

# Association between secondhand smoke exposure in pregnant women and their socioeconomic status and its interaction with age: A cross-sectional study

**Zhou Wensu**

Central South University

**Zhu Xidi**

Central South University

**Hu Zhao**

Central South University

**Li Shaojie**

Central South University

**Zheng Baohua**

Central South University

**Yu Yunhan**

Central South University

**Xie Donghua** (✉ [2210685350@qq.com](mailto:2210685350@qq.com))

Maternal and Child Health Hospital of Hunan Province

---

## Research Article

**Keywords:** pregnancy, socioeconomic status, secondhand smoke, cross-sectional study, China

**Posted Date:** April 21st, 2022

**DOI:** <https://doi.org/10.21203/rs.3.rs-1553069/v1>

**License:**   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

**Objectives:** This study aimed to explore the effect of individual socioeconomic status (SES) on SHS exposure among pregnant women and its interaction effect of age.

**Methods:** A total of 678 nonsmoking pregnant women from 14 communities in a medium-sized city were recruited for this survey. Exposure to SHS was defined as a self-reported smoking habit of spouse/partner. Individual SES consisted of marital status, educational attainment, employment and per capita monthly income.

**Results:** There were 238 (35.1%) of participants who suffered from SHS exposure. Compared to the pregnant women who were employed, others who were unemployed were more likely to suffer from SHS exposure (OR=1.697, 95% CI: 1.102-2.614). Participants who had high school or technical secondary school education were more likely to exposure to SHS compared with women with a college or above education (OR=1.577, 95% CI: 1.020-2.437). Enhanced age was a protective factor for participants with a college or above education level (OR=0.939, 95% CI: 0.884-0.997), but age increased the risk of SHS exposure among women who had unstable marriage (OR=1.256, 95% CI: 1.019-1.549).

**Conclusion:** Exposure to SHS was very common among pregnant women. Pregnant women with low education level and SES and older age should be considered a key population for the implementation of public health interventions.

## 1. Introduction

The most well-known unhealthy habit, smoking, is common among adults, especially males. Overall, 50% and 35% of males have smoking habits in developing and developed countries, respectively [1]. Namely, many females suffer from secondhand smoke (SHS) exposure, especially women who are pregnant. Over the past few decades, many epidemiological studies have also suggested that exposure of pregnant women to SHS sources from their partner was very common during pregnancy, even though they were nonsmokers [2–4]. Previous studies have shown that exposure to SHS is more serious than active smoking [5–7] because it is 3 to 4 times more damaging per gram of particulate matter than smoking directly inhaled by the smoker [8]. An increasing number of studies have indicated that exposure to SHS affects almost every type of adverse pregnancy outcome, such as depression disorder, low levels of health-related quality of life, preterm labor, rupture of membranes, and fetal weight loss [6, 9, 10].

Socioeconomic status (SES), which is considered a construct, mainly involves many factors, such as educational attainment, occupational status, income and wealth [11]. SES represents a person's capacity for resources and is associated with health behavior, attitude and outcomes [12]. Previous studies indicated that individual characteristics of socioeconomic status (SES) not only affected active smoking behavior but were also linked with SHS exposure [13–15]. However, whether SES affects SHS exposure during pregnancy is debatable. For instance, Madureira et al. reported that a duration of educational attainment over 13 years was a protective factor for reducing environmental tobacco exposure during

pregnancy [15], which was similar to other studies [2, 16, 17]. The probability of daily SHS exposure at home was negatively associated with household income and family wealth of pregnant women [2, 16]. However, although researchers found that occupation was significantly associated with active smoking and SHS exposure during pregnancy [18, 19], Reece and colleagues did not identify this association [2]. Moreover, many researchers have found marital functioning to be consequential for health and considered it a positive indicator linked to reducing harmful exposure and engaging in health behavior [20], but statistical significance was not reported in two studies focused on the relationship between marital status and SHS exposure during pregnancy [21, 22]. In addition, the magnitude of SHS exposure and its association with SES could vary by region, as a previous study showed great heterogeneity in cultural background, tobacco use and attitude across countries [4, 21], which means that the conclusions drawn from different countries may not reflect the same situation in other countries. Some conclusions are expected to be updated when sufficient evidence from new research conducted in other populations becomes available.

In addition, pregnant women's age was also considered another indicator to predict SHS exposure during pregnancy, and it was positively associated with SHS exposure [21, 23, 24]. The accumulation hypothesis showed that the level of SES-based health advantage progressively declined with age [25]. This might suggest an age interaction with SES. Meanwhile, age is an important risk factor for pregnant women because the older women are, the higher the risk of death or injury for the fetus. Thus, the effect of age and SES on SHS exposure is of particular interest, but the present literature is not clear on its connection.

In summary, the current study relied on a community-based sample to reflect the association between individual SES and SHS exposure among pregnant women and explored the interaction effect between age and SES on SHS exposure. It is of great importance to facilitate the design and implementation of effective public health prevention programs and policies.

## **2. Methods**

### **2.1 Study design and participants**

Data were derived from a cross-sectional study based on a community investigation conducted in Hengyang city, Hunan Province, China, from July to September 2019. Hengyang city is a typical industrial city located in Central China. The survey used a stratified random sampling strategy, with districts as the primary sampling unit. First, 5 streets were randomly selected from 5 districts of Hengyang city. Then, communities were selected randomly based on a community and streets at a ratio of 3:1. Finally, 4 communities of Zhengxiang Street, 3 communities of Qingshan Street, 3 communities of Baishazhou Street, 2 communities of Guangdong Road Street and 2 communities of Zhurong Street with a total of 819 pregnant women in the third trimester were recruited in this study. The inclusion criteria were as follows: 1) aged over 18 years; 2) voluntarily participating in the project; 3) registered pregnancy in the community health centers and lived in the community for more than 6 months; 4) nonsmokers during pregnancy; and 5) living with spouse/partner during pregnancy. Among the recruited women, 6

participants were excluded for missing information on smoking habits and exposure, and 135 participants were excluded due to not meeting the inclusion criteria. A total of 678 pregnant women in the 3rd trimester was included in the analysis. All of the participants were asked to interview for twenty minutes and complete a structured questionnaire to collect information about them. Meanwhile, the participants signed informed consent forms. This study was approved by the Ethics Committee of Xiangya School of public health of Central South University on 15 July 2019 (XYGW-2019-056). The flow chart of this study is presented in Fig. 1 and Fig. 2 shows the the geographic position of five districts of Hengyang city, Hunan province of China.

## **2.2 Assessment of exposure to passive SHS**

According to the definition for secondhand smoke exposure (SHS) in the Global Adult Tobacco Survey 2010, all pregnant women were asked to respond to the question “Has your spouse/partner smoked at home at least 1 day per week while you’ve been pregnant?” assessed by a specific questionnaire. Those who responded “yes” and “always” were considered to be exposed to secondhand smoke at home during pregnancy.

## **2.3 Assessment of individual socioeconomic status (SES)**

Considering the concept of social age, individual socioeconomic status was measured by asking about individual educational level, employment status, marital status and per capita monthly income. Among them, educational level was categorized as junior middle school or below, high school or technical secondary school and college or above, employment status was categorized as yes and no, and marital status was classified as single/divorced or married. In addition, per capita income per month was divided into three groups:  $\leq 3000$  RMB, 3001–7999 RMB and  $\geq 8000$  RMB.

## **2.4 Covariates**

Several variables that were included in the analysis were considered covariates: age and household registration status (hukou) (rural areas and urban areas). The behavioral lifestyle of the participants included smoking habits (never and former), exercising at present (yes and no) and drinking at present (yes and no). Family-related factors included the educational attainment of spouse/partner (junior middle school or below, high school or technical secondary school and college or above), drinking habit of spouse/partner in the last year (yes and no) and living with aunt/uncle after getting married (yes and no).

## **2.5 Statistical analysis**

The characteristics of the participants are presented as the means and standard deviations for continuous variables that met a normal distribution, as the median and interquartile range for continuous variables that did not meet a normal distribution, or as numbers and percentages for categorized variables. The difference in exposure to passive SHS according to demographic characteristics, SES and family factors was examined using the chi-square test. The difference in age at SHS exposure was analyzed using a nonparametric Kruskal–Wallis test since age was not confirmed to be normally

distributed. Binary logistic regression analysis with the enter method was applied to explore the association between SES and exposure to passive SHS in the 3rd trimester among pregnant women after controlling for age, ethnicity, household registration status, smoking habit, exercising and drinking at present, employment of spouse/partner, educational attainment of spouse/partner, drinking habit of spouse/partner in the last year, living with aunt/uncle after getting married, regular antenatal examinations and complications of pregnancy. Model 1 was a multivariate logistic regression model that only included educational attainment, marital status, employment and per capita monthly income. Model 2 was a multivariate logistic regression model after adjusting for covariates. Last, we included a product term in the multivariate logistic regression model to examine the effects of age and SES on SHS exposure. Then, we tested statistical significance of differences between effect estimates of SES by calculating the 95% confidence interval (CI) as  $CI = \beta \pm 1.96 \times SE$ , where  $\beta$  and  $SE$  were the estimate for the two categories, and  $\beta$  and  $SE$  are their respective standard errors

Associations are presented as crude and adjusted odds ratios (ORs) with 95% confidence intervals (95% CIs). All analyses were conducted using R v4.0.5. A *P* value < 0.05 was considered statistically significant.

## 3. Results

### 3.1 Demographics of the study sample

Table 1 shows the individual demographics and the comparison of respondents. Overall, of the 678 pregnant women included in this community-based survey, 35.1% (238) had SHS exposure at home. The mean age of the participants was 29.1 years (SD = 4.6). A total of 97.8% of them were of Han ethnicity with an urban household registration status (73.2%). A total of 95.4% of the women were married and living together with a partner/spouse and employed (74.9%). The proportions of the participants who had a junior middle school or below, high school or technical secondary school and college or above education were 19.5%, 23.7% and 56.8%, respectively. Regarding per capita income per month, 8.8%, 71.1% and 20.1% of them received less than 3000 RMB, between 3001–7999 RMB and more than 8000 RMB, respectively. Only 4.3% and 9.7% of them reported that they had a smoking habit before pregnancy and drank at present. Regarding the characteristics of spouses/partners, over half of spouses/partners were employed and had a college or above education as well as drinking habits in the last year. A total of 64.0% of the participants lived with an aunt/uncle after getting married. The percentages of regular antenatal examinations and complications during pregnancy were 91.6% and 10.5%, respectively.

Table 1  
 Characteristics of the pregnant women in the 3rd trimester according to exposure to SHS

Characteristic	Total n = 678	Never exposed to SHS during pregnancy n = 440	Current exposure to SHS during pregnancy n = 238	<i>p</i> Value
Age	29.1 ± 4.60	29.2 ± 4.67	28.8 ± 4.48	0.310
Ethnicity				
Han	663 (97.8)	427 (97.0)	236 (99.2)	0.074
Minority	15.0 (2.2)	13.0 (3.0)	2.00 (0.8)	
Household registration status (hukou)				
Rural areas	182 (26.8)	115 (26.1)	67.0 (28.2)	0.572
Urban areas	496 (73.2)	325 (73.9)	171 (71.8)	
Individual SES				
Marital Status				
Married and living together	647 (95.4)	417 (94.8)	230 (96.6)	0.267
Divorced but living together/Cohabiting relationship	31.0 (4.6)	23.0 (5.2)	8.00 (3.4)	
Employment				
Yes	508 (74.9)	346 (78.6)	162 (68.1)	<b>0.002</b>
No	170 (25.1)	94.0 (21.4)	76.0 (31.9)	
Educational attainment				
Junior middle school or below	132 (19.5)	82.0 (18.6)	50.0 (21.0)	0.129
High school or technical secondary school	161 (23.7)	96.0 (21.8)	65.0 (27.3)	
College or above	385 (56.8)	262 (59.5)	123 (51.7)	

Characteristic	Total n = 678	Never exposed to SHS during pregnancy n = 440	Current exposure to SHS during pregnancy n = 238	<i>p</i> Value
Per capita monthly income in RMB				
≤ 3000	60.0 (8.8)	40.0 (9.1)	20.0 (8.4)	0.878
3001–7999	482 (71.1)	314 (71.4)	168 (70.6)	
≥ 8000	136 (20.1)	86.0 (19.5)	50.0 (21.0)	
Smoking habit				
Never	649 (95.7)	419 (95.2)	230 (96.6)	0.386
Former	29.0 (4.3)	21.0 (4.8)	8.00 (3.4)	
Exercising at present				
Yes	620 (91.4)	399 (90.7)	221 (92.9)	0.334
No	58.0 (8.6)	41.0 (9.3)	17.0 (7.1)	
Drinking at present				
No	612 (90.3)	408 (92.7)	204 (85.7)	<b>0.003</b>
Yes	66.0 (9.7)	32.0 (7.3)	34.0 (14.3)	
Educational attainment of spouse/partner				
Junior middle school or below	94.0 (13.9)	66.0 (15.0)	28.0 (11.8)	0.218
High school or technical secondary school	172 (25.4)	117 (26.6)	55.0 (23.1)	
College or above	412 (60.8)	257 (58.4)	155 (65.1)	
Employment of spouse/partner				
Yes	665 (98.1)	431 (98.0)	234 (98.3)	0.741

Characteristic	Total n = 678	Never exposed to SHS during pregnancy n = 440	Current exposure to SHS during pregnancy n = 238	<i>p</i> Value
No	13.0 (1.9)	9.00 (2.0)	4.00 (1.7)	
Drinking habit of spouse/partner in the last year				
No	252 (37.2)	119 (27.0)	133 (55.9)	< <b>0.001</b>
Yes	426 (62.8)	321 (73.0)	105 (44.1)	
Living with aunt/uncle after getting married				
No	244 (36.0)	177 (40.2)	67.0 (28.2)	<b>0.002</b>
Yes	434 (64.0)	263 (59.8)	171 (71.8)	
Regular antenatal examinations				
Yes	621 (91.6)	392 (89.1)	229 (96.2)	<b>0.001</b>
No	57.0 (8.4)	48.0 (10.9)	9.00 (3.8)	
Complications of pregnancy				
No	607 (89.5)	391 (88.9)	216 (90.8)	0.442
Yes	71.0 (10.5)	49.0 (11.1)	22.0 (9.2)	

After analyzing the differences under different demographic characteristic conditions, we observed significant differences in employment ( $p = 0.002$ ), drinking at present ( $p = 0.003$ ), drinking habits of spouse/partner in the last year ( $p < 0.001$ ), living with aunt/uncle after getting married ( $p = 0.002$ ) and regular antenatal examinations ( $p = 0.001$ ) (Table 1).

### 3.2 The association between SES and SHS exposure among pregnant women in the 3rd trimester

We used binary logistic regression analysis to explore the association between SES and SHS exposure among pregnant women. Models 1 and 2 are summarized in Table 2. Model 1 was the base model in

which only educational attainment, employment, marital status and personal income per month were included, which showed that unemployed participants (OR = 1.658, 95% CI: 1.126–2.441) were more likely to be exposed to SHS at home. After controlling for covariates including age, ethnicity, household registration status, smoking habit, exercising and drinking at present, employment of spouse/partner, educational attainment of spouse/partner, drinking habit of spouse/partner in the last year, living with aunt/uncle after getting married, regular antenatal examinations and complications of pregnancy, Model 2 showed that unemployed women (OR = 1.697, 95% CI: 1.102–2.614) had a higher risk for exposure to SHS than employed women. Participants with a high school or technical secondary school education were more likely to be exposed to SHS than women with a college or above education (OR = 1.577, 95% CI: 1.020–2.437).

Table 2

Binary logistic regression models for the association between SES and SHS among pregnant women in the 3rd trimester

	Model 1	OR(95% CI)	Model 2	OR(95% CI)
Marital Status				
Divorced but living together/Cohabiting relationship	0.537	0.232–1.244	0.562	0.227–1.390
Married and living together	1		1	
Employment				
No	<b>1.658</b>	<b>1.126–2.441</b>	<b>1.697</b>	<b>1.102–2.614</b>
Yes	1		1	
Educational attainment				
Junior middle school or below	1.161	0.739–1.824	1.311	0.797–2.157
High school or technical secondary school	1.317	0.879–1.972	<b>1.577</b>	<b>1.020–2.437</b>
College or above	1		1	
Personal income per month in RMB				
≤ 3000	0.759	0.392–1.469	0.896	0.442–1.816
3001–7999	0.864	0.576–1.295	0.955	0.619–1.472
≥ 8000	1		1	
Model 1 includes marital status, employment, educational attainment and personal income per month.				
Model 2: Model 1 + adjustment for age, ethnicity, household registration status, smoking habit, exercising and drinking at present, employment of spouse/partner, educational attainment of spouse/partner, drinking habit of spouse/partner in the last year, living with aunt/uncle after getting married, regular antenatal examinations and complications of pregnancy.				

### 3.3 The interaction effect between SES and age on SHS exposure

Table 3 indicates the interaction effect between age and SES on SHS among pregnant women in the 3rd trimester. Herein, we observed that after controlling for covariates, the significant interaction effects

between marital status and educational attainment and age on SHS were detected, with *P*-values for interaction were 0.008 and 0.009, respectively.

Table 3

The interaction effect between age and SES on SHS among pregnant women in the 3rd trimester

<b>Variables</b>	<b>Categories</b>	<b>P for interaction</b>
Marital Status		
	Divorced but living together/Cohabiting relationship	<b>0.008</b>
	Married and living together	
Employment		
	No	0.244
	Yes	
Educational attainment		
	Junior middle school or below	<b>0.009</b>
	High school or technical secondary school	
	College or above	
Personal income per month in RMB		
	≤ 3000	0.304
	3001–7999	
	≥ 8000	
All of analysis was adjusted for age, ethnicity, household registration status, smoking habit, exercising and drinking at present, employment of spouse/partner, educational attainment of spouse/partner, drinking habit of spouse/partner in the last year, living with aunt/uncle after getting married, regular antenatal examinations and complications of pregnancy.		

Table 4 lists the results of the association between SES and SHS affected by age. We could see age was a risk factor for SHS in women who were divorced but living together/cohabiting (OR = 1.256, 95% CI: 1.019–1.549). Whereas, a decreased risk for exposure to SHS according to age was observed in participants with a collage or above education level (OR = 0.939, 95% CI: 0.884–0.997).

Table 4

The interaction effect of age on the association between SES and SHS among pregnant women in the 3rd trimester

Variables	Categories	Model 1	P for difference between stratum
Marital Status			
	Married and living together	0.982 (0.943– 1.023)	[reference]
	Divorced but living together/Cohabiting relationship	<b>1.256</b> ( <b>1.019–</b> <b>1.549</b> )	<b>&lt; 0.05</b>
Educational attainment			
	Junior middle school or below	1.039 (0.945– 1.143)	[reference]
	High school or technical secondary school	1.049 (0.969– 1.135)	<b>&lt; 0.05</b>
	College or above	<b>0.939</b> ( <b>0.884–</b> <b>0.997</b> )	<b>&lt; 0.05</b>
All of analysis was adjusted for age, ethnicity, household registration status, smoking habit, exercising and drinking at present, employment of spouse/partner, educational attainment of spouse/partner, drinking habit of spouse/partner in the last year, living with aunt/uncle after getting married, regular antenatal examinations and complications of pregnancy.			

## 4. Discussion

To the best of our knowledge, there is a dearth of studies on the relationship between individual SES and SHS exposure at home among pregnant women in the 3rd trimester in China. This study not only provided insight into the status of SHS exposure but also examined this relationship with SES. Unemployment and high school or technical secondary school educational attainment had significant effects on SHS exposure. In the present study, we found that an unstable marriage (cohabiting relationship) and college or above education level were associated with an elevated and decreased risk of SHS exposure enhanced by age.

The finding showed that the current SHS exposure prevalence from this study was 35.1%, which was lower than that of a previous national-level study from 2013 (47.2%) [26]. The prevalence of SHS exposure in this paper was also lower than that reported in prior population-based studies conducted in Henan Province and Sichuan Province. Overall, 60–70% of pregnant women experienced SHS exposure, and 75.1% of nonsmoking pregnant women suffered from chronic SHS exposure from their respective spouses [4, 27]. As a previous study reported, higher probabilities of SHS exposure occurred in low- and middle-income countries [2]. It could be perceived that the rate of SHS exposure among pregnant women varied by region, with some locations having a high level of exposure but other regions having a low level. China is the country with the most tobacco production and consumers in the world, and approximately 47.2% of males had smoking habits in an investigation conducted in 2013 [26]. Tobacco plays a very important role in China's economics and culture. The government has tried to encourage adults to give up tobacco, but a great number of males still have smoking habits in China. Overall, smoking was a widely acceptable behavior in China, although SHS has become a major public health problem and has caused a heavy burden of disease worldwide [28]. Exposure to SHS during pregnancy was common in the pregnant women population.

Our results are in line with prior studies [15, 29] showing that women's higher educational attainment was an independent protective factor for reducing SHS exposure. Education is one aspect of the basic drivers of human behavior that can promote healthy behavior and keep individuals away from harmful exposure [30]. Generally, pregnant women who are more educated have greater awareness of tobacco and reduced exposure. Meanwhile, the availability of various medical and economic resources may depend on educational attainment. Thus, educational attainment can be regarded as a vital determinant of SHS exposure. In our study, we also confirmed that unemployed participants had a greater risk for SHS exposure. Employment and education were strongly associated, and both have impacts on household income and the social conditions of resources. Previous studies have shown that unemployment or manual labor are predictors of maternal SHS exposure during pregnancy [24, 31, 32]. Participants who were more educated were more likely to have steady jobs, which increased the likelihood of engaging in healthy behaviors and actively staying away from harmful exposures [33]. Conversely, unemployed women have limited health education resources, low awareness of the harms of exposure to SHS and a self-perception of relatively low status within the family, increasing the possibility of SHS exposure. Interestingly, we found that lower personal income per month might be considered a protective factor for SHS exposure, which might reflect a shift in the association between income and SHS exposure. These observations supported those of previous studies conducted by Recea et al. and Mahmoodabad et al. [2, 19] but contradicted the evidence from Yang and colleagues [27]. Nevertheless, as far as we are concerned, after adjustment for related background variables, there was no significant association between income and SHS exposure. The reason behind whether high income increases the risk of SHS exposure among pregnant women is still undetermined, and further research will be needed to explain this phenomenon. The significant results in our findings indicated that those women who were exposed to SHS were often less educated and unemployed.

Notably, age influences the relationship between a higher level of educational attainment and unstable marital status, that is, lower level of SES increased the risk of exposure to SHS. Currently, several studies have indicated that age was a potential mediator to SHS exposure. Younger women were more likely to be exposed to SHS [17, 34–36], but in the study by St Helen et al., women aged over 35 years had higher levels of UC (urinary cotinine) due to SHS exposure at home [37]. However, the combined effects of age and individual's SES on SHS have not been studied previously. This modification effect is plausible because SES is a fundamental cause of disease because it is closely associated with access to important resources and affects multiple disease outcomes through multiple mechanisms [38]. However, the capacity to use resources to gain a health advantage is increasingly weak in populations with relatively low levels of SES with age. In particular, women were expected to be obedient to their spouse in families with traditional Chinese cultural backgrounds. It could be speculated that pregnant women with a lower level of educational attainment and an unstable marriage were less likely to change the smoking behavior of their spouse/partner, and exposure to SHS might occur more frequently.

Avoiding SHS exposure during pregnancy is an important health priority for health care professionals and policy-makers. However, researchers have stated that it is still difficult to eliminate SHS exposure during pregnancy in LMICs, China included. First, the awareness of harmful outcomes attributed to SHS exposure was lower in LMICs [39]. Second, pregnant women may not argue with males due to the existence of a male-dominated ideology, even though they have already realized the risk of SHS exposure [40]. Importantly, although smokers tried to avoid direct contact with pregnant women, SHS was much more difficult to avoid. One important reason was that the hidden demon called “thirdhand smoke (THS)” still remained in the environment, especially on skin and clothes, which poses a new threat to pregnant women; nonetheless, the risk of THS is rarely known by pregnant women and their family members [41]. In addition, family consensus on smoking bans may be an effective strategy [23], as in pregnancy, women are well protected in the family, particularly by their spouse/partner, who values their advice. In summary, it is imperative for both pregnant women and their spouse/partner to be included in interventions for tobacco control and the ongoing implementation of SHS prevention and pregnancy health education.

Some limitations of this study should be recognized. First, the status of exposure to SHS was determined using participants' self-reports, which might have led to a recall bias of the measurement effect of SHS to some extent. However, prior investigations found that measuring SHS exposure by self-report is still a satisfactory and acceptable approach to determining SHS exposure and is widely used in an increasing number of studies [42]. This cross-sectional study had practical limitations in terms of causal inference. Longitudinal and qualitative research is needed to help identify the association between SHS exposure and SES. In addition, the spouse/partner's SES also partially explained the association between SHS exposure and social status [19]. However, no significant differences were observed between these SES variables of the spouse/partner in terms of group comparison analysis. Last, we only took the spouse/partner as an account for sources of SHS exposure. However, we considered that the contribution of other sources of SHS, such as workplaces and restaurants, was negligible, given that pregnant women generally spend most of their time with spouses/partners during pregnancy.

In summary, risk perceptions and communication were related to SES [43], which could suggest that SES may have practical applications to smoking cessation implementation. Pregnant women are a key subpopulation that should implement tobacco control efforts for their spouse/partner because both cigarettes and smokeless tobacco pose serious threats to the mother and fetus. This paper's results indicated that, to a certain extent, a lower level of SES leads to a higher likelihood of SHS exposure. An educated spouse can change their smoking behavior and protect the health of pregnant women.

## **5. Conclusion**

In conclusion, our findings showed that SHS exposure is still a challenge for pregnant women's health. It is important to provide preventative strategies for passive smoking and focus on vulnerable populations with low SES and pregnant woman of advanced age when targeting future smoking cessation interventions for their benefit and that of others who plan to become pregnant.

## **Declarations**

### **6. Ethics approval and consent to participate**

Researchers confirm that all methods used in this study were carried out in accordance with the declaration of Helsinki. The study was reviewed and approved by the Ethics Committee of Xiangya School of public health of Central South University on 15 July 2019 (XYGW-2019-056). All participants provided written or digital informed consent, and the ethics committee approved the procedures.

### **7. Consent for publication**

Not Applicable.

### **8. Availability of data and materials**

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

### **9. Competing Interest**

None.

## **10. Funding**

This work was supported by the Foundation of the Ministry of Health of Hunan Province, China (202212034013) and the Key Program of Maternal and Child Health Hospital of Hunan Province (2021RX05).

## 11. Author Contributions

Wensu Zhou, Baohua Zhen, Yunhan Yu, Xidi Zhu, Zhao Hu: Collect data; Wensu Zhou, Xidi Zhu, Zhao Hu: Conceptualization; Wensu Zhou, Donghua Xie: Data curation, Writing, Original draft preparation, Methodology, Software, Reviewing; Wensu Zhou, Xidi Zhu, Zhao Hu, Li Shaojie: Visualization, Investigation. Xidi Zhu, Zhao Hu, Li Shaojie, Donghua Xie: Supervision.

## 12. Acknowledgments

This is a short text to acknowledge the contributions of specific colleagues, institutions, or agencies that aided the efforts of the authors.

## 13. Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## References

1. Organization WH: **Gender, Health, Tobacco and Equity, 2011**. 2011.
2. Reece S, Morgan C, Parascandola M, Siddiqi K: **Secondhand smoke exposure during pregnancy: a cross-sectional analysis of data from Demographic and Health Survey from 30 low-income and middle-income countries**. *Tob Control* 2019, **28**(4):420–426.
3. Chomba E, Tshefu A, Onyamboko M, Kaseba-Sata C, Moore J, McClure EM, Moss N, Goco N, Bloch M, Goldenberg RL: **Tobacco use and secondhand smoke exposure during pregnancy in two African countries: Zambia and the Democratic Republic of the Congo**. *Acta Obstet Gynecol Scand* 2010, **89**(4):531–539.
4. Zhang L, Hsia J, Tu X, Xia Y, Zhang L, Bi Z, Liu H, Li X, Stanton B: **Exposure to secondhand tobacco smoke and interventions among pregnant women in China: a systematic review**. *Prev Chronic Dis* 2015, **12**:E35.
5. Golan R, Kloog I, Almog R, Gesser-Edelsburg A, Negev M, Jolles M, Shalev V, Eisenberg VH, Koren G, Abu Ahmad W *et al*: **Environmental exposures and fetal growth: the Haifa pregnancy cohort study**. *BMC Public Health* 2018, **18**(1):132.
6. Sun W, Huang X, Wu H, Zhang CJP, Yin Z, Fan Q, Wang H, Jayavanth P, Akinwunmi B, Wu Y *et al*: **Maternal tobacco exposure and health-related quality of life during pregnancy: a national-based study of pregnant women in China**. *Health Qual Life Outcomes* 2021, **19**(1):152.
7. Eiden RD, Molnar DS, Leonard KE, Colder CR, Homish GG, Maiorana N, Schuetze P, Connors GJ: **Sources and frequency of secondhand smoke exposure during pregnancy**. *Nicotine Tob Res* 2011, **13**(8):653–660.

8. **WHO report on the global tobacco epidemic, 2009: Implementing smoke-free environments.** Geneva, 2009 [<http://www.who.int/tobacco/mpower/2009/en/index.html>]
9. Windhama GC, Eatona A, Hopkins B: **Evidence for an association between environmental tobacco smoke exposure and birthweight: a metaanalysis and new data.** Paediatric and Perinatal Epidemiology 1999, **13**:35–57.
10. Huang J, Wen G, Yang W, Yao Z, Wu C, Ye X: **The association between second-hand smoke exposure and depressive symptoms among pregnant women.** Psychiatry Res 2017, **256**:469–474.
11. Farah MJ: **Socioeconomic status and the brain: prospects for neuroscience-informed policy.** Nat Rev Neurosci 2018, **19**(7):428–438.
12. Stanford-Moore G, Bradshaw PT, Weissler MC, Zevallos JP, Brennan P, Anantharaman D, Abedi-Ardekani B, Olshan AF: **Interaction between known risk factors for head and neck cancer and socioeconomic status: the Carolina Head and Neck Cancer Study.** Cancer Causes Control 2018, **29**(9):863–873.
13. Smedberg J, Lupattelli A, Mårdby A-C, Nordeng H: **Characteristics of women who continue smoking during pregnancy: a cross-sectional study of pregnant women and new mothers in 15 European countries.** BMC Pregnancy and Childbirth 2014, **14**:213–229.
14. Mishra GA, Kulkarni SV, Gupta SD, Shastri SS: **Smokeless tobacco use in Urban Indian women: Prevalence and predictors.** Indian journal of medical and paediatric oncology: official journal of Indian Society of Medical & Paediatric Oncology 2015, **36**(3):176–182.
15. Madureira J, Camelo A, Silva AI, Reis AT, Esteves F, Ribeiro AI, Teixeira JP, Costa C: **The importance of socioeconomic position in smoking, cessation and environmental tobacco smoke exposure during pregnancy.** Sci Rep 2020, **10**(1):15584.
16. Cai L, Wu X, Goyal A, Han Y, Cui W, Xiao X, He J, Zhao K, Song Y, Jiao F: **Patterns and socioeconomic influences of tobacco exposure in tobacco cultivating rural areas of Yunnan Province, China.** BMC Public Health 2012, **12**(1):842.
17. Hikita N, Haruna M, Matsuzaki M, Sasagawa E, Murata M, Oidovsuren O, Yura A: **Prevalence and risk factors of secondhand smoke (SHS) exposure among pregnant women in Mongolia.** Sci Rep 2017, **7**(1):16426.
18. Rocheleau CM, Bertke SJ, Lawson CC, Romitti PA, Desrosiers TA, Agopian AJ, Bell E, Gilboa SM, National Birth Defects Prevention S: **Factors associated with employment status before and during pregnancy: Implications for studies of pregnancy outcomes.** Am J Ind Med 2017, **60**(4):329–341.
19. Mahmoodabad SSM, Karimiankakolaki Z, Kazemi A, Mohammadi NK, Fallahzadeh H: **Exposure to secondhand smoke in Iranian pregnant women at home and the related factors.** Tob Prev Cessat 2019, **5**:7.
20. Kiecolt-Glaser JK, Newton TL: **Marriage and health: his and hers.** Psychological bulletin 2001, **127**(4):472–503.
21. Ngobese SP, Egbe CO, Londani M, Ayo-Yusuf OA: **Non-Smoker's Exposure to Second-Hand Smoke in South Africa during 2017.** Int J Environ Res Public Health 2020, **17**(21).

22. Mistry R, Dasika A: **Antenatal Tobacco Use and Secondhand Smoke Exposure in the Home in India.** *Nicotine Tob Res* 2018, **20**(2):258–261.
23. Chen J, Li X, Fang P: **Influence of family resources on secondhand smoking in pregnant women: a cross-sectional study in the border and minority urban areas of Northwest China.** *BMC Pregnancy Childbirth* 2020, **20**(1):642.
24. Yaya S, Uthman OA, Adjiwanou V, Bishwajit G: **Exposure to tobacco use in pregnancy and its determinants among sub-Saharan Africa women: analysis of pooled cross-sectional surveys.** *J Matern Fetal Neonatal Med* 2020, **33**(9):1517–1525.
25. Prus SG: **Age, SES, and health: a population level analysis of health inequalities over the lifecourse.** *Sociol Health Illn* 2007, **29**(2):275–296.
26. Wang M, Luo X, Xu S, Liu W, Ding F, Zhang X, Wang L, Liu J, Hu J, Wang W: **Trends in smoking prevalence and implication for chronic diseases in China: serial national cross-sectional surveys from 2003 to 2013.** *The Lancet Respiratory medicine* 2019, **7**(1):35–45.
27. Yang L, Tong EK, Mao Z, Hu TW: **Exposure to secondhand smoke and associated factors among non-smoking pregnant women with smoking husbands in Sichuan province, China.** *Acta Obstet Gynecol Scand* 2010, **89**(4):549–557.
28. Carreras G, Lugo A, Gallus S, Cortini B, Fernandez E, Lopez MJ, Soriano JB, Lopez-Nicolas A, Semple S, Gorini G *et al*: **Burden of disease attributable to second-hand smoke exposure: A systematic review.** *Prev Med* 2019, **129**:105833.
29. Hawkins SS, Dacey C, Gennaro S, Keshinover T, Gross S, Gibeau A, Lulloff A, Aldous KM: **Secondhand smoke exposure among nonsmoking pregnant women in New York City.** *Nicotine Tob Res* 2014, **16**(8):1079–1084.
30. Stormacq C, Van den Broucke S, Wosinski J: **Does health literacy mediate the relationship between socioeconomic status and health disparities? Integrative review.** *Health Promot Int* 2019, **34**(5):e1-e17.
31. de Wolff MG, Backhausen MG, Iversen ML, Bendix JM, Rom AL, Hegaard HK: **Prevalence and predictors of maternal smoking prior to and during pregnancy in a regional Danish population: a cross-sectional study.** *Reprod Health* 2019, **16**(1):82.
32. Al-Sahab B, Saqib M, Hauser G, Tamim H: **Prevalence of smoking during pregnancy and associated risk factors among Canadian women: a national survey.** *BMC Pregnancy Childbirth* 2010, **10**:24.
33. Xu X, Rao Y, Wang L, Liu S, Guo JJ, Sharma M, Zhao Y: **Smoking in pregnancy: a cross-sectional study in China.** *Tob Induc Dis* 2017, **15**:35.
34. Polanska K, Krol A, Kaluzny P, Ligocka D, Mikolajewska K, Shaheen S, Walton R, Hanke W: **Estimation of Saliva Cotinine Cut-Off Points for Active and Passive Smoking during Pregnancy-Polish Mother and Child Cohort (REPRO\_PL).** *Int J Environ Res Public Health* 2016, **13**(12).
35. Norsa'adah B, saliNah O: **The Effect of Second-Hand Smoke Exposure during Pregnancy on the Newborn Weight in Malaysia** *Malays J Med Sci* 2014, **21**(2):44–53.

36. Aurrekoetxea JJ, Murcia M, Rebagliato M, Fernandez-Somoano A, Castilla AM, Guxens M, Lopez MJ, Lertxundi A, Espada M, Tardon A *et al*: **Factors associated with second-hand smoke exposure in non-smoking pregnant women in Spain: self-reported exposure and urinary cotinine levels.** *Sci Total Environ* 2014, **470–471**:1189–1196.
37. St Helen G, Bernert JT, Hall DB, Sosnoff CS, Xia Y, Balme JR, Vena JE, Wang JS, Holland NT, Naeher LP: **Exposure to secondhand smoke outside of a bar and a restaurant and tobacco exposure biomarkers in nonsmokers.** *Environ Health Perspect* 2012, **120(7)**:1010–1016.
38. Link BG, Phelan J: **Social conditions as fundamental causes of disease.** *J Health Soc Behav* 1995, **Spec No**:80–94.
39. Yousuf H, Hofstra M, Tijssen J, Leenen B, Lindemans JW, van Rossum A, Narula J, Hofstra L: **Estimated Worldwide Mortality Attributed to Secondhand Tobacco Smoke Exposure, 1990–2016.** *JAMA Netw Open* 2020, **3(3)**:e201177.
40. Passey ME, Longman JM, Robinson J, Wiggers J, Jones LL: **Smoke-free homes: what are the barriers, motivators and enablers? A qualitative systematic review and thematic synthesis.** *BMJ Open* 2016, **6(3)**:e010260.
41. Lidon-Moyano C, Fu M, Perez-Ortuno R, Ballbe M, Garcia E, Martin-Sanchez JC, Pascual JA, Fernandez E, Martinez-Sanchez JM: **Third-hand exposure at homes: Assessment using salivary cotinine.** *Environ Res* 2021, **196**:110393.
42. Lee BE, Hong YC, Park H, Ha M, Kim JH, Chang N, Roh YM, Kim BN, Kim Y, Oh SY *et al*: **Secondhand smoke exposure during pregnancy and infantile neurodevelopment.** *Environ Res* 2011, **111(4)**:539–544.
43. Wagner GA, Sanchez ZM, Fidalgo TM, Caetano SC, Carliner H, Martins SS: **Sociodemographic factors associated with smoking risk perception in adolescents in Sao Paulo, Brazil.** *Braz J Psychiatry* 2019, **41(6)**:546–549.

## Figures

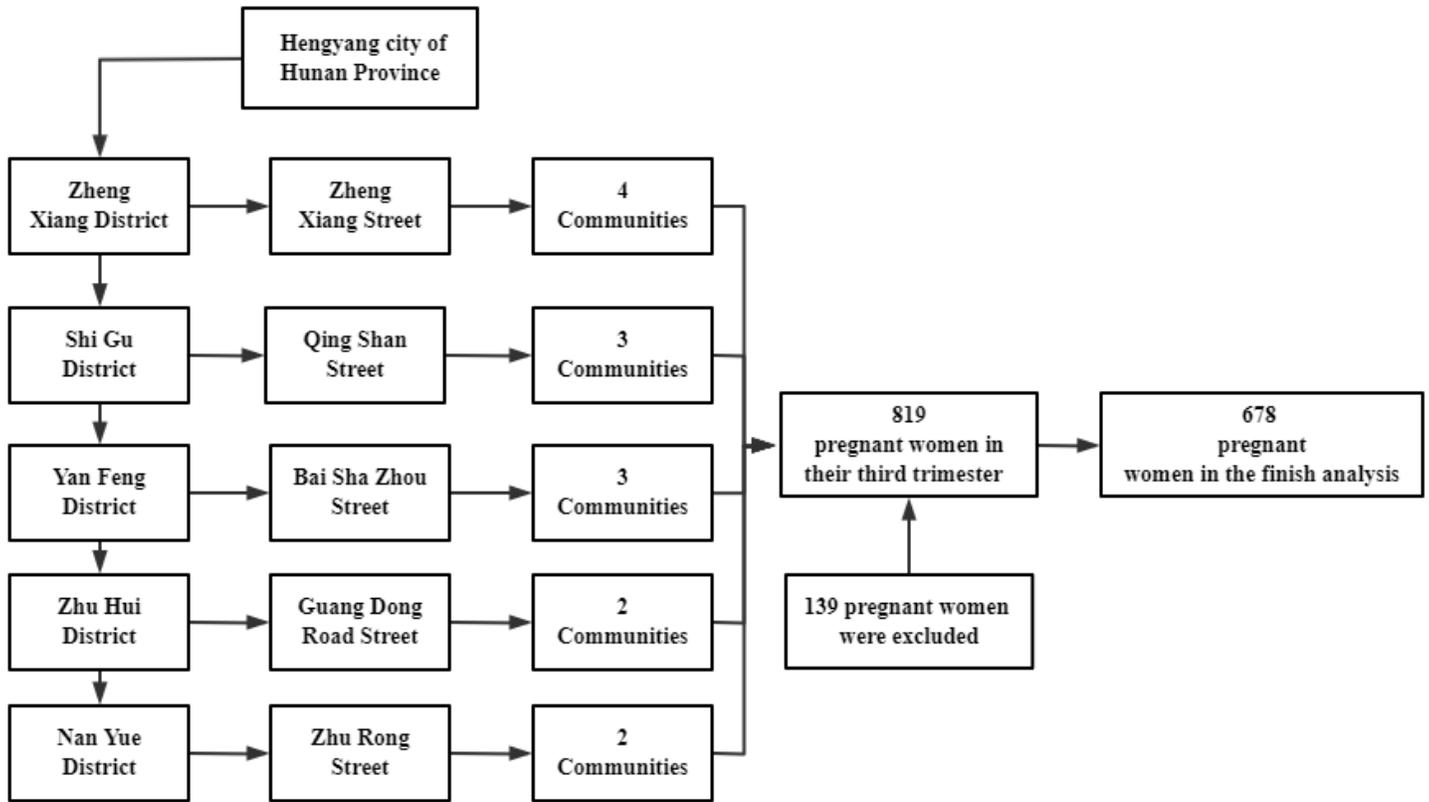
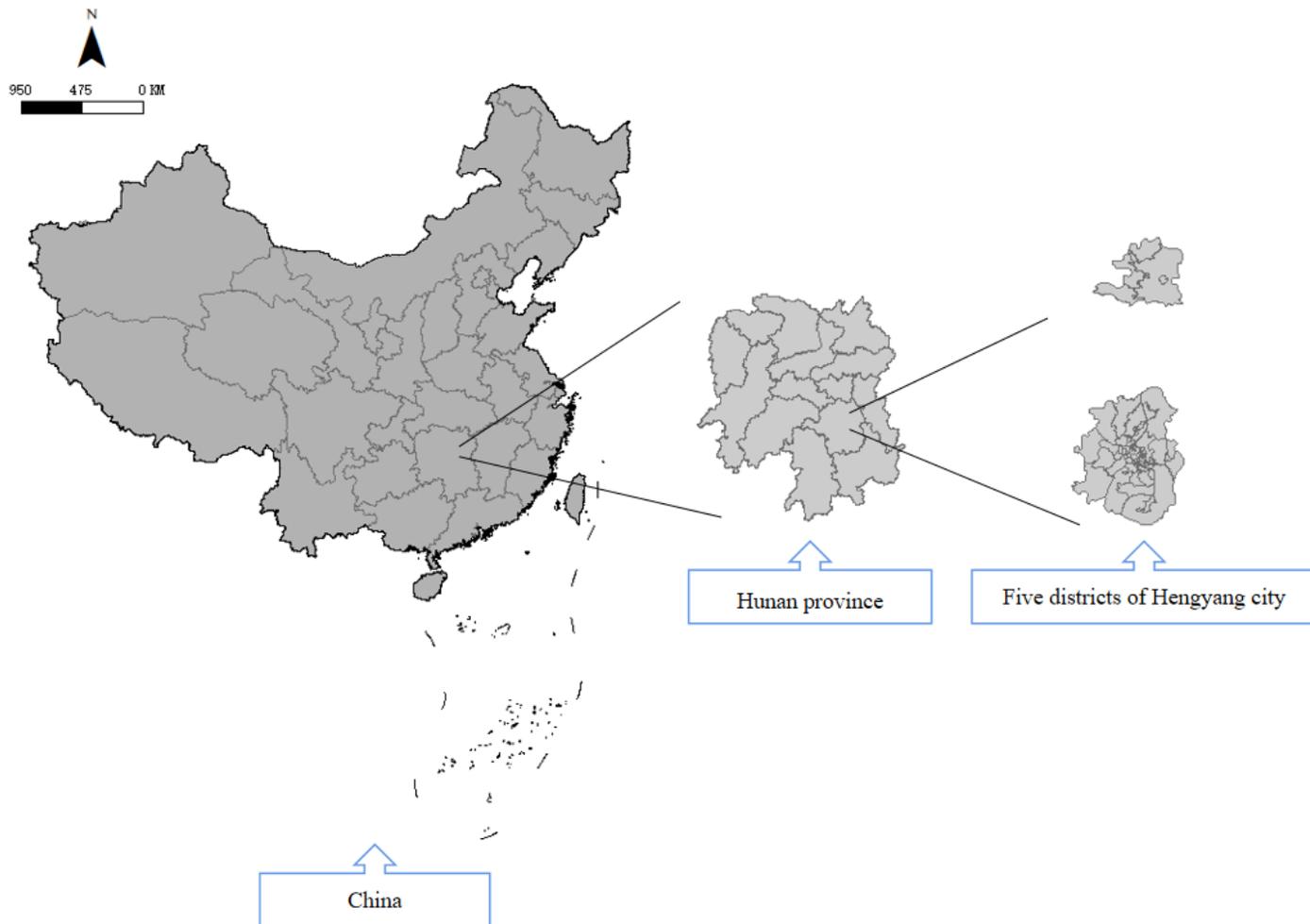


Figure 1

the selection flow of the current study



**Figure 2**

**The geographic position of five districts of Hengyang city, Hunan province of China**