immunization was only 29.3% in this study. Thus, the findings illustrate that hepatitis B immunization for childbearing-age women is important and necessary.

The HBeAg seroprevalence among HBsAg-positive childbearing-age women was 9.97% in this study, lower than 24.6%, 34.8%, and 38.4% in Henan, Shangdong province, and Hong Kong [20,21,37]. It was higher than the rate of 7.95% found in HBsAg-positive reproductive women in German [38]. The lower HBeAg seroprevalence in Mianyang might be attributed to several reasons, including the varied distribution of HBV e-minus mutants [39], and/or improved specificity of the detection method. Newborns with both HBeAg-positive and HBsAg-positive mothers are more likely to get infected and become chronic carriers than are newborns with mothers who are only HBsAg-positive [12,13]. The high HBeAg seroprevalence among HBsAg-positive childbearing-age women emphasized again that further efforts were needed for childbearing-age women to protect them from being infected, and to cut off vertical, horizontal, and sexual transmissions of HBV prospectively.

The highest HBeAg seroprevalence was 46.54% in the 15–19 year age group, and the lowest was 3.84% in the 44–49 year age group. The HBeAg seroprevalence decreased gradually with increased age, which was consistent with the studies of Chen *et al*. [27] and Ott *et al*. [40]. The highest HBeAg seroprevalence in women 15–19 years of age might be associated with the immature immune system and immune-tolerant phase of teenagers [28]. There are several reasons explaining why HBeAg seroprevalence decreases gradually with increasing age. First, the older population might have been infected for many years and have achieved a certain immune clearance mechanism [28]. Second, HBeAg clearance rate tends to increase with increasing age [41]. The highest HBeAg seroprevalence in women 15–19 years of age highlighted that the vaccination program funded by the government should be implemented not only in infants and children, but also in women 15–19 years of age. This study also showed that women 20–29 years of age, who were at the peak period of pregnancy, had a high HBsAg seroprevalence and a high HBeAg seroprevalence. Thus, premarital medical examination, screening, vaccination, and education for women 20–29 years of age are particularly important. They should be screened for HBV automatically, and those who are HBV susceptible should have priority to be vaccinated.

This study had some limitations. First, it was cross-sectional, which made it difficult to establish causal relationships. However, the findings provided important demographic insights on HBsAg seroprevalence and HBeAg seroprevalence among childbearing-age women. Second, seroprevalence of antibody to hepatitis B surface antigen (anti-HBs) and antibody to hepatitis B core antigen (anti-HBc) was not included. This information could help elucidate on the level of HBV exposure and/or success of vaccination. Third, the demographic information about education level and economic income were not included. To a certain extent, the information might be identified from the occupational status. Finally, other risk factors for HBV transmission such as sharing needles, exposure to contaminated medical devices, acupuncture, and tattoos were not included. However, these findings about the associated factors in this study also could provide scientific evidence for taking efficient measures to reduce the prevalence of HBV infection among childbearing-age women.

Conclusions

The findings in this study significantly contribute to the understanding of the actual epidemiology of HBsAg and HBeAg among childbearing-age women. These findings can provide scientific evidence for the Chinese government to plan efficient healthcare services and prevention initiatives, and to allocate health resources reasonably for childbearing-age women. The Chinese government formulated some strategies to control the spread of HBV infection, but the prevalence of HBV infection still remains high, and special efficient strategies for childbearing-age women are lacking. Thus, we should make efforts to prevent HBV infection among childbearing-age women by focusing on these reported associated factors. We suggest that a vaccination program funded by the government should be implemented not only in infants and children, but also in women 15–19 years of age. In addition, the premarital medical examination should be mandatory for women intending to get married. Furthermore, we should encourage women 20–29 years of age to screen for HBV automatically. Women susceptible to HBV should have priority to get vaccinated. Finally, health education is important and urgent for childbearing-age women, especially agriculture workers, to increase their awareness of HBV infection and knowledge about transmission routes.

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Corresponding author
Professor Ping Yuan
Department of Epidemiology and Statistics
West China School of Public Health, Sichuan University
No.17, 3 section South Renmin Road
Chengdu, Sichuan 610041, China
Phone: +86-28-85501604
Fax: +86-28-85501604
Email: yuanp1117@126.com

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