Prevalence and Determinants of Secondhand Smoke Exposure Among Adolescent Girls — China, 2019

Fulin Huang; Xinying Zeng; Xinbo Di; Lin Xiao; Shiwei Liu

Summary

What is already known about this topic?
The rate of secondhand smoke (SHS) exposure among female junior high students in 2013–2014 in China was 69.9%.

What is added by this report?
The rate of SHS among adolescent girls in 2019 in China was 62.8%, with 60.8% in junior high and 65.3% in senior high school, meanwhile, higher SHS exposure was correlated to higher grade levels, senior high school over junior high school, urban areas, those with more pocket money, those who’ve attempted smoking, exposure to tobacco advertisements, those with parents who smoke, those with close friends who smoke, use of e-cigarettes, and belief that SHS exposure is detrimental to health.

What are the implications for public health practice?
The rate of SHS exposure among adolescent girls in China still remains extraordinarily high. Targeted public health initiatives to curb SHS exposure among adolescent girls are urgently needed in China.

Secondhand smoke (SHS) exposure is harmful to health: there is no risk-free level, and it negatively influences smoking behaviors as well (1–2). Girls are particularly vulnerable to the adverse health outcomes associated with SHS; a recent study indicated exposure to SHS increases the risk of developing breast cancer, especially when the exposure occurs in puberty when breast cell proliferation is most rapid (3). The prevalence of SHS exposure in China (69.9%) in 2013–2014 was much higher than that in 68 other low-income and middle-income countries (54.1%) in 2006–2013 for girls aged 12–15 (4). However, the prevalence of SHS exposure at the present is unknown, and the research on its determinants among adolescent girls is limited in China. This study aims to describe the status quo of SHS exposure and explore its determinants among adolescent girls.

The data for this study were extracted from the 2019 China National Youth Tobacco Survey (NYTS), in which a multi-stage, stratified, cluster random sampling design was used to acquire a nationally representative sample. First, 347 districts or counties were selected with a probability proportional to the population size sampling (PPS) method from 31 provincial-level administrative divisions (PLADs) in China. Second, 3 junior high schools and 3 senior high schools (2 academic and 1 vocational) were selected using PPS in each sampled district or county. Third, a class was selected randomly in every grade of each sampled school. All students of the selected class were invited to complete paper-based questionnaires distributed by well-trained investigators independently without the presence of teachers. A total of 154,287 junior high and 149,764 senior high school students were included, with the overall response rates being 95.5% and 94.1%, respectively. The average median age of students surveyed was 15 years old.

In the 2019 China NYTS, all the participants were asked: 1) In the past 7 days, how many days did someone smoke in your home in your presence? 2) In the past 7 days, how many days did someone smoke in any indoor public places in your presence, such as teaching buildings, indoor venues, gymnasiums, internet cafes, stores, restaurants, shopping malls, or cinemas? 3) During the past 7 days, how many days did someone smoke in any outdoor public places in your presence, such as playgrounds, sidewalks, stations, building entrances, or parks? and 4) How many days did someone smoke in your presence in public transportation such as trains, buses, or taxis over the past 7 days? Being exposed to SHS at any place (i.e., at home, in indoor public places, in outdoor public places, or on public transportation) on ≥1 day in the past 7 days was defined as SHS exposure.

All parameter estimations were weighted based on a complex sampling design. Multilevel modeling of complex survey data was used to explore determinants of SHS exposure, with individuals being level-1 units and schools being level-2 clusters. Point values with 95% confidence intervals (CI) were presented for each...
parameter, and the difference with no overlap in CIs was identified to be statistically significant between subgroups. All analyses were conducted by SAS software (version 9.4, SAS Institute Inc., Cary, USA).

In this study, 70,778 and 72,169 female students in junior high and senior high schools, respectively, accomplished the questionnaire, of which 62.8% (61.5, 64.1) on average overall [60.8% (59.3, 62.1) from junior high and 65.3% (63.7, 67.0) from senior high school] were exposed to SHS in any place — with 31.7% (30.6, 32.8) at home, 46.5% (45.4, 47.6) in indoor public places, 48.8% (47.5, 50.0) in outdoor public places, and 22.1% (21.1, 23.1) on public transportation. The prevalence of SHS exposure in indoor public and outdoor public places was significantly higher than that at home and on public transportation — despite smoking or not and across different types of schools. In terms of geographic location, be it at home or in public places, there was no significant difference observed in the rate of SHS exposure between urban and rural areas. However, more girls in rural areas were exposed to SHS in public transportation than those in urban areas. For female non-smokers, the SHS exposure rate of senior high school students [64.8% (63.1, 66.4)] was higher than that of junior high school students [60.2% (58.8, 61.6)], but no significant difference between schools in SHS exposure was observed for female smokers [91.6% (88.2, 95.0) vs. 91.7% (89.1, 94.3)]. (Table 1)

The null model in multilevel modeling showed a statistically significant random part of level-2 accounting for 12 percent of the total variance (P<0.0001) and indicated the hierarchical structure of the data in this study. As a result, the introduction of Multilevel modeling was needed.

The results of the Multilevel modeling showed that higher grade levels [grade one as reference, grade two: odds ratio (OR)=1.438; grade three: OR=1.456], senior high school status (junior high school as reference: OR=1.158), urban areas (rural as reference: OR=1.302), more pocket money (OR=1.334), current smoking behaviors (no as reference: OR=2.441), exposure to tobacco advertisements (none as reference, one venue: OR=2.047; two venues: OR=2.222; three venues: OR=3.639), parental smoking behaviors (no one as reference: OR=2.098), close friends’ smoking behaviors (no one as reference: OR=1.950), use of e-cigarettes (no as reference: OR=1.654), and believing SHS exposure is detrimental to health (no as reference, maybe not: OR=1.504; maybe yes: OR=1.952; certainly: OR=2.430) were factors associated with higher SHS exposure (Table 2).

**DISCUSSION**

The prevalence of SHS exposure among Chinese adolescent girls (62.8%) in 2019 was similar to that among those aged 12 to 16 globally (62.9%) in 2010–2018 (5). The percentage of SHS exposure at home in China (32.0%) in 2019 was lower than that in Malaysia in 2016 (38.1%) but higher than that in the U.S. (25.3%) in 2019 (6–7).

In any place, be it at home (32.0%), indoor public places (43.4%), outdoor public places (46.3%), or public transportation (20.5%), the rate of SHS exposure among girls in junior high school in 2019 was markedly lower than that from 2013–2014 (42.1%, 53.9%, 55.3%, and 34.5%) (8). The fastest decline was observed for public transportation while the slowest was observed for outdoor public places. Both in 2013–2014 and 2019, the rates of SHS exposure in public places were critically higher than those at home, which is consistent with the results of another research (5). These findings not only highlight the improvement of tobacco control regulation but also showcase the importance of enhanced implementation of smoke-free public places and homes in conjunction with continuous efforts to implement tobacco control regulation in public transportation (9).

Despite the fact that tobacco use among adolescent girls is very low in China, more than half of non-smokers (62.2%) were affected by tobacco use. Moreover, non-smokers exposed to SHS at home and in other places were 1.4–2.1 and 1.3–1.8 times more likely to be vulnerable to initiating smoking than those not exposed, respectively (1). From January 2006, when the World Health Organization’s Framework Convention on Tobacco Control (FCTC) came into force in China, to August 2019, 22 cities implemented local or government regulations for tobacco control (9). However, the people protected by these laws only account for 15% of the total population of the country. In order to protect more people from tobacco use, regulations need to be introduced in more cities as soon as possible (9).

According to the results of the Multilevel modeling, use of electronic cigarettes (e-cigarettes) was associated with secondhand smoke exposure. In other words, this study found that adolescent girls with experience of using e-cigarettes were more susceptible to SHS.

Among females, the odds of being exposed to SHS were higher among those with one or both parents
smoking. This finding was also discovered in several other studies, one of which reported that parents were responsible for 90% of children’s SHS exposure (10–11). Therefore, educating parents about the hazard of SHS and enforcing complete smoking bans at home is critical to keeping adolescents away from SHS (3). As demonstrated in another study, adolescent girls whose intimate friends were smokers had an increased likelihood of being exposed to SHS. Hence, parents should also be involved in the lives of adolescents and keep an eye on their close friends (10).

Exposure to tobacco advertisements increased the possibility of being exposed to SHS, suggesting that comprehensive bans on tobacco advertisements, sponsorships, and marketing were also effective in avoiding exposure to SHS in China (12). Girls who believed in the harm of SHS had significantly more SHS exposure than those who did not, which may be due to better health consciousness or higher sensitivity to secondhand smoke (13).

Limitations exist in this study. First, SHS exposure was collected by self-reporting rather than identified by

| Types of school | Region | Places of exposure, % (95% CI) | Home | Indoor public places | Outdoor public places | Public transport | Any place |
|-----------------|--------|--------------------------------|------|---------------------|----------------------|-----------------|----------|
| Overall         | Total  | 31.7 (30.6, 32.8) | 46.5 (45.4, 47.6) | 48.8 (47.5, 50.0) | 22.1 (21.1, 23.1) | 62.8 (61.5, 64.1) |
| Urban           | 31.5 (29.9, 33.2) | 45.8 (44.1, 47.5) | 49.5 (47.3, 51.7) | 19.5 (18.2, 20.7) | 63.3 (61.1, 65.5) |
| Rural           | 31.8 (30.3, 33.2) | 46.8 (45.3, 48.3) | 48.2 (46.7, 49.8) | 23.9 (22.5, 25.4) | 62.4 (61.0, 64.0) |
| Junior high school | Total | 32.0 (30.9, 33.1) | 43.4 (42.2, 44.6) | 46.3 (45.0, 47.7) | 20.5 (19.3, 21.6) | 60.8 (59.3, 62.1) |
| Urban           | 31.6 (30.2, 33.0) | 43.4 (41.8, 45.0) | 48.2 (46.0, 50.4) | 18.5 (17.2, 19.8) | 62.0 (60.0, 64.0) |
| Rural           | 32.2 (30.6, 33.8) | 43.5 (41.8, 45.1) | 45.2 (43.6, 47.0) | 21.7 (20.1, 23.4) | 60.1 (58.2, 62.0) |
| Senior high school | Total | 31.3 (29.8, 32.7) | 50.2 (48.6, 51.8) | 51.7 (50.1, 53.3) | 24.0 (22.7, 25.4) | 65.3 (63.7, 67.0) |
| Urban           | 31.5 (29.1, 33.9) | 48.5 (46.1, 51.0) | 50.9 (48.2, 53.7) | 20.5 (18.8, 22.2) | 64.9 (62.0, 67.7) |
| Rural           | 31.1 (29.4, 32.9) | 51.3 (49.2, 53.4) | 52.2 (50.2, 54.1) | 26.8 (24.9, 28.7) | 65.6 (63.7, 67.5) |
| Non-smoker      | Overall | 31.1 (30.0, 32.2) | 45.8 (44.7, 47.0) | 48.1 (47.0, 49.4) | 21.6 (20.6, 22.6) | 62.2 (61.0, 63.5) |
| Urban           | 31.1 (29.4, 32.8) | 45.3 (43.6, 47.0) | 49.0 (46.8, 51.2) | 19.1 (17.9, 20.3) | 62.9 (60.7, 65.0) |
| Rural           | 31.1 (29.7, 32.5) | 46.1 (44.6, 47.6) | 47.6 (46.1, 49.1) | 23.4 (22.0, 24.8) | 61.8 (60.3, 63.3) |
| Junior high school | Total | 31.4 (30.3, 32.5) | 42.8 (41.6, 43.9) | 45.8 (44.5, 47.1) | 20.0 (18.9, 21.1) | 60.2 (58.8, 61.6) |
| Urban           | 31.2 (29.9, 32.6) | 43.0 (41.3, 44.6) | 47.8 (45.6, 50.0) | 18.2 (16.9, 19.5) | 61.6 (59.5, 63.6) |
| Rural           | 31.5 (29.9, 33.1) | 42.7 (41.1, 44.3) | 44.6 (43.0, 46.3) | 21.2 (19.6, 22.7) | 59.4 (57.5, 61.2) |
| Senior high school | Total | 30.7 (29.3, 32.1) | 49.6 (48.0, 51.2) | 51.1 (49.5, 52.7) | 23.6 (22.2, 24.9) | 64.8 (63.1, 66.4) |
| Urban           | 31.0 (28.6, 33.4) | 47.9 (45.5, 50.3) | 50.3 (47.6, 53.1) | 20.1 (18.4, 21.8) | 64.3 (61.4, 67.2) |
| Rural           | 30.5 (28.7, 33.2) | 50.7 (48.6, 52.8) | 51.6 (49.6, 53.5) | 26.3 (24.4, 28.2) | 65.1 (63.2, 67.0) |
| Smoker          | Overall | 61.8 (58.7, 64.9) | 79.8 (76.4, 83.3) | 78.5 (75.5, 81.4) | 42.1 (38.7, 45.5) | 91.6 (89.5, 93.8) |
| Urban           | 56.4 (51.4, 61.5) | 77.8 (73.4, 82.2) | 79.5 (75.2, 83.8) | 38.0 (34.0, 42.1) | 91.2 (87.4, 95.0) |
| Rural           | 64.4 (60.5, 68.3) | 80.8 (76.2, 85.5) | 78.0 (74.1, 81.8) | 44.3 (39.5, 49.2) | 91.9 (89.3, 94.5) |
| Junior high school | Total | 64.4 (60.3, 68.5) | 80.2 (75.5, 84.8) | 77.1 (72.5, 81.7) | 42.8 (37.3, 48.3) | 91.7 (89.1, 94.3) |
| Urban           | 61.4 (54.8, 68.0) | 80.9 (77.2, 84.6) | 82.2 (78.2, 86.1) | 41.4 (34.5, 48.3) | 92.8 (89.8, 95.8) |
| Rural           | 65.3 (60.2, 70.3) | 79.9 (74.0, 85.9) | 75.5 (69.6, 81.5) | 43.3 (36.1, 50.5) | 91.4 (88.1, 94.6) |
| Senior high school | Total | 59.0 (54.3, 63.7) | 79.5 (75.3, 83.7) | 80.0 (76.5, 83.4) | 41.4 (37.4, 45.4) | 91.6 (88.2, 95.0) |
| Urban           | 53.5 (46.5, 60.5) | 76.0 (69.7, 82.3) | 78.0 (72.2, 83.8) | 36.0 (30.5, 41.4) | 90.2 (84.5, 96.0) |
| Rural           | 63.1 (56.6, 69.6) | 82.2 (76.5, 87.8) | 81.5 (77.3, 85.7) | 45.6 (39.5, 51.7) | 92.6 (88.4, 96.8) |

Abbreviation: CI=confidence interval.
| Parameter                          | Estimate (95% CI) | SE     | t      | P      | OR (95% CI) |
|-----------------------------------|-------------------|--------|--------|--------|-------------|
| **Fixed effects**                 |                   |        |        |        |             |
| Intercept                         | −1.952 (−2.339, −1.565) | 0.198  | −9.880 | <0.001 |             |
| **School types**                  |                   |        |        |        |             |
| Junior high school                |                   |        |        |        |             |
| Senior high school                | 0.147 (0.035, 0.259) | 0.057  | 2.570  | 0.010  | 1.158 (1.035, 1.295) |
| **Grade**                         |                   |        |        |        |             |
| One                               |                   |        |        |        |             |
| Two                               | 0.364 (0.214, 0.513) | 0.076  | 4.760  | <0.001 | 1.438 (1.238, 1.671) |
| Three                             | 0.376 (0.256, 0.495) | 0.061  | 6.150  | <0.001 | 1.456 (1.292, 1.641) |
| **Regions**                       |                   |        |        |        |             |
| Rural                             |                   |        |        |        |             |
| Urban                             | 0.264 (0.141, 0.387) | 0.063  | 4.220  | <0.001 | 1.302 (1.152, 1.472) |
| **Pocket money**                  |                   |        |        |        |             |
| No                                |                   |        |        |        |             |
| Yes                               | 0.288 (0.139, 0.438) | 0.076  | 3.770  | 0.001  | 1.334 (1.149, 1.550) |
| **Smoking**                       |                   |        |        |        |             |
| No                                |                   |        |        |        |             |
| Yes                               | 0.893 (0.138, 1.647) | 0.385  | 2.320  | 0.021  | 2.441 (1.148, 5.193) |
| **Others’ smoking does harm to you** |           |        |        |        |             |
| No                                |                   |        |        |        |             |
| Maybe not                         | 0.408 (−0.059, 0.876) | 0.239  | 1.710  | 0.087  | 1.504 (0.942, 2.402) |
| Maybe yes                         | 0.669 (0.328, 1.009) | 0.174  | 3.850  | 0.001  | 1.952 (1.389, 2.743) |
| Certainly                         | 0.888 (0.541, 1.234) | 0.177  | 5.020  | <0.001 | 2.430 (1.718, 3.436) |
| **Exposure to tobacco advertisement** |           |        |        |        |             |
| None                              |                   |        |        |        |             |
| One venue                         | 0.717 (0.611, 0.822) | 0.054  | 13.350 | <0.001 | 2.047 (1.843, 2.274) |
| Two venues                        | 0.798 (0.648, 0.949) | 0.077  | 10.390 | <0.001 | 2.222 (1.911, 2.583) |
| Three venues                      | 1.292 (1.057, 1.527) | 0.120  | 10.780 | <0.001 | 3.639 (2.877, 4.603) |
| **Tobacco use of parents**        |                   |        |        |        |             |
| No one                            |                   |        |        |        |             |
| At least one                      | 0.741 (0.637, 0.845) | 0.053  | 13.990 | <0.001 | 2.098 (1.891, 2.328) |
| **Tobacco use of close friends**  |                   |        |        |        |             |
| No one                            |                   |        |        |        |             |
| At least one                      | 0.668 (0.537, 0.799) | 0.067  | 9.970  | <0.001 | 1.950 (1.711, 2.224) |
| **Use of e-cigarette**            |                   |        |        |        |             |
| No                                |                   |        |        |        |             |
| Yes                               | 0.503 (0.288, 0.718) | 0.110  | 4.590  | <0.01  | 1.654 (1.334, 2.050) |
| **Random effects**                |                   |        |        |        |             |
| Level 2 $\sigma^2_\text{u}$      | 0.577             | 0.060  | 9.652  | <0.001 |             |

Abbreviation: CI=confidence interval; SE=standard error; OR=odd ratio; $\sigma^2_\text{u}=$random coefficient.
biomarkers such as serum cotinine, which might lead to misreporting or recall bias. However, self-reported SHS exposure is widely adopted across similar epidemiological studies: making these results comparable to other research (3,10). Second, this study cannot analyze the changes in SHS exposure among senior high school students over time, as this was investigated for the first time in 2019.

In conclusion, SHS exposure among adolescent girls in China is still an important public health issue. In order to better curb SHS exposure, targeted public health initiatives need to be strengthened in China.

**Funding:** Chinese Central Government Key Project of Public Health Program (Z195110010005).

doi: 10.46234/ccdcw2022.198

* Corresponding author: Shiwei Liu, liuws@chinacdc.cn.

1 Tobacco Control Office, Chinese Center for Disease Control and Prevention, Beijing, China.

Submitted: February 28, 2022; Accepted: May 11, 2022

**REFERENCES**

1. Bettcher DW, Peruga A, Baptiste J, El Awa F, Nikogosian H, Rahman K, et al. Exposure to secondhand smoke among students aged 13–15 years worldwide, 2000–2007. MMWR Morb Mortal Wkly Rep 2007. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5620a2.htm#tab. [2021-12-20].

2. Okoli CT, Kelly T, Hahn EJ. Secondhand smoke and nicotine exposure: a brief review. Addict Behav 2007;32(10):1977–1988. https://www.sciencedirect.com/science/article/pii/S0306460307000020?via%3Dihub.

3. Schwartz J, Graham RB, Richardson CG, Okoli CT, Struijk LL, Bottorff JL. An examination of exposure and avoidance behavior related to second-hand cigarette smoke among adolescent girls in Canada. BMC Public Health 2014;14:468. https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-14-468.

4. Xi B, Liang YJ, Liu YX, Yan YK, Zhao M, Ma CW, et al. Tobacco use and second-hand smoke exposure in young adolescents aged 12–15 years: data from 68 low-income and middle-income countries. Lancet Glob Health 2016;4(11):e795–805. https://www.sciencedirect.com/science/article/pii/S2214109X16301875?via%3Dihub.

5. Ma CW, Heiland EG, Li ZL, Zhao M, Liang YJ, Xi B. Global trends in the prevalence of secondhand smoke exposure among adolescents aged 12–16 years from 1999 to 2018: an analysis of repeated cross-sectional surveys. Lancet Glob Health 2021;9(12):e1667–1678. https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(21)00365-X/fulltext.

6. Ling MYJ, Lim KH, Hasani WSR, Rifin HM, Majid NLA, Lourdes TGR, et al. Exposure to secondhand smoke among school-going adolescents in Malaysia: Findings from the tobacco and e-cigarettes survey among Malaysian adolescents (TECMA). Tob Induc Dis 2020;18:96. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7694740/.

7. Walton K, Gentzke AS, Murphy-Hoerter R, Kenemer B, Neff LJ. Exposure to secondhand smoke in homes and vehicles among US youths, United States, 2011–2019. Prev Chronic Dis 2020;17:E103. https://www.cdc.gov/pcd/issues/2020/pdf/20_0107.pdf.

8. Liang XF. Survey Report on Youth Tobacco in China in 2014[M]. Beijing: People’s Medical Publishing House, 2014. (In Chinese)

9. Yang J, Li Q, Zhou S, Xi Z, Luo XW, Song LL. Tobacco control regulations in cities of China, 2006-2019. Cap J Public Health 2019;13(5):226 – 9. http://dx.doi.org/10.16760/j.cnki.sdggws.2019.05.001. (In Chinese).

10. Raute LJ, Pednekar MS, Mistry R, Gupta PC, Pimple SA, Shastri SS. Determinants of exposure to second-hand smoke at home and outside the home among students aged 11–17 years: results from the Mumbai student tobacco survey 2010. Indian J Cancer 2012;49(4):419-24. https://pubmed.ncbi.nlm.nih.gov/23442407/.

11. Environmental Protection Agency. FACT SHEET: National survey on environmental management of asthma and children’s environmental tobacco smoke. (NSEMA/CEE). 2004. https://www.epa.gov/sites/default/files/2015-08/documents/survey_fact_sheet.pdf. [2021-12-20].

12. Zhu ZY, Zheng PP. Secondhand smoke exposure on campus and influencing factors among college students in Shanghai. J Environ Occup Med 2017;34(4):304 – 10. http://dx.doi.org/10.13213/j.cnki. jeom.2017.16774. (In Chinese).

13. Bayly JE, Bernat D, Porter L, O’Dare K, Choi K. Prevalence and characteristics of secondhand smoke and secondhand vapour exposure among youth. Tob Control 2019;28(3):305–10. https://tobaccocontrol.bmj.com/content/28/3/305.long.