

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities (TFC) initiative in five Chinese cities: a pooled cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044570
Article Type:	Original research
Date Submitted by the Author:	07-Sep-2020
Complete List of Authors:	Duan, Zongshuan; Georgia State University, School of Public Health Wang, Yu; Georgia State University, School of Public Health Huang, Jidong; Georgia State University, School of Public Health Redmon, Pamela; Emory University, Global Health Institute Eriksen, Michael ; Georgia State University, School of Public Health
Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 **Secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities**
4 **(TFC) initiative in five Chinese cities: a pooled cross-sectional study**
5

6
7 Zongshuan Duan¹, Yu Wang¹, Jidong Huang^{1*}, Pamela B. Redmon², Michael P. Eriksen¹
8

9 ¹ School of Public Health, Georgia State University, Atlanta, GA, 30303, USA

10 ² Global Health Institutes, Emory University, Atlanta, GA, 30322, USA
11
12
13
14
15
16
17
18

19 *Corresponding Author:

20 Jidong Huang, Ph.D. Associate Professor

21 Department of Health Policy & Behavioral Sciences

22 School of Public Health

23 Georgia State University

24 Urban Life Building, Suite 859

25 140 Decatur Street, Atlanta, GA 30303

26 Email: jhuang17@gsu.edu

27 Office Phone: 404-413-9337
28
29
30
31
32

33 Type of Submission: Original research

34 Word Count: 3,779

35 Number of Tables/Figures: 4

36 Number of Supplemental Tables: 4
37
38
39
40
41
42

43 **Keywords:** secondhand smoke exposure, SHS, Tobacco Free Cities, TFC, tobacco control, China, city
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Objectives: To assess the levels of secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities (TFC) initiative.

Design: Citywide representative, cross-sectional surveys were conducted in each participating city before and after the implementation of TFC.

Setting: Five large Chinese cities, including Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an, participated in the TFC initiative.

Participants: There was a total of 10,104 participants and 10,233 participants in 2015 and 2018, respectively.

Interventions: The TFC initiative, which includes targeted media campaigns, educational programs, implementing citywide smoke-free policies, and providing cessation interventions, was implemented in these five cities between 2015-2018.

Main outcome: Self-reported SHS exposure in indoor workplaces, restaurants, and homes.

Data analysis: The pre- and post-TFC SHS exposure levels were compared among all residents and among certain population subgroups. Multivariate logistic regressions were used to estimate the adjusted associations between SHS exposure and individual characteristics.

Results Across all five cities, the overall rate of self-reported SHS exposure declined from 49.6% (95% CI: 46.4%-52.8%) to 41.2% (95% CI: 37.7%-44.7%) in indoor workplaces, from 72.4% (95% CI: 69.8%-74.9%) to 61.7% (95% CI: 58.7%-64.7%) in indoor areas of restaurants, and from 39.8% (95% CI: 36.9%-42.7%) to 34.7% (95% CI: 31.5%-37.8%) in homes from 2015 to 2018. Adjusted logistic regressions indicated that these declines were statistically significant after controlling for individual characteristics. The SHS exposure was associated with sex, age, education level, occupation, and current smoking status. The associations varied by venues.

Conclusions Our analysis showed that compared with the nationwide SHS exposure levels reported in concurrent national surveys, the declines in SHS exposure in these five Chinese cities implemented the TFC initiative were larger in indoor workplaces and restaurants. Our findings suggest that the TFC initiative was effective in reducing SHS exposure in Chinese cities.

Strengths and limitations of this study

- Multistage sampling method was applied to select a citywide representative sample for each city participated in the Tobacco Free Cities (TFC) initiative.
- Surveys were conducted before and after the implementation of the TFC initiative to assess secondhand exposure (SHS) in public indoor areas and homes, which provided empirical evidence on the potential effectiveness of the TFC initiative in reducing SHS exposure.
- The pre- and post-TFC SHS exposure levels were compared among certain population subgroups and multivariate logistic regressions were used to estimate the adjusted associations between SHS exposure and individual characteristics.
- The associations between SHS exposure and individual level characteristics may not be generalized to other cities or rural areas in China.
- We could not estimate changes of SHS exposure before and after the implementation of the TFC initiative at the individual level since the data we used were from pooled cross-sectional surveys.

Introduction

Secondhand smoke (SHS) exposure is a major preventable cause of diseases for infants, children, and nonsmoking adults.¹⁻³ It has been well documented that there is no risk-free level of exposure to SHS.² As the largest tobacco consumption country in the world, China has more than 300 million smokers, exposing an estimated 740 million people to harmful environmental tobacco smoke.⁴ Recent nationwide surveys showed that exposure to SHS had been declining in China over the last decade. For example, the China Adult Tobacco Survey (CATS) found that from 2015 to 2018, SHS exposure in indoor places had declined significantly, particularly in homes (57.1% to 44.9%), workplaces (54.3% to 50.9%), government buildings (38.1% to 31.1%), healthcare facilities (36.8% to 24.4%), restaurants (76.3% to 73.3%), and public transportation (16.4% to 12.9%).^{5,6}

Previous studies indicated that the decline in SHS exposure in China was likely due to the implementation of smoke-free air policies in public places in recent years.⁷⁻⁹ Since 2013, the Chinese government issued a guideline for all government officials to take the lead in making public places smoke-free.^{4,10} In 2014, the Ministry of Education and the National Health Commission (now National Health and Family Planning Commission) issued directives for all schools and healthcare facilities in China to become 100% smoke-free.^{4,10} To date, more than 20 largest Chinese cities, including Beijing, Shanghai, Shenzhen, and Xi'an, have adopted citywide smoke-free air policies.⁵

Despite progress in smoke-free legislation and tobacco control efforts, more than half (50.9%) of adults who worked indoors were still exposed to tobacco smoke at their workplaces, and more than 500 million adults were exposed to SHS at home.⁵ To support Chinese cities to develop effective, comprehensive and sustainable tobacco control programs, researchers from Georgia State University (GSU) and China Centers for Disease Control and Prevention (China CDC) selected five Chinese cities, including Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an, to participate in the Tobacco Free Cities (TFC) initiative in 2015. The three-year initiative aimed to achieve the goal of creating cities where no tobacco use is the norm, by providing grant funds and experts' support to help the cities implement best practice interventions, including adoption of tobacco-free policies, communication strategies to increase knowledge on harms of tobacco use, and provision and utilization of cessation services.¹¹ The research team in GSU collaborated with the ThinkTank Research Center for Health Development, a China-based non-governmental organization, the China CDC, and the National Health Commission (now National Health and Family Planning Commission) to identify a non-random sample of 10 potential cities for the TFC initiative in 2015. All candidate cities submitted a description of their project intent that was reviewed by the selection committee. Site visits and telephone interviews were conducted to determine the level of commitment to the goals of the TFC initiative. Five metropolitan cities were selected based on

1
2
3 population size, societal influence in China, local government support for tobacco control efforts, and
4 stage of readiness to take action to change social norms of tobacco use in their city. None of these five
5 cities had citywide smoke-free air policies at the time of selection. The cities were required to have a
6 dedicated public health team to establish or enhance a tobacco control program, and commitment to the
7 TFC initiative requirements. The population size of these five participating cities ranged from about 4
8 million in Xiamen to about 30 million in Chongqing (see the Supplemental Table 1 for detail).

9
10
11
12
13 The TFC initiative in these five cities started in April 2015.¹¹ From 2015 to 2018, these cities
14 executed activities, including implementing citywide and sector-wide smoke-free policies, launching
15 health education interventions and mass media campaigns, and providing cessation interventions for
16 smokers who want to quit (see the Supplemental Table 1 for a detailed list of tobacco control activities in
17 each city). Two waves of citywide representative household surveys were conducted in these five cities in
18 2015, prior to the implementation of the TFC initiative, and in 2018, at the end of the TFC initiative. The
19 surveys assessed tobacco use, exposure to secondhand smoke (SHS) and knowledge, attitudes, and beliefs
20 towards various tobacco and nicotine products, using the Tobacco Questions for Surveys (TQS)
21 questionnaire. TQS was a subset of key questions adapted from the Global Adult Tobacco Survey
22 (GATS), developed by the World Health Organization (WHO) and the U.S. Centers for Disease Control
23 and Prevention (U.S. CDC).¹²

24
25
26
27
28
29
30
31 This study aims to conduct a preliminary assessment of the effectiveness of the TFC initiative in
32 reducing SHS exposure in indoor areas. Although a few small randomized controlled trials had been
33 conducted to show the effectiveness of tobacco control intervention programs in reducing SHS
34 exposure,^{13 14} the evidence on the effectiveness of citywide tobacco control activities in reducing SHS
35 exposure in China is scarce. In addition, because smoking behavior and its determinants may differ
36 considerably between urban and rural areas in China, the overall SHS exposure status at the national level
37 may mask the differences across regions and population subgroups.¹⁵⁻¹⁷ Importantly, due in part to a lack
38 of representative, citywide data on SHS exposure in China, very little is known about SHS exposure in
39 large cities, where the population is more concentrated than small cities and rural areas, and SHS
40 exposure may be more pronounced. This study is designed to fill this research gap by examining the level
41 of SHS exposure in indoor workplaces, indoor areas of restaurants, and at home in five large Chinese
42 cities before and after the implementation of the TFC initiative in those cities. This study also investigates
43 the potential differences in SHS exposure across population subgroups. It was hypothesized that the
44 decline in SHS exposure at workplaces, restaurants, and homes between 2015 and 2018 would be more
45 pronounced in these five cities with the TFC initiative, compared with the nationwide trend. In addition,
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 the SHS exposure was hypothesized to vary among population subgroups characterized by socio-
4 demographic factors and smoking status.
5

6 **Methods**

7 **Study design and survey participants**

8
9
10
11 In 2015 and 2018, two waves of citywide representative household surveys were conducted by
12 the local municipal health department under the supervision of the China CDC in five Chinese cities
13 participating in the TFC initiative, i.e., Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an. The first-wave
14 data was collected from October 2015 to March 2016, and the second-wave surveys were conducted from
15 November 2017 to March 2018 (see a detailed timeline in Supplemental Table 2). Participants were
16 recruited using a household-based, multistage cluster sampling scheme designed to represent non-
17 institutionalized adults (defined as age 15 and above at the survey time) residing in urban areas of these
18 five cities, based on the principles outlined in the GATS Sample Design Manual.¹⁸ Detailed sampling
19 procedures and weight calculations were described in previously published studies.^{19,20} The response rate
20 and sample size for each city in 2015 and 2018 were listed in Supplemental Table 2. The household
21 surveys were conducted through indoor face-to-face interviews using handheld computer-assisted devices
22 to reduce measurement errors. These surveys were approved by the local IRB of each city's municipal
23 health department. Written informed consent was obtained from all participants.
24
25
26
27
28
29
30
31

32 **Measures and variables**

33 *Outcomes*

34
35
36 Primary outcome variables in this study included self-reported SHS exposure status in indoor
37 areas of workplaces, restaurants, and homes in the past 30 days. All study participants were asked
38 whether they usually worked indoors. Participants who responded "yes" were asked whether they had
39 noticed anyone smoking in indoor areas of workplaces in the past 30 days. In addition, all participants
40 were asked whether they had visited any restaurants in the past 30 days. If so, they were asked to report
41 whether they had observed anyone smoking inside any of the restaurants they visited in the past 30 days.
42 In addition, respondents were asked whether anyone had smoked in their homes in the past 30 days.
43
44
45
46
47

48 *Current tobacco smoking status*

49
50 Participants were asked whether they were currently using any smoking tobacco products,
51 including cigarettes, cigars, and pipes, daily, occasionally, or not at all. Participants who were currently
52 using smoking tobacco products daily or occasionally were categorized as current smokers. Participants
53 who were not using any smoking tobacco products at all were categorized as current nonsmokers.
54
55
56
57
58
59
60

Demographic characteristics

Demographic variables included biological sex, age, highest education level, and occupation type. The categorizations of individual characteristics were consistent with other nationally representative surveys conducted in China.^{5 21} Age was categorized into 15-24, 25-44, 45-64, and 65 years and older. Education was categorized into primary school completed or below, junior high school completed, senior high school completed, and college degree or above. The occupation was categorized into “government employee, teacher, healthcare provider,” “factory, business, agriculture, and service industry employee,” and “not in the labor force,” which included the unemployed, students, homemakers, and retired. Teachers and health care providers were categorized together with government employees because most schools and hospitals are government-owned in China. In addition, existing smoke-free policies are generally implemented in government buildings, public schools, and hospitals in China.¹¹

Data Analyses

SAS[®] 9.4 (SAS Institute, Cary, NC, USA) was used for data analyses. Complex sampling procedures were accounted for in analyses by using the survey procedures in SAS. Pairwise deletion was used to handle missing values.²² We estimated the percentages and 95% confidence intervals (CIs) of urban adult residents who had been exposed to SHS in the past 30 days at selected venues, in total and by demographic characteristics, including biologic sex, age, education, occupation, and current smoking status. The Rao-Scott Chi-Square test was used to check the unadjusted associations between SHS exposure and survey years in total and by demographic characteristics. In addition, multivariate logistic regression was used to estimate the adjusted associations between SHS exposure and survey years, controlling for demographic characteristics, including age, gender, education, occupational status, and smoking status.

Patient and public involvement

This study was done without patient involvement. The target population of TQS was non-institutionalized adults residing in urban areas of the five participating Chinese cities.

Results

Demographic characteristics and smoking status

Among urban adult residents in all five participating cities, in 2015, about 11% of them completed primary school or below, and 37% had a college degree or above. Approximately 11% worked as government employees, teachers, or healthcare providers, and 44% were not in the labor force. In

2018, approximately 9% completed primary school or below, and 42% had a college degree or above. There were about 11% of adult residents working as government employees, teachers, or healthcare providers, and more than half of them (51%) were not in the labor force. Approximately 23% of them were current smokers in 2015 and 2018. (Supplemental Table 3)

SHS exposure in indoor workplaces

As shown in Table 1, the overall exposure to SHS in indoor workplaces decreased from 49.6% (95% CI: 46.4%-52.8%) in 2015 to 41.2% (95% CI: 37.7%-44.7%) in 2018 ($p=0.0003$). In 2015, 58.3% (95% CI: 54.5%-62.0%) of men and 39.2% (95% CI: 35.8%-42.7%) of women reported exposure to SHS, while 49.2% (95% CI: 45.1%-53.2%) of men and 32.2% (95% CI: 28.4%-36.0%) reported SHS exposure in their indoor workplaces in 2018 ($p=0.0007$ and $p=0.0055$ for men and women, respectively). Regarding age, the rate of SHS exposure was the highest among adults aged 45 to 64 years old in 2015 and 2018. From 2015 to 2018, the decline in SHS exposure was statistically significant for adults aged 25 to 44 years old (47.9%, 95% CI: 44.4%-51.4% vs. 41.2%, 95% CI: 37.4%-45.0%, $p=0.0086$) and 45 to 64 years old (58.6%, 95% CI: 53.9%-63.3% vs. 46.9%, 95% CI: 42.0%-51.8%, $p=0.0005$). Exposure to SHS followed a gradient, i.e., exposure decreases as education levels increase, in both 2015 and 2018 surveys. The decline in SHS exposure was statistically significant for people with senior high school completed or above (51.5%, 95% CI: 46.8%-56.2% vs. 44.6%, 95% CI: 40.0%-49.1%, $p=0.0356$) and college degree or above (45.8%, 95% CI: 42.3%-49.3% vs. 37.2%, 95% CI: 33.1%-41.4%, $p=0.0012$). A significant decrease in the self-reported SHS exposure was observed for both government employees, teachers, or healthcare providers and factory, business, and service industry employees. In 2015, 70.7% (95% CI: 66.0%-75.3%) of smokers and 42.8% (95% CI: 39.4%-46.1%) of nonsmokers reported exposed to SHS at their indoor workplace, and the corresponding rates in 2018 significantly decreased to 63.6% (95% CI: 59.1%-68.1%) and 34.6% (95% CI: 31.0%-38.2%) for smokers and nonsmokers, respectively.

Table 1: Secondhand smoke (SHS) exposure in indoor workplaces before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=4,710)		Year 2018 (N=5,011)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	49.61	46.37 - 52.85	41.24	37.74 - 44.74	0.0003
<i>Sex</i>					
Male	58.25	54.52 - 61.98	49.15	45.13 - 53.18	0.0007
Female	39.23	35.8 - 42.66	32.21	28.39 - 36.03	0.0055
<i>Age (Years)</i>					
15-24	44.83	39.31 - 50.35	37.34	31.34 - 43.34	0.0717

25-44	47.88	44.4 - 51.35	41.21	37.41 - 45.01	0.0086
45-64	58.58	53.87 - 63.3	46.88	42.01 - 51.75	0.0005
65 and above	41.66	20.05 - 63.26	25.39	16.05 - 34.74	0.1183
<i>Education Level</i>					
Primary school completed or below	64.16	54.51 - 73.8	52.85	42.17 - 63.53	0.1071
Junior high school completed	56.33	50.59 - 62.06	48.05	41.63 - 54.46	0.0511
Senior high school completed	51.47	46.76 - 56.17	44.57	40.02 - 49.11	0.0356
College degree or above	45.81	42.33 - 49.29	37.25	33.05 - 41.44	0.0012
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	39.39	33.96 - 44.82	30.43	24.89 - 35.97	0.0304
Factory, business, service industry employee	52.22	49.02 - 55.42	44.08	40.21 - 47.95	0.0003
<i>Current smoking status</i>					
Yes	70.65	65.99 - 75.31	63.59	59.06 - 68.12	0.0313
No	42.76	39.39 - 46.14	34.59	30.97 - 38.22	0.0007

SHS exposure in indoor areas of restaurants

As shown in Table 2, the overall exposure to SHS in indoor areas of restaurants decreased significantly from 72.4% (95% CI: 69.8%-74.9%) in 2015 to 61.7% (95% CI: 58.7%-64.7%) in 2018 ($p < 0.0001$). Both men and women reported significantly less exposure to SHS from 2015 to 2018 (for men, 77.4%, 95% CI: 74.8%-80.0% vs. 66.0%, 95% CI: 62.6%-69.4%, $p < 0.0001$; for women: 66.3%, 95% CI: 63.0%-69.6% vs. 56.9%, 95% CI: 53.4%-60.3%, $p < 0.0001$). In addition, the rate of reporting SHS exposure in indoor areas of restaurants had declined significantly for people in age groups below 65 years old but remained the same (59.4%) for residents who were 65 years old or above from 2015 to 2018. In 2015, adults with primary school completed or below had the lowest rate (64.6%, 95% CI: 58.6%-70.7%) of reporting exposure to SHS at indoor areas of restaurants in 2015. However, this group reported the highest rate (69.9%, 95% CI: 64.0%-75.8%) in 2018. The rate of reporting SHS exposure declined significantly in another three education level groups. In addition, respondents in all three occupation categories had experienced a significant decline in SHS exposure in indoor areas of restaurants. In 2015, 83.6% (95% CI: 80.5%-86.6%) of current smokers and 68.6% (95% CI: 65.8%-71.4%) of current nonsmokers reported SHS exposure in indoor areas of restaurants, and the rates significantly decreased to 74.3% (95% CI: 70.1%-78.5%) and 57.40% (95% CI: 54.2%-60.6%) in 2018 for current smokers and nonsmokers, respectively ($p < 0.0001$ and $p = 0.0002$, respectively).

Table 2: Secondhand smoke (SHS) exposure in indoor areas of restaurants before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=6,576)		Year 2018 (N=6,878)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	72.37	69.81 - 74.92	61.70	58.66 - 64.74	<.0001
<i>Sex</i>					
Male	77.37	74.76 - 79.98	66.00	62.57 - 69.43	<.0001
Female	66.27	62.99 - 69.55	56.88	53.44 - 60.31	<.0001
<i>Age (Years)</i>					
15-24	71.56	67.35 - 75.76	55.37	50.74 - 59.99	<.0001
25-44	73.00	69.98 - 76.03	63.47	60.12 - 66.82	<.0001
45-64	74.56	71.21 - 77.91	64.80	60.21 - 69.38	0.0004
65 and above	59.40	54.2 - 64.59	59.36	52.74 - 65.98	0.9931
<i>Education Level</i>					
Primary school completed or below	64.63	58.59 - 70.67	69.92	64.04 - 75.79	0.2197
Junior high school completed	73.59	70.44 - 76.75	64.95	59.17 - 70.74	0.0074
Senior high school completed	73.37	70.03 - 76.7	61.10	57.44 - 64.75	<.0001
College degree or above	72.15	69.05 - 75.25	60.04	56.52 - 63.57	<.0001
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	71.71	66.38 - 77.04	58.8	52.5 - 65.11	0.0010
Factory, business, service industry employee	74.96	72.35 - 77.58	64.92	61.5 - 68.33	<.0001
Not in the labor force ¹	69.22	65.5 - 72.93	60.09	56.2 - 63.98	0.0008
<i>Current smoking status</i>					
Yes	83.55	80.48 - 86.62	74.33	70.13 - 78.54	<.0001
No	68.57	65.77 - 71.38	57.40	54.23 - 60.57	0.0002

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

SHS exposure at home

As shown in Table 3, the overall exposure to SHS at home decreased significantly from 39.8% (95% CI: 36.9%-42.7%) in 2015 to 34.6% (95% CI: 31.5%-37.8%) in 2018 ($p=0.0178$). The decline was only significant for women (34.7%, 95% CI: 31.6%-37.8% vs. 27.7%, 95% CI: 24.8%-30.6%, $p=0.0009$), not for men. Regarding age, the rate of self-reported SHS exposure at home was found to be declining in all age groups, but the decline was statistically significant only among 25 to 44 years old age group (37.4%, 95% CI: 34.1%-40.7% vs. 31.9%, 95% CI: 28.0%-35.8%, $p=0.0327$). The rate of reporting SHS exposure at home was found declining among urban residents of all education levels, but the decline was statistically significant among residents with a college degree or above (33.8%, 95% CI: 30.4%-37.3% vs. 27.7%, 95% CI: 24.9%-30.5%, $p=0.0052$). The rate of self-reported SHS exposure at home was lowest

among government employees, teachers, or healthcare providers, and did not change significantly from 2015 to 2018 ($p=0.7085$). A significant decrease in the rate of reporting SHS exposure at home was observed for adults working in factory, business, and service industry (41.6%, 95% CI: 38.2%-45.1% vs. 36.0%, 95% CI: 32.0%-39.9%, $p=0.0299$), and who were not in the labor force (40.0%, 95% CI: 37.0%-42.9% vs. 34.6%, 95% CI: 31.0%-38.3%, $p=0.0288$) from 2015 to 2018. During the same period, there was a statistically significant decline of reported SHS exposure at home for current nonsmokers (29.4%, 95% CI: 26.6%-32.1% vs. 23.2%, 95% CI: 20.5%-25.8%, $p=0.0015$), the decline was not significant for current smokers.

Table 3: Secondhand smoke (SHS) exposure at home before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=9,943)		Year 2018 (N=10,086)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	39.80	36.89 - 42.71	34.65	31.49 - 37.81	0.0178
<i>Sex</i>					
Male	44.58	41.19 - 47.97	41.36	37.37 - 45.35	0.2293
Female	34.73	31.65 - 37.8	27.70	24.82 - 30.58	0.0009
<i>Age (Years)</i>					
15-24	42.70	37.81 - 47.6	37.56	32.86 - 42.26	0.1412
25-44	37.40	34.06 - 40.73	31.87	27.97 - 35.78	0.0327
45-64	43.30	39.87 - 46.72	38.33	34.37 - 42.28	0.0627
65 and above	33.94	30.51 - 37.37	28.79	24.65 - 32.93	0.0612
<i>Education Level</i>					
Primary school completed or below	43.35	38.55 - 48.14	39.85	33.74 - 45.97	0.3936
Junior high school completed	43.10	39.26 - 46.93	40.09	35.62 - 44.56	0.3224
Senior high school completed	43.78	40.23 - 47.32	39.24	35.22 - 43.27	0.0974
College degree or above	33.81	30.35 - 37.26	27.71	24.87 - 30.54	0.0052
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	31.63	26.29 - 36.98	30.81	26.11 - 35.51	0.7085
Factory, business, service industry employee	41.63	38.18 - 45.08	35.96	32.03 - 39.9	0.0299
Not in the labor force ¹	39.96	36.97 - 42.95	34.64	30.97 - 38.30	0.0288
<i>Current smoking status</i>					
Yes	74.61	71.09 - 78.12	72.07	68.01 - 76.12	0.3518
No	29.38	26.63 - 32.13	23.15	20.45 - 25.85	0.0015

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

Adjusted odds ratios (ORs) of SHS exposure at workplaces, restaurants, and homes

As shown in Table 4, in 2018, urban adult residents from all five cities were significantly less likely to report SHS exposure in indoor workplaces (aOR=0.70, 95% CI: 0.57-0.86), in indoor areas of restaurants (aOR=0.63, 95% CI: 0.52-0.75), and at home (aOR=0.76, 95% CI: 0.63-0.93) compared to in 2015, controlling for biological sex, age, education, occupation, and current smoking status. Men were more likely to report SHS exposure in indoor workplaces (aOR=1.52, 95% CI: 1.32-1.76) and indoor areas of restaurants (aOR=1.24, 95% CI: 1.11-1.38), but less likely to report SHS exposure at home (aOR=0.59, 95% CI: 0.51-0.68) than women controlling for survey year, age, education, occupation, and current smoking status. Compared with adults aged 65 years or above, adults in younger age groups were more likely to report SHS exposure in indoor areas of restaurants and at home. In addition, adults with higher education levels were less likely to report SHS exposure in restaurants and homes compared to adults with primary school completed or below, controlling for survey year and other individual characteristics. Compared with government employees, teachers, or healthcare providers, people who worked in factories, businesses, and service industries were more likely to be exposed to workplace SHS (aOR=1.49, 95% CI: 1.26-1.77), controlling for the survey year and other individual characteristics. In addition, after controlling for survey year and other individual characteristics, current smokers were found significantly more likely to be exposed to SHS than their current nonsmokers in indoor workplaces (aOR=2.20, 95% CI: 1.83-2.63), indoor areas of restaurants (aOR=1.88, 95% CI: 1.59-2.21), and at home (aOR=11.27, 95% CI: 9.62-13.20).

Table 4: Adjusted¹ odds ratios (ORs) between secondhand smoke (SHS) exposure and survey year, socio-demographic characteristics, and smoking status in indoor workplaces, indoor areas of restaurants, and homes in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Workplaces		Restaurants		Home	
	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>						
2015	Ref.		Ref.		Ref.	
2018	0.70	0.57 - 0.86	0.63	0.52 - 0.75	0.76	0.63 - 0.93
<i>Sex</i>						
Male	1.52	1.32 - 1.76	1.24	1.11 - 1.38	0.59	0.51 - 0.68
Female	Ref.		Ref.		Ref.	
<i>Age Group</i>						
15-24	1.80	0.81 - 3.98	1.15	0.91 - 1.45	2.06	1.67 - 2.55
25-44	1.65	0.76 - 3.60	1.31	1.08 - 1.59	1.25	1.04 - 1.50
45-64	1.87	0.86 - 4.05	1.35	1.10 - 1.65	1.21	1.05 - 1.40
65 and above	Ref.		Ref.		Ref.	
<i>Education</i>						
Primary school completed or below	Ref.		Ref.		Ref.	

Junior high school completed	0.65	0.45 - 0.94	1.02	0.82 - 1.26	0.82	0.69 - 0.96
Senior high school completed	0.62	0.43 - 0.88	0.93	0.75 - 1.16	0.77	0.65 - 0.91
College degree or above	0.49	0.33 - 0.72	0.91	0.73 - 1.14	0.52	0.43 - 0.63
<i>Occupation</i>						
Gov. employee, teacher, healthcare provider	Ref.		1.01	0.83 - 1.23	0.86	0.71 - 1.04
Factory, business, service industry employee	1.49	1.26 - 1.77	1.17	1.02 - 1.35	0.98	0.86 - 1.13
Not in the labor force ²			Ref.		Ref.	
<i>Current smoking status</i>						
Yes	2.20	1.83 - 2.63	1.88	1.59 - 2.21	11.27	9.62 - 13.20
No	Ref.		Ref.		Ref.	

¹ Multivariate logistic regression models were used to estimate the adjusted ORs, controlling survey year, sex, age, education, occupation, and current smoking status.

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

Discussion

This study analyzed data from two waves of citywide representative household surveys conducted before and after the implementation of the TFC initiative in five participating Chinese cities. Our study results showed that across all five Chinese cities, the rates of SHS exposure declined significantly in indoor workplaces, indoor areas of restaurants, and homes from 2015 to 2018. Compared with the overall levels of SHS exposure reported in the nationwide surveys,^{5,21} the decline of SHS exposure in indoor workplaces and indoor areas of restaurants was significantly larger in these five TFC cities (see the Supplemental Table 4), indicating the potential effectiveness of the TFC initiative in reducing SHS exposure in public indoor areas in large Chinese cities.

Our results also showed that the change of SHS exposure between 2015 and 2018 varied across population subgroups characterized by demographic and socioeconomic characteristics and smoking status. For example, although the SHS exposure in indoor areas of restaurants did not change among adult urban residents with primary school completed or below between 2015 and 2018, it decreased significantly for those with higher education levels during the same period. The subgroup analysis in our study revealed important variations in SHS exposure that were not reported by previous national surveys, which only reported SHS exposure at the national level.

In addition, our study found that the associations between SHS exposure and individual characteristics varied by venues, which contributes to the existing literature that has so far focused primarily on SHS exposure in homes and in all public indoor areas in China. Our analyses reveal that although, in general, being younger, having lower levels of education, and being current smokers were

1
2
3 associated with higher rates of SHS exposure, which were consistent with the findings from previous
4 studies, the strengths of the associations were different at different venues. For example, participants with
5 higher education levels were less likely to report SHS exposure in indoor workplaces and homes
6 compared with participants with primary school completed or below; however, this association was not
7 significant in indoor areas of restaurants.
8
9
10

11 Furthermore, our study found that men were significantly more likely to be exposed to SHS than
12 women in workplaces and restaurants, but less likely to be exposed at home, controlling for survey year
13 and other individual characteristics. Previous studies also indicated that men were more likely to be
14 exposed to SHS generally,²³ but women were more likely to be exposed to SHS at home.²⁴ Given the
15 disproportional high smoking prevalence among men in China (about 50% for men and 2% for women),⁵
16 these findings suggested men were the major sources of household SHS for most homes. Men who smoke
17 at home expose the entire family to harmful SHS. Therefore, we would expect a further decline in SHS
18 exposure at home if smoking cessation programs could help male smokers quit smoking.
19
20
21
22
23

24 It is worth noting that compared with people who were government employees, teachers, and
25 healthcare providers, people who worked in factories, businesses, and service industries were found to be
26 more likely to be exposed to SHS at workplaces, controlling for the survey year and other individual
27 characteristics. This difference, which was not identified by previous studies, could be partially attributed
28 to the implementation of national-level policies of smoke-free government buildings, smoke-free
29 healthcare facilities, and smoke-free schools.^{4 5 21}
30
31
32
33
34

35 Our study provided empirical evidence that comprehensive tobacco control programs, such as the
36 TFC initiative, which included implementing smoke-free policies, health education/mass media
37 campaigns, and cessation interventions, could help reduce SHS exposure in indoor public places,
38 specifically, in workplaces and restaurants. Comprehensive and sustainable tobacco control programs are
39 needed to reduce SHS exposure in China.^{25 26} China ratified the WHO Framework Convention on
40 Tobacco Control (FCTC) in 2005,²⁷ which required universal protection of public SHS exposure.²⁸
41 However, to date, China still does not have nationwide comprehensive smoke-free air policy to prevent
42 SHS exposure in public areas. In cities where smoke-free policies have been adopted, the strengths of
43 policies and the enforcement of such policies varied significantly across different regions in China.^{29 30} In
44 addition, the prevalence of smoking and SHS exposure are still alarmingly high among certain population
45 subgroups. The findings of our study indicated that cities could play an important role in local tobacco
46 control and protect their residents from the harm of SHS through adopting citywide tobacco control
47 policies and programs, and strengthening their enforcement when national regulations are absent.
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 Our study has limitations. First, the associations between SHS exposure and individual level
4 characteristics were estimated based on data from surveys conducted in five participating cities, therefore,
5 the results may not be generalized to other cities or rural areas in China. Second, smoking status and SHS
6 exposure at three venues were self-reported, which may suffer from recall bias and social desirability
7 bias, and undermine the validity of study findings.^{31 32} In addition, since the data we used were from
8 pooled cross-sectional surveys, we could not estimate changes of SHS exposure before and after the
9 implementation of the TFC initiative at the individual level.
10
11
12
13

14
15 Despite these limitations, our study provides strong evidence to support the need to adopt
16 citywide comprehensive tobacco control programs in Chinese cities without such programs, which
17 include adopting smoke-free policies in public venues, encouraging smoke-free homes, implementing
18 targeted media and education campaigns, and offering cessation interventions to smokers.
19
20
21
22

23 **Conclusion**

24
25 The SHS exposure in indoor workplaces, restaurants, and homes decreased significantly in five
26 large Chinese cities that have implemented the TFC initiative between 2015 and 2018. The TFC initiative
27 activities include citywide smoke-free policies in public indoor venues, targeted media and education
28 campaigns, and cessation interventions effort to help smokers quit. Exposure to SHS in China can be
29 further reduced by expanding the TFC initiative to other Chinese cities without comprehensive tobacco
30 control programs.
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

References

1. US Department of Health and Human Services. The health consequences of smoking—50 years of progress: a report of the Surgeon General: Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, 2014.
2. US Department of Health and Human Services. The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General: Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, 2006.
3. Prevention and Health Promotion (US), Office on Smoking and Health (US). How tobacco smoke causes disease: the biology and behavioral basis for smoking-attributable disease: a report of the Surgeon General: US Government Printing Office 2010.
4. Yang G, Wang Y, Wu Y, et al. The road to effective tobacco control in China. *The Lancet* 2015;385(9972):1019-28.
5. China Center of Disease Control and Prevention. Global Adult Tobacco Survey Fact Sheet - China 2018 [cited 2020 Feb 20]. Available from: https://www.who.int/docs/default-source/wpro---documents/countries/china/2018-gats-china-factsheet-cn-en.pdf?sfvrsn=3f4e2da9_2.
6. Nan Y, Xi Z, Yang Y, et al. The 2015 China Adult Tobacco Survey: exposure to second-hand smoke among adults aged 15 and above and their support to policy on banning smoking in public places. *Zhonghua liu xing bing xue za zhi= Zhonghua liuxingbingxue zazhi* 2016;37(6):810-15.
7. Fong GT, Sansone G, Yan M, et al. Evaluation of smoke-free policies in seven cities in China, 2007–2012. *Tobacco control* 2015;24(Suppl 4):iv14-iv20.
8. Ye X, Yao Z, Gao Y, et al. Second-hand smoke exposure in different types of venues: before and after the implementation of smoke-free legislation in Guangzhou, China. *BMJ open* 2014;4(2)
9. Zheng P, Berg CJ, Kegler MC, et al. Smoke-free homes and home exposure to secondhand smoke in Shanghai, China. *International journal of environmental research and public health* 2014;11(11):12015-28.
10. Yang G. Tobacco Control in China: Springer 2018.
11. Koplan J, Redmon P, Duan Y, et al. The role of cities in reducing smoking in China. *Annals of Global Health* 2015;1(81):36.
12. Group GATSC. Tobacco questions for surveys: A subset of key questions from the Global Adult Tobacco Survey (GATS): Centers for Disease Control and Prevention Atlanta, GA, 2011.
13. Yu S, Duan Z, Redmon PB, et al. mHealth intervention is effective in creating smoke-free homes for newborns: A randomized controlled trial study in China. *Scientific Reports* 2017;7(1):1-9.
14. Yang L, Tong EK, Mao Z, et al. A clustered randomized controlled trial to reduce secondhand smoke exposure among nonsmoking pregnant women in Sichuan Province, China. *Nicotine & Tobacco Research* 2016;18(5):1163-70.
15. Stillman F, Navas-Acien A, Ma J, et al. Second-hand tobacco smoke in public places in urban and rural China. *Tobacco control* 2007;16(4):229-34.
16. Xia C, Zheng R, Zeng H, et al. Provincial-level cancer burden attributable to active and second-hand smoking in China. *Tobacco control* 2019;28(6):669-75.
17. Duan Z. Smoking behaviors, implementation of smoke-free policy and determinants among hotel and restaurant employees in Hangzhou, China. Emory University, 2014.

- 1
- 2
- 3
- 4 18. The Global Adult Tobacco Survey (GATS): sample design and related methods. Proceedings of the Section on Survey Methods, Joint Statistical Meetings Alexandria: American Statistical Association; 2010.
- 5
- 6 19. Huang J, Duan Z, Wang Y, et al. Use of Electronic Nicotine Delivery Systems (ENDS) in
- 7 China: Evidence from Citywide Representative Surveys from Five Chinese Cities in
- 8 2018. *International Journal of Environmental Research and Public Health*
- 9 2020;17(7):2541.
- 10
- 11 20. Redmon P, Huang J, Duan Z, et al. Secondhand Smoke (SHS) Exposure and Perceived
- 12 Health Risks of Tobacco Use among Urban Residents in Five Cities in China. *Annals of*
- 13 *Global Health* 2017;1(83):113-14.
- 14
- 15 21. Chinese Center for Disease Control and Prevention. 2015 China Adult Tobacco Survey
- 16 Report 2016 [Available from: [http://www.tcrc.org.cn/UploadFiles/2016-](http://www.tcrc.org.cn/UploadFiles/2016-03/318/201603231215175500.pdf)
- 17 [03/318/201603231215175500.pdf](http://www.tcrc.org.cn/UploadFiles/2016-03/318/201603231215175500.pdf) accessed March 28 2020.
- 18
- 19 22. Peugh JL, Enders CK. Missing data in educational research: A review of reporting practices
- 20 and suggestions for improvement. *Review of educational research* 2004;74(4):525-56.
- 21
- 22 23. Yang T, Jiang S, Barnett R, et al. Individual and city-level determinants of secondhand
- 23 smoke exposure in China. *International journal of health geographics* 2015;14(1):36.
- 24
- 25 24. Yao T, Sung H-Y, Mao Z, et al. Secondhand smoke exposure at home in rural China.
- 26 *Cancer Causes & Control* 2012;23(1):109-15.
- 27
- 28 25. Sansone G, Fong GT, Yan M, et al. Secondhand smoke exposure and support for smoke-
- 29 free policies in cities and rural areas of China from 2009 to 2015: a population-based
- 30 cohort study (the ITC China Survey). *BMJ open* 2019;9(12)
- 31
- 32 26. Zhao J, Li X, Stewart SL, et al. Cigarette smoking and secondhand smoke exposure before
- 33 and after a tobacco-free Olympic policy period: Qingdao, China. *Nicotine and Tobacco*
- 34 *Research* 2019;21(11):1531-38.
- 35
- 36 27. World Health Organization. Tobacco in China [Available from:
- 37 <https://www.who.int/china/health-topics/tobacco> accessed Feb 20 2020.
- 38
- 39 28. World Health Organization. WHO framework convention on tobacco control: World Health
- 40 Organization 2003.
- 41
- 42 29. Lin H, Chang C, Liu Z, et al. Subnational smoke-free laws in China. *Tobacco induced*
- 43 *diseases* 2019;17
- 44
- 45 30. Wan X, Stillman F, Liu H, et al. Development of policy performance indicators to assess the
- 46 implementation of protection from exposure to secondhand smoke in China. *Tobacco*
- 47 *control* 2013;22(suppl 2):ii9-ii15.
- 48
- 49 31. Coughlin SS. Recall bias in epidemiologic studies. *Journal of clinical epidemiology*
- 50 1990;43(1):87-91.
- 51
- 52 32. Grimm P. Social desirability bias. *Wiley international encyclopedia of marketing* 2010
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

Funding

This work was supported by Pfizer, Inc. through a grant from the China Tobacco Control Partnership (grant numbers CON009013). The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. The content is solely the responsibility of the authors and does not necessarily represent the official view of Pfizer, Inc. or the China Tobacco Control Partnership.

Conflict of Interest

The authors declare no conflicts of interest.

Authors' Contributions

Conceptualization, J.H. and P.B.R.; methodology, J.H., Z.D. and Y.W.; data collection, P.B.R.; formal analysis, Z.D. and Y.W.; writing—original draft preparation, Z.D. and Y.W.; writing—review and editing, J.H., Z.D., Y.W. and P.B.R.; project administration, M.E. and P.B.R.; funding acquisition, M.P.E. and P.B.R. All authors have read and agreed to the published version of the manuscript.

Data availability statement

De-identified study data can be accessed through a written request to the TFC initiative.

Acknowledgements

Technical assistance was provided by China CDC, Chengdu Institute of Health Education, Wuhan Institute of Health Education, Xiamen CDC, Xi'an Institute of Health Education, the ThinkTank Research Center for Health Development, and RTI International.

Supplemental Table 1. Description of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative and city-specific activities implemented from 2015 to 2018

City, (Population, GDP)	Smoke-Free Policy Goal (n or adoption date)	Policy Inspection Frequency	# of Media Mentions	Health Education/Mass Media Campaigns	Cessation Interventions
Chengdu (16 million, 1.39 trillion yuan)	SF government worksites (n=21) SF business worksites (n=15)	Every 2 months	110	WNTD and CNY mass media campaigns; PSAs on subways; city educational events	Cessation training for healthcare workers
Chongqing (30.75 million, 1.95 trillion yuan)	SF government worksites (n=1500) SF business worksites (n=2)	Twice per year	132	WNTD and CNY mass media campaigns; PSAs on TV and outdoor media outlets	Cessation counseling at two large businesses
Wuhan (10.89 million, 1.34 trillion yuan)	SF government worksites (n=106) SF business worksites (190) SF campus (n=38)	Monthly	102	WNTD and CNY mass media campaigns; PSAs on subways; city educational websites; knowledge competitions via WeChat	Citywide cessation completion; cessation hotline
Xi'an (9.06 million, 746.69 billion)	SF public places (August 2018); effective November 2018 SF business (n=65) SF homes (n=2200) SF government worksites (n=33)	Quarterly	263	WNTD and CNY mass media campaigns; PSAs on subways; citywide “no butts fall to the ground, Xian is beautiful” campaign	Free cessation clinics; citywide cessation competition
Xiamen (4.1 million, 435 billion yuan)	SF business worksites (n=86) SF scenery districts, including a UNESCO site(n=3)	Twice per year	116	WNTD and CNY mass media campaigns; SF business awards ceremonies	Cessation services provided to SF government and business workers

Abbreviations: World No Tobacco Day (WNTD); Chinese New Year (CNY); Public Service Announcements (PSA)

Supplemental Table 2: Sample size, response rate, and survey date for each of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative, 2015 and 2018

Locations	Number of Interviews			Response Rate ¹	Survey Date
	Overall	Male	Female		
2015					
Chengdu	1,946	903	1,043	89.6%	Feb 2016 - Mar 2016
Chongqing	1,852	843	1,009	79.8%	Oct 2015 - Nov 2015
Wuhan	2,163	1,018	1,145	98.3%	Oct 2015 - Dec 2015
Xiamen	2,174	1,055	1,119	92.5%	Oct 2015 - Jan 2016
Xi'an	2,049	962	1,087	89.4%	Nov 2015 - Feb 2016
2018					
Chengdu	1,913	876	1,037	93.5%	Feb 2018 - April 2018
Chongqing	1,813	832	981	90.8%	Sep 2017 - Nov 2017
Wuhan	2,251	1,158	1,093	97.8%	Dec 2017 - Jan 2018
Xiamen	2,116	1,121	995	89.7%	April 2018 - May 2018
Xi'an	2,123	1,092	1,031	87.2%	June 2018 - July 2018

¹ Overall response rate is a product of household response rate and individual response rate

Supplemental Table 3. Demographic characteristics of adult urban residents in all five Chinese cities participated in the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Demographic Characteristics	2015 (N=10184)		2018 (N=10233)	
	n	%	n	%
Sex				
Male	4781	51.58	4897	50.75
Female	5403	48.42	5336	49.25
Age (Years)				
15-24	940	18.97	840	20.37
25-44	4222	40.84	4124	39.44
45-64	3354	29.73	3539	29.72
65 and above	1668	10.45	1730	10.47
Education Level				
Primary school completed or below	1626	10.86	1325	9.39
Junior high school completed	2317	22.12	2265	20.51
Senior high school completed	2825	30.08	2821	28.15
College degree or above	3304	36.95	3759	41.95
Occupation				
Government employee, teacher, healthcare provider	972	10.69	1080	11.47
Factory, business, service industry employee	4358	45.63	3795	37.84
Not in the labor force ¹	4773	43.68	5231	50.69
Current smoking status				
Yes	2275	22.75	2339	23.36
No	7909	77.25	7885	76.64

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 4 Secondhand smoke (SHS) exposure in indoor workplaces, indoor areas of restaurants and homes in 2015 and 2018 nationwide in China and in the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative

	Indoor workplace			Indoor Restaurants			Home		
	2015	2018	% change	2015	2018	% change	2015	2018	% change
CATS ¹	54.3	50.9	6.3%	76.3	73.3	3.9%	57.1	44.9	21.4%
TQS ²	49.6	41.2	16.9%	72.4	61.7	14.7%	39.8	34.7	12.9%

¹ CATS, China Adult Tobacco Survey, conducted in 2015 and 2018, consisted of a representative sample of adults in China.

² TQS, Tobacco Questions for Survey, conducted in 2015 and 2018 in the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative consisted of a representative sample of adult urban residents in these five cities.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5, 6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6, 7
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6, 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7
		(e) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	8,9,10,11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8,9,10,11,12,13
		(b) Report category boundaries when continuous variables were categorized	8,9,10,11,12,13
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13,14,15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities (TFC) initiative in five Chinese cities: a pooled cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044570.R1
Article Type:	Original research
Date Submitted by the Author:	16-Nov-2020
Complete List of Authors:	Duan, Zongshuan; Georgia State University, School of Public Health Wang, Yu; Georgia State University, School of Public Health Huang, Jidong; Georgia State University, School of Public Health Redmon, Pamela; Emory University, Global Health Institute Eriksen, Michael ; Georgia State University, School of Public Health
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health policy, Epidemiology, Smoking and tobacco
Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 **Secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities**
4 **(TFC) initiative in five Chinese cities: a pooled cross-sectional study**
5

6 Zongshuan Duan¹, Yu Wang¹, Jidong Huang^{1*}, Pamela B. Redmon², Michael P. Eriksen¹
7
8

9 ¹ School of Public Health, Georgia State University, Atlanta, GA, 30303, USA

10 ² Global Health Institutes, Emory University, Atlanta, GA, 30322, USA
11
12
13
14
15
16
17
18

19 *Corresponding Author:

20 Jidong Huang, Ph.D. Associate Professor

21 Department of Health Policy & Behavioral Sciences

22 School of Public Health

23 Georgia State University

24 Urban Life Building, Suite 859

25 140 Decatur Street, Atlanta, GA 30303

26 Email: jhuang17@gsu.edu

27 Office Phone: 404-413-9337
28
29
30
31
32

33 Type of Submission: Original research

34 Word Count: 4,247

35 Number of Tables/Figures: 5

36 Number of Supplemental Tables: 12
37
38
39
40
41
42

43 **Keywords:** secondhand smoke exposure, SHS, Tobacco Free Cities, TFC, tobacco control, China, city
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Objectives: To assess the levels of secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities (TFC) initiative.

Design: Citywide representative, cross-sectional surveys (Tobacco Questions for Surveys, TQS) were conducted in each participating city before and after the implementation of TFC.

Setting: Five large Chinese cities (Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an) participated in the TFC initiative.

Participants: A total of 10,184 adults participated in the 2015 TQS survey, and 10,233 adults participated in the 2018 TQS survey, respectively.

Interventions: The TFC initiative, which included targeted media campaigns, educational programs, implementing citywide smoke-free policies, and providing cessation interventions, was implemented in these five cities between 2015-2018.

Main outcome: Self-reported past-30-day (P30D) SHS exposure in indoor workplaces, restaurants, and homes.

Data analysis: The pre- and post-TFC SHS exposure levels were compared among all residents and among certain population subgroups. Multivariate logistic regressions were used to estimate the adjusted associations between P30D SHS exposure and individual characteristics.

Results Across all five cities, the overall rate of self-reported P30D SHS exposure declined in indoor workplaces (from 49.6% (95% CI: 46.4%-52.8%) to 41.2% (95% CI: 37.7%-44.7%)), restaurants (from 72.4% (95% CI: 69.8%-74.9%) to 61.7% (95% CI: 58.7%-64.7%)), and homes (from 39.8% (95% CI: 36.9%-42.7%) to 34.7% (95% CI: 31.5%-37.8%)) from 2015 to 2018. These declines were statistically significant after controlling for individual characteristics. The P30D SHS exposure was associated with sex, age, education level, occupation, and current smoking status. The associations varied by venues.

Conclusions Our analysis showed that compared with the nationwide SHS exposure levels reported in concurrent national surveys, the declines in P30D SHS exposure in five Chinese cities implemented the TFC initiative were larger in indoor workplaces and restaurants. Our findings suggest that the TFC initiative was effective in reducing SHS exposure in Chinese cities.

Strengths and limitations of this study

- Multistage sampling method was applied to select a citywide representative sample of adults (aged 15 and above) for each of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative.
- Tobacco Questions for Surveys (TQS) were administered to the study sample in each city to assess the levels of secondhand exposure (SHS) in workplaces, restaurants, and homes before and after the implementation of the TFC initiative.
- The pre- and post-TFC SHS exposure levels were compared among all adult city residents, as well as among certain population subgroups, using multivariate logistic regressions controlling for individual characteristics.
- Limitations of this study included self-reported smoking status and SHS exposure, which may be subject to recall bias and social desirability bias, and the inability to estimate the SHS exposure changes before and after the implementation of the TFC initiative at the individual level using pooled cross-sectional surveys.
- The associations between SHS exposure and individual level characteristics reported in this study may not be generalized to other cities or rural areas in China.

Introduction

Secondhand smoke (SHS) exposure is a major preventable cause of diseases for infants, children, and nonsmoking adults.¹⁻³ It has been well documented that there is no risk-free level of exposure to SHS.² As the largest tobacco consumption country in the world, China has more than 300 million smokers, exposing an estimated 740 million people to harmful environmental tobacco smoke.⁴ According to the findings from a cross-country comparison of past-30-day (P30D) SHS exposure among adults in 14 countries (Bangladesh, Brazil, China, Egypt, India, Mexico, Philippines, Poland, Russia, Thailand, Turkey, Ukraine, Uruguay, and Vietnam), China had the highest rates of P30D SHS exposure in indoor workplaces (63.3%) and restaurants (88.5%) in 2010.^{5,6} In addition, the rate of P30D exposure to SHS at home in China (67.3%) was the second highest among these 14 countries,⁵ resulting in more than 164 million children being exposed to SHS at home in 2010.⁷

Recent nationwide surveys showed that exposure to SHS had been declining in China over the last decade. For example, the China Adult Tobacco Survey (CATS) found that from 2015 to 2018, the P30D SHS exposure in indoor places had declined, particularly in homes (57.1% to 44.9%), workplaces (54.3% to 50.9%), government buildings (38.1% to 31.1%), healthcare facilities (36.8% to 24.4%), restaurants (76.3% to 73.3%), and public transportation (16.4% to 12.9%).^{8,9} Previous studies indicated that the decline in SHS exposure in China was likely due to the implementation of smoke-free air policies in public places in recent years.^{10,11} In 2013, the Chinese Central government issued a notice prohibiting government officials smoking in public to set an example for all to follow.^{4,12} In 2014, the Ministry of Education and the National Health Commission (now National Health and Family Planning Commission) issued directives for all schools and healthcare facilities in China to become 100% smoke-free.^{4,12} To date, more than 20 largest Chinese cities, including Beijing, Shanghai, Shenzhen, and Xi'an, have adopted citywide smoke-free air policies.⁸

Despite progress in smoke-free legislation and tobacco control efforts, to date, there is still no comprehensive smoke-free air laws at the national level in China. The 2015 CATS estimated that more than half (54.3%) of adults who worked indoors were still exposed to tobacco smoke at their workplaces, and more than 500 million adults were exposed to SHS at home.¹³ Even in cities where smoke-free air policies have been adopted, the strengths and enforcement of these policies varied significantly at local level.^{14,15} To support Chinese cities to develop effective, comprehensive and sustainable tobacco control programs, researchers from Georgia State University (GSU) and China Centers for Disease Control and Prevention (China CDC) selected five Chinese cities to participate in the Tobacco Free Cities (TFC) initiative in 2015. The TFC initiative was a three-year program aimed to achieve the goal of creating cities where no tobacco use is the norm, by providing grant funds and experts' support to help the cities

1
2
3 implement best practice interventions, including adoption of tobacco-free policies, communication
4 strategies to increase knowledge on harms of tobacco use, and provision of cessation services.¹⁶ The
5 research team in GSU collaborated with the ThinkTank Research Center for Health Development, a
6 China-based non-governmental organization, the China CDC, and the National Health Commission to
7 identify a non-random sample of 10 potential cities for the TFC initiative in 2015. Five metropolitan cities
8 were selected based on population size, societal influence in China, local government support for tobacco
9 control efforts, and stage of readiness to take action to change social norms of tobacco use in their city.
10 These five cities selected were Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an. None of these five
11 cities had citywide smoke-free air policies at the time of selection. The population size of these five
12 participating cities ranged from about 4 million in Xiamen to about 30 million in Chongqing (see the
13 Supplemental Table 1 for detail).
14
15
16
17
18
19
20

21 This study aims to conduct a preliminary assessment of the effectiveness of the TFC initiative in
22 reducing SHS exposure in indoor areas. Studies using the International Tobacco Control (ITC) data
23 indicated that partial smoke-free air policies had minimal impact on reducing SHS exposure in indoor
24 workplaces, restaurants, and bars in China.^{10 17} Although a few small randomized controlled trials had
25 demonstrated the effectiveness of tobacco control intervention programs in reducing SHS exposure in
26 China,^{18 19} the evidence on the effectiveness of citywide tobacco control activities in reducing SHS
27 exposure in China is scarce. In addition, because smoking behavior and its determinants may differ
28 considerably between urban and rural areas in China, the overall SHS exposure status at the national level
29 may mask the differences across regions and population subgroups.^{20 21} Importantly, due in part to a lack
30 of representative, citywide data on SHS exposure in China, very little is known about SHS exposure in
31 large cities, where the population is more concentrated than small cities and rural areas, and SHS
32 exposure may be more pronounced. One study using the ITC data from seven cities and five rural areas of
33 China found that from 2009 to 2015, there were no significant differences in SHS exposure between
34 smokers and non-smokers except that SHS exposure among smokers was higher than among non-smokers
35 in rural workplaces.¹⁷
36
37
38
39
40
41
42
43
44

45 This study is designed to enrich the literature by examining the level of SHS exposure in indoor
46 workplaces, indoor areas of restaurants, and at home in five large Chinese cities before and after the
47 implementation of the TFC initiative in those cities. This study also investigates the potential differences
48 in SHS exposure across population subgroups. It was hypothesized that the decline in SHS exposure at
49 workplaces, restaurants, and homes between 2015 and 2018 would be more pronounced in these five
50 cities with the TFC initiative, compared with the nationwide trend. In addition, the SHS exposure was
51
52
53
54
55
56
57
58
59
60

1
2
3 hypothesized to vary among population subgroups characterized by socio-demographic factors and
4 smoking status.
5

6 **Methods**

7 **Study design and survey participants**

8
9
10
11 The TFC initiative was implemented in the five selected cities, i.e. Chengdu, Chongqing, Wuhan,
12 Xiamen, and Xi'an, from 2015 to 2018.¹⁶ During this period, these cities executed activities, including
13 implementing citywide and sector-wide smoke-free polices, launching health education interventions and
14 mass media campaigns, and providing cessation interventions for smokers who want to quit (see the
15 Supplemental Table 1 for a detailed list of tobacco control activities in each city). Two citywide
16 representative household surveys were conducted in each city, one before the TFC initiative and the
17 second one after the TFC initiative, by the local municipal health department under the supervision of the
18 China CDC. The surveys assessed tobacco use, exposure to secondhand smoke (SHS) and knowledge,
19 attitudes, and beliefs towards various tobacco and nicotine products, using the Tobacco Questions for
20 Surveys (TQS) questionnaire. TQS was a subset of key questions adapted from the Global Adult Tobacco
21 Survey (GATS), developed by the World Health Organization (WHO) and the US Centers for Disease
22 Control and Prevention (US CDC).²²
23
24
25
26
27
28
29

30
31 The first TQS survey was conducted from October 2015 to March 2016 (data were collected
32 mainly in 2015, referred to as TQS 2015 below), and the second TQS survey was conducted from
33 November 2017 to March 2018 (data were collected mainly in 2018, referred to as TQS 2018 below) (see
34 a detailed timeline in Supplemental Table 2). Participants were recruited using a household-based,
35 multistage cluster sampling scheme designed to represent non-institutionalized adults (defined as age 15
36 and above at the survey time) residing in urban areas of these five cities, based on the principles outlined
37 in the GATS Sample Design Manual.²³ Detailed sampling procedures and weight calculations were
38 described in previously published studies.^{24,25} The household surveys were conducted through indoor
39 face-to-face interviews using handheld computer-assisted devices to reduce measurement errors. These
40 surveys were approved by the local IRB of each city's municipal health department. Written informed
41 consent was obtained from all participants. A total of 10,184 participant completed the household survey
42 in 2015/2016, and 10,233 participants completed the survey in 2017/2018. The response rate and sample
43 size overall and for each city were listed in Supplemental Table 2. Secondary data analyses were
44 approved by the GSU IRB.
45
46
47
48
49
50
51
52

53 **Measures and variables**

54 *Outcomes*

1
2
3 Primary outcome variables in this study were self-reported P30D SHS exposure status in indoor
4 areas of workplaces, restaurants, and homes. All study participants were asked whether they usually
5 worked indoors. Participants who responded “yes” were then asked whether they had noticed anyone
6 (including themselves) smoking in indoor areas of workplaces in the past 30 days. In addition, all
7 participants were asked whether they had visited any restaurants in the past 30 days, and if so, whether
8 they had observed anyone (including themselves) smoking inside any of the restaurants they visited in the
9 past 30 days. Finally, all participants were asked whether anyone (including themselves) had smoked in
10 their homes in the past 30 days.
11
12
13
14
15

16 *Current tobacco smoking status*

17
18 Participants were asked whether they were currently using any smoking tobacco products,
19 including cigarettes, cigars, and pipes, daily, occasionally, or not at all. Participants who were currently
20 using smoking tobacco products daily or occasionally were categorized as current smokers. Participants
21 who were not using any smoking tobacco products at all were categorized as current nonsmokers.
22
23
24

25 *Demographic characteristics*

26
27 Demographic variables included biological sex, age, highest education level, and occupation type.
28 Age was categorized into 15-24, 25-44, 45-64, and 65 years and older. Education was categorized into
29 primary school completed or below, junior high school completed, senior high school completed, and
30 college degree or above. The occupation was categorized into “government employee, teacher, healthcare
31 provider,” “factory, business, agriculture, and service industry employee,” and “not in the labor force,”
32 which included the unemployed, students, homemakers, and retired. The TQS survey grouped
33 “Government employee, teacher, healthcare provider” into one single category because most schools and
34 hospitals in China are government owned. On the contrary, “factory, business, agriculture, and service
35 industry employees” are generally considered to be working in the private sector in China. The rationale
36 for this grouping method was because existing smoke-free policies in China were generally implemented
37 in government buildings, schools, and hospitals.¹⁶ The categorization of individual characteristics and the
38 grouping method for occupation were consistent with the method used in other national level surveys in
39 China, such as the 2015 and 2018 China Adult Tobacco Survey (CATS).^{8 13}
40
41
42
43
44
45
46
47

48 *Data Analyses*

49
50 SAS® 9.4 (SAS Institute, Cary, NC, USA) was used for data analyses. Complex sampling
51 procedures were accounted for in analyses by using the survey procedures in SAS. Invalid answers, i.e.,
52 “I don’t know” and “Refused”, were coded as missing. The main resources of missing data were outcome
53 variables (about 2% of respondents with missing values for SHS exposure at each venue) and self-
54
55
56
57
58
59
60

1
2
3 reported occupation types (about 1% of respondents with missing values). The proportion of respondents
4 with missing values on any key variable included in data analyses for each venue was less than 5%. We
5 assumed that missing was at random (MCR) and used pairwise deletion to handle missing values.²⁶ We
6 estimated the percentages and 95% confidence intervals (CIs) of urban adult residents who had been
7 exposed to SHS in the past 30 days at selected venues, in total and by demographic characteristics,
8 including biologic sex, age, education, occupation, and current smoking status. The Rao-Scott Chi-Square
9 test was used to check the unadjusted associations between P30D SHS exposure and survey years in total
10 and by demographic characteristics. In addition, multivariate logistic regression was used to estimate the
11 adjusted associations between P30D SHS exposure and survey years, controlling for demographic
12 characteristics, including age, gender, education, occupational status, and smoking status.
13
14
15
16
17
18

19 Patient and public involvement

20
21 This study was done without patient involvement. The target population of TQS was non-
22 institutionalized adults residing in urban areas of the five participating Chinese cities.
23
24
25
26

27 Results

28 Demographic characteristics and smoking status

29
30 Among urban adult residents in all five participating cities, in 2015, about 11% of them
31 completed primary school or below, and 37% had a college degree or above. Approximately 11% worked
32 as government employees, teachers, or healthcare providers, and 44% were not in the labor force. In
33 2018, approximately 9% completed primary school or below, and 42% had a college degree or above.
34 There were about 11% of adult residents working as government employees, teachers, or healthcare
35 providers, and more than half of them (51%) were not in the labor force. Approximately 23% of them
36 were current smokers in 2015 and 2018. (Supplemental Table 3)
37
38
39
40
41
42

43 P30D SHS exposure in indoor workplaces

44
45 As shown in Table 1, 4,710 and 5,011 respondents usually worked indoors and reported P30D
46 SHS exposure status in 2015 and 2018, respectively. The overall P30D SHS exposure in indoor
47 workplaces decreased from 49.6% (95% CI: 46.4%-52.8%) in 2015 to 41.2% (95% CI: 37.7%-44.7%) in
48 2018 ($p=0.0003$). In 2015, 58.3% (95% CI: 54.5%-62.0%) of men and 39.2% (95% CI: 35.8%-42.7%) of
49 women reported P30D SHS exposure, while 49.2% (95% CI: 45.1%-53.2%) of men and 32.2% (95% CI:
50 28.4%-36.0%) reported P30D SHS exposure in their indoor workplaces in 2018 ($p=0.0007$ and $p=0.0055$
51 for men and women, respectively). Regarding age, the rate of P30D SHS exposure was the highest among
52
53
54
55
56
57
58
59
60

adults aged 45 to 64 years old in 2015 and 2018. From 2015 to 2018, the decline in P30D SHS exposure was statistically significant for adults aged 25 to 44 years old (47.9%, 95% CI: 44.4%-51.4% vs. 41.2%, 95% CI: 37.4%-45.0%, $p=0.0086$) and 45 to 64 years old (58.6%, 95% CI: 53.9%-63.3% vs. 46.9%, 95% CI: 42.0%-51.8%, $p=0.0005$). Exposure to SHS followed a gradient, i.e., exposure decreases as education levels increase, in both 2015 and 2018 surveys. The decline in P30D SHS exposure was statistically significant for people with senior high school completed or above (51.5%, 95% CI: 46.8%-56.2% vs. 44.6%, 95% CI: 40.0%-49.1%, $p=0.0356$) and college degree or above (45.8%, 95% CI: 42.3%-49.3% vs. 37.2%, 95% CI: 33.1%-41.4%, $p=0.0012$). A significant decrease in the self-reported P30D SHS exposure was observed for both government employees, teachers, or healthcare providers and factory, business, and service industry employees. In 2015, 70.7% (95% CI: 66.0%-75.3%) of smokers and 42.8% (95% CI: 39.4%-46.1%) of nonsmokers reported exposed to SHS at their indoor workplace in the past 30 days, and the corresponding rates in 2018 significantly decreased to 63.6% (95% CI: 59.1%-68.1%) and 34.6% (95% CI: 31.0%-38.2%) for smokers and nonsmokers, respectively.

Table 1: P30D Secondhand smoke (SHS) exposure in indoor workplaces before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=4,710)		Year 2018 (N=5,011)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	49.61	46.37 - 52.85	41.24	37.74 - 44.74	0.0003
<i>Sex</i>					
Male	58.25	54.52 - 61.98	49.15	45.13 - 53.18	0.0007
Female	39.23	35.8 - 42.66	32.21	28.39 - 36.03	0.0055
<i>Age (Years)</i>					
15-24	44.83	39.31 - 50.35	37.34	31.34 - 43.34	0.0717
25-44	47.88	44.4 - 51.35	41.21	37.41 - 45.01	0.0086
45-64	58.58	53.87 - 63.3	46.88	42.01 - 51.75	0.0005
65 and above	41.66	20.05 - 63.26	25.39	16.05 - 34.74	0.1183
<i>Education Level</i>					
Primary school completed or below	64.16	54.51 - 73.8	52.85	42.17 - 63.53	0.1071
Junior high school completed	56.33	50.59 - 62.06	48.05	41.63 - 54.46	0.0511
Senior high school completed	51.47	46.76 - 56.17	44.57	40.02 - 49.11	0.0356
College degree or above	45.81	42.33 - 49.29	37.25	33.05 - 41.44	0.0012
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	39.39	33.96 - 44.82	30.43	24.89 - 35.97	0.0304
Factory, business, service industry employee	52.22	49.02 - 55.42	44.08	40.21 - 47.95	0.0003
<i>Current smoking status</i>					
Yes	70.65	65.99 - 75.31	63.59	59.06 - 68.12	0.0313

No	42.76	39.39 - 46.14	34.59	30.97 - 38.22	0.0007
----	-------	---------------	-------	---------------	--------

P30D SHS exposure in indoor areas of restaurants

As shown in Table 2, 6,576 and 6,878 respondents had visited any indoor areas of restaurant in the past 30 days and reported SHS exposure status in 2015 and 2018, respectively. The overall P30D SHS exposure in indoor areas of restaurants decreased significantly from 72.4% (95% CI: 69.8%-74.9%) in 2015 to 61.7% (95% CI: 58.7%-64.7%) in 2018 ($p<0.0001$). Both men and women reported significantly less exposure to SHS from 2015 to 2018 (for men, 77.4%, 95% CI: 74.8%-80.0% vs. 66.0%, 95% CI: 62.6%-69.4%, $p<0.0001$; for women: 66.3%, 95% CI: 63.0%-69.6% vs. 56.9%, 95% CI: 53.4%-60.3%, $p<0.0001$). In addition, the rate of reporting P30D SHS exposure in indoor areas of restaurants had declined significantly for people in age groups below 65 years old but remained the same (59.4%) for residents who were 65 years old or above from 2015 to 2018. In 2015, adults with primary school completed or below had the lowest rate (64.6%, 95% CI: 58.6%-70.7%) of reporting P30D SHS exposure in indoor areas of restaurants in 2015. However, this group reported the highest rate (69.9%, 95% CI: 64.0%-75.8%) in 2018. The rate of reporting P30D SHS exposure declined significantly in another three education level groups. In addition, respondents in all three occupation categories had experienced a significant decline in P30D SHS exposure in indoor areas of restaurants. In 2015, 83.6% (95% CI: 80.5%-86.6%) of current smokers and 68.6% (95% CI: 65.8%-71.4%) of current nonsmokers reported P30D SHS exposure in indoor areas of restaurants, and the rates significantly decreased to 74.3% (95% CI: 70.1%-78.5%) and 57.40% (95% CI: 54.2%-60.6%) in 2018 for current smokers and nonsmokers, respectively ($p<0.0001$ and $p=0.0002$, respectively).

Table 2: P30D Secondhand smoke (SHS) exposure in indoor areas of restaurants before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=6,576)		Year 2018 (N=6,878)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	72.37	69.81 - 74.92	61.70	58.66 - 64.74	<.0001
<i>Sex</i>					
Male	77.37	74.76 - 79.98	66.00	62.57 - 69.43	<.0001
Female	66.27	62.99 - 69.55	56.88	53.44 - 60.31	<.0001
<i>Age (Years)</i>					
15-24	71.56	67.35 - 75.76	55.37	50.74 - 59.99	<.0001

25-44	73.00	69.98 - 76.03	63.47	60.12 - 66.82	<.0001
45-64	74.56	71.21 - 77.91	64.80	60.21 - 69.38	0.0004
65 and above	59.40	54.2 - 64.59	59.36	52.74 - 65.98	0.9931
<i>Education Level</i>					
Primary school completed or below	64.63	58.59 - 70.67	69.92	64.04 - 75.79	0.2197
Junior high school completed	73.59	70.44 - 76.75	64.95	59.17 - 70.74	0.0074
Senior high school completed	73.37	70.03 - 76.7	61.10	57.44 - 64.75	<.0001
College degree or above	72.15	69.05 - 75.25	60.04	56.52 - 63.57	<.0001
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	71.71	66.38 - 77.04	58.8	52.5 - 65.11	0.0010
Factory, business, service industry employee	74.96	72.35 - 77.58	64.92	61.5 - 68.33	<.0001
Not in the labor force ¹	69.22	65.5 - 72.93	60.09	56.2 - 63.98	0.0008
<i>Current smoking status</i>					
Yes	83.55	80.48 - 86.62	74.33	70.13 - 78.54	<.0001
No	68.57	65.77 - 71.38	57.40	54.23 - 60.57	0.0002

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

P30D SHS exposure at home

As shown in Table 3, 9,943 and 10,086 respondents reported P30D SHS exposure status at home in 2015 and 2018, respectively. The overall exposure to SHS in the past 30 days at home decreased significantly from 39.8% (95% CI: 36.9%-42.7%) in 2015 to 34.6% (95% CI: 31.5%-37.8%) in 2018 ($p=0.0178$). The decline was only significant for women (34.7%, 95% CI: 31.6%-37.8% vs. 27.7%, 95% CI: 24.8%-30.6%, $p=0.0009$), not for men. Regarding age, the rate of self-reported P30D SHS exposure at home was found to be declining in all age groups, but the decline was statistically significant only among 25 to 44 years old age group (37.4%, 95% CI: 34.1%-40.7% vs. 31.9%, 95% CI: 28.0%-35.8%, $p=0.0327$). The rate of reporting P30D SHS exposure at home was found declining among urban residents of all education levels, but the decline was statistically significant only among residents with a college degree or above (33.8%, 95% CI: 30.4%-37.3% vs. 27.7%, 95% CI: 24.9%-30.5%, $p=0.0052$). The rate of self-reported P30D SHS exposure at home was lowest among government employees, teachers, or healthcare providers, and did not change significantly from 2015 to 2018 ($p=0.7085$). A significant decrease in the rate of reporting P30D SHS exposure at home was observed for adults working in factory, business, and service industry (41.6%, 95% CI: 38.2%-45.1% vs. 36.0%, 95% CI: 32.0%-39.9%, $p=0.0299$), and who were not in the labor force (40.0%, 95% CI: 37.0%-42.9% vs. 34.6%, 95% CI: 31.0%-38.3%, $p=0.0288$) from 2015 to 2018. During the same period, there was a statistically significant decline of reported P30D SHS exposure at home for current nonsmokers (29.4%, 95% CI: 26.6%-32.1% vs. 23.2%, 95% CI: 20.5%-25.8%, $p=0.0015$), the decline was not significant for current smokers.

Table 3: P30D Secondhand smoke (SHS) exposure at home before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=9,943)		Year 2018 (N=10,086)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	39.80	36.89 - 42.71	34.65	31.49 - 37.81	0.0178
<i>Sex</i>					
Male	44.58	41.19 - 47.97	41.36	37.37 - 45.35	0.2293
Female	34.73	31.65 - 37.8	27.70	24.82 - 30.58	0.0009
<i>Age (Years)</i>					
15-24	42.70	37.81 - 47.6	37.56	32.86 - 42.26	0.1412
25-44	37.40	34.06 - 40.73	31.87	27.97 - 35.78	0.0327
45-64	43.30	39.87 - 46.72	38.33	34.37 - 42.28	0.0627
65 and above	33.94	30.51 - 37.37	28.79	24.65 - 32.93	0.0612
<i>Education Level</i>					
Primary school completed or below	43.35	38.55 - 48.14	39.85	33.74 - 45.97	0.3936
Junior high school completed	43.10	39.26 - 46.93	40.09	35.62 - 44.56	0.3224
Senior high school completed	43.78	40.23 - 47.32	39.24	35.22 - 43.27	0.0974
College degree or above	33.81	30.35 - 37.26	27.71	24.87 - 30.54	0.0052
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	31.63	26.29 - 36.98	30.81	26.11 - 35.51	0.7085
Factory, business, service industry employee	41.63	38.18 - 45.08	35.96	32.03 - 39.9	0.0299
Not in the labor force ¹	39.96	36.97 - 42.95	34.64	30.97 - 38.30	0.0288
<i>Current smoking status</i>					
Yes	74.61	71.09 - 78.12	72.07	68.01 - 76.12	0.3518
No	29.38	26.63 - 32.13	23.15	20.45 - 25.85	0.0015

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

Adjusted odds ratios (ORs) of P30D SHS exposure at workplaces, restaurants, and homes

Table 4 presented adjusted odds ratios between SHS exposure and survey year, socio-demographic characteristics, and smoking status using multivariate logistic regressions. Urban adult residents from all five cities were significantly less likely to report P30D SHS exposure in indoor workplaces (aOR=0.70, 95% CI: 0.57-0.86), indoor areas of restaurants (aOR=0.63, 95% CI: 0.52-0.75), and at home (aOR=0.76, 95% CI: 0.63-0.93) in 2018 compared to in 2015. Men were more likely to report P30D SHS exposure in indoor workplaces (aOR=1.52, 95% CI: 1.32-1.76) and indoor areas of restaurants (aOR=1.24, 95% CI: 1.11-1.38), but less likely to report P30D SHS exposure at home (aOR=0.59, 95% CI: 0.51-0.68) than women. Compared with adults aged 65 years or above, adults in

1
2
3 younger age groups were more likely to report P30D SHS exposure in indoor areas of restaurants and at
4 home. In addition, adults with higher education levels were less likely to report P30D SHS exposure in
5 restaurants and homes compared to adults with primary school completed or below. Compared with
6 government employees, teachers, or healthcare providers, people who worked in factories, businesses,
7 and service industries were more likely to be exposed to workplace SHS in the past 30 days (aOR=1.49,
8 95% CI: 1.26-1.77). In addition, current smokers were found significantly more likely to be exposed to
9 SHS than their nonsmoking counterparts in indoor workplaces (aOR=2.20, 95% CI: 1.83-2.63), indoor
10 areas of restaurants (aOR=1.88, 95% CI: 1.59-2.21), and at home (aOR=11.27, 95% CI: 9.62-13.20) in
11 the past 30 days. Subgroup analyses results by sex and current smoking status were presented in
12 Supplemental Tables 4-9. Generally, there were no significant differences in SHS exposure changes
13 between men and women, and between current smokers and non-smokers, controlling for other
14 covariates. City-specific analyses results were presented in Supplemental Tables 10-12. Again, no
15 significant differences were found across cities in terms of SHS exposure changes between 2015 and
16 2018.

27
28 Table 4: Adjusted¹ odds ratios (ORs) between P30D secondhand smoke (SHS) exposure and survey year,
29 socio-demographic characteristics, and smoking status in indoor workplaces, indoor areas of restaurants,
30 and homes in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and
31 2018
32

Indicators	Workplaces (n=9,587)		Restaurants (n=13,239)		Home (n=19,712)	
	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>						
2015	Ref.		Ref.		Ref.	
2018	0.71	0.58 - 0.88	0.63	0.52 - 0.75	0.76	0.63 - 0.93
<i>Sex</i>						
Male	1.53	1.32 - 1.76	1.24	1.11 - 1.38	0.59	0.51 - 0.68
Female	Ref.		Ref.		Ref.	
<i>Age Group</i>						
15-24	1.77	0.79 - 3.98	1.15	0.91 - 1.45	2.06	1.67 - 2.55
25-44	1.62	0.73 - 3.60	1.31	1.08 - 1.59	1.25	1.04 - 1.50
45-64	1.85	0.84 - 4.07	1.35	1.10 - 1.65	1.21	1.05 - 1.40
65 and above	Ref.		Ref.		Ref.	
<i>Education</i>						
Primary school completed or below	Ref.		Ref.		Ref.	
Junior high school completed	0.65	0.45 - 0.95	1.02	0.82 - 1.26	0.82	0.69 - 0.96
Senior high school completed	0.62	0.44 - 0.89	0.93	0.75 - 1.16	0.77	0.65 - 0.91
College degree or above	0.50	0.34 - 0.74	0.91	0.73 - 1.14	0.52	0.43 - 0.63

Occupation

Gov. employee, teacher, healthcare provider	Ref.		1.01	0.83 - 1.23	0.86	0.71 - 1.04
Factory, business, service industry employee	1.56	1.32 - 1.85	1.17	1.02 - 1.35	0.98	0.86 - 1.13
Not in the labor force ²			Ref.		Ref.	

Current smoking status

Yes	2.21	1.84 - 2.65	1.88	1.59 - 2.21	11.27	9.62 - 13.20
No	Ref.		Ref.		Ref.	

¹ Multivariate logistic regression models were used to estimate the adjusted ORs, controlling survey year, sex, age, education, occupation, and current smoking status.

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

Discussion

This study analyzed data from two citywide representative household surveys conducted before and after the implementation of the TFC initiative in five participating Chinese cities. Our study results showed that across all five Chinese cities, the rates of P30D SHS exposure declined significantly in indoor workplaces, indoor areas of restaurants, and homes from 2015 to 2018. In addition, compared with the overall levels of P30D SHS exposure reported in the nationwide surveys over the same time period,^{8 13} the decline of P30D SHS exposure in indoor workplaces and indoor areas of restaurants was significantly larger in these five TFC cities (see Table 5), indicating the potential effectiveness of the TFC initiative in reducing SHS exposure in public indoor areas in large Chinese cities. This declining trend in SHS exposure in workplaces, restaurants, and homes in China was similar to those observed in other Asian countries that have adopted smoke-free policies over the past decade.²⁷ It is notable that the decrease in SHS exposure at home in our five study cities (from 39.8% to 34.7%) was less than that at the national level (from 57.1% to 44.9%) between 2015 and 2018, and that smoking prevalence did not change in these five cities from 2015 to 2018 despite the TFC initiative. Although these results were consistent with the hypothesis of substitution of smoking in public indoor places with home smoking because of the implementation of smoke-free policies at public indoor places,^{28 29} individual level longitudinal data are needed to examine whether prohibiting smoking in public indoor places had the unintended consequences of increasing smoking at home.

Table 5. Secondhand smoke (SHS) exposure in indoor workplaces, indoor areas of restaurants and homes in 2015 and 2018 nationwide in China and in the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative

Indoor workplace	Indoor Restaurants	Home
------------------	--------------------	------

	2015	2018	% change	2015	2018	% change	2015	2018	% change
CATS ¹	54.3	50.9	6.3%	76.3	73.3	3.9%	57.1	44.9	21.4%
TQS ²	49.6	41.2	16.9%	72.4	61.7	14.7%	39.8	34.7	12.9%

¹ CATS, China Adult Tobacco Survey, conducted in 2015 and 2018, consisted of a representative sample of adults in China.

² TQS, Tobacco Questions for Survey, conducted in 2015 and 2018 in the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative consisted of a representative sample of adult urban residents in these five cities.

Our results also showed that the change of P30D SHS exposure between 2015 and 2018 varied across population subgroups characterized by demographic and socioeconomic characteristics and smoking status. For example, although the P30D SHS exposure in indoor areas of restaurants did not change among adult urban residents with primary school completed or below between 2015 and 2018, it decreased significantly for those with higher education levels during the same period. Given that education level was positively correlated with socioeconomic status (SES), respondents with higher SES may be more likely to dine in the restaurants that were more likely to have smoke-free air policies, or the policies were better implemented/enforced. The subgroup analysis in our study revealed important variations in P30D SHS exposure that were not reported by previous national surveys, which only reported P30D SHS exposure at the national level.

In addition, our study found that the associations between P30D SHS exposure and individual characteristics varied by venues, which contributes to the existing literature that has so far focused primarily on SHS exposure in homes and in overall public indoor areas in China. Consistent with previous findings, our study also found that, in general, being younger, having lower levels of education, and being current smokers were associated with higher rates of SHS exposure.^{11 30 31} As discussed previously, age and education level were usually positively associated with income, or SES, therefore, younger respondents or respondents having lower levels of education may be more likely to work, dine, or live in places that had higher rates of smoking, hence more likely to be exposed to SHS. Smokers may be more likely to have peers who smoke, therefore exposing themselves to the SHS produced by their smoking peers. In addition, smokers would be exposed to SHS if they themselves smoked in workplaces, restaurants, and their homes. Our study further revealed that the strengths of the associations varied by venue. For example, the association between smoking status and SHS exposure at home was much stronger than in restaurants (aOR: 11.27 vs. 1.88). This may be due to the fact that home smoking restrictions are not common in China.^{32 33}

Furthermore, our study found that men were significantly more likely to be exposed to SHS than women in workplaces and restaurants, but less likely to be exposed at home, controlling for survey year

1
2
3 and other individual characteristics. Previous studies also indicated that men were more likely to be
4 exposed to SHS generally,³⁴ but women were more likely to be exposed to SHS at home.³⁵ Given the
5 disproportional high smoking prevalence among men in China (about 50% for men and 2% for women),⁸
6 these findings suggested that many married women in China were exposed to SHS at home because of
7 their smoking husbands. A decline in SHS exposure at home could be expected if more Chinese male
8 smokers quit smoking as China further strengthens its tobacco control policies.
9
10
11
12

13 It is worth noting that compared with people who were government employees, teachers, and
14 healthcare providers, people who worked in factories, businesses, and service industries were found to be
15 more likely to be exposed to SHS at workplaces, controlling for the survey year and other individual
16 characteristics. This difference, which was not identified by previous studies, could be partially attributed
17 to the implementation of national-level smoke-free policies in government buildings, healthcare facilities,
18 and schools.^{4 8 13}
19
20
21
22

23 Our study provided important evidence to support the implementation of tobacco control
24 interventions, such as the TFC initiative, which included implementing smoke-free policies, health
25 education/mass media campaigns, and cessation interventions. Our results show that these interventions
26 have the potential to reduce SHS exposure in indoor public places, such as workplaces and restaurants.
27 Although SHS exposure had decreased in China from 2015 to 2018, the prevalence of smoking among
28 men and SHS exposure of all population subgroups are still alarmingly high in China. China ratified the
29 WHO Framework Convention on Tobacco Control (FCTC) in 2005,³⁶ which required universal protection
30 of SHS exposure in public indoor places.³⁷ Unfortunately, to date, China still does not have nationwide
31 comprehensive smoke-free air policy to prevent SHS exposure in public indoor areas. In Chinese cities
32 where smoke-free policies have been adopted, the strengths of policies and the enforcement of such
33 policies varied significantly.^{14 15} The findings of our study indicated that, in the absence of a national level
34 smoke-free policy, cities can play an important role in local tobacco control and protect their residents
35 from the harm of SHS through adoption of comprehensive, strong, and well-enforced citywide tobacco
36 control policies and programs.
37
38
39
40
41
42
43
44

45 Our study has limitations. First, the associations between SHS exposure and individual level
46 characteristics were estimated based on data from surveys conducted in five participating cities, therefore,
47 our results may not be generalized to other cities or rural areas in China. Second, smoking status and SHS
48 exposure at three venues were self-reported, which may suffer from recall bias and social desirability
49 bias.^{38 39} In addition, since the data we used were from pooled cross-sectional surveys, we were not able to
50 estimate changes of SHS exposure before and after the implementation of the TFC initiative at the
51 individual level.
52
53
54
55
56
57
58
59
60

Conclusion

The P30D SHS exposure in indoor workplaces, restaurants, and homes decreased significantly in five large Chinese cities that implemented the TFC initiative between 2015 and 2018. The TFC initiative activities include citywide smoke-free policies in public indoor venues, targeted media and education campaigns, and cessation interventions effort to help smokers quit. Exposure to SHS in China can be further reduced by expanding the TFC initiative to other Chinese cities without comprehensive tobacco control policies/programs.

References

1. US Department of Health and Human Services. The health consequences of smoking—50 years of progress: a report of the Surgeon General: Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, 2014.
2. US Department of Health and Human Services. The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General: Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, 2006.
3. Prevention and Health Promotion (US), Office on Smoking and Health (US). How tobacco smoke causes disease: the biology and behavioral basis for smoking-attributable disease: a report of the Surgeon General: US Government Printing Office 2010.
4. Yang G, Wang Y, Wu Y, et al. The road to effective tobacco control in China. *The Lancet* 2015;385(9972):1019-28.
5. King BA, Mirza SA, Babb SD. A cross-country comparison of secondhand smoke exposure among adults: findings from the Global Adult Tobacco Survey (GATS). *Tobacco control* 2013;22(4):e5-e5.
6. Asma S. The GATS atlas: global adult tobacco survey. 2015
7. Mbulo L, Palipudi KM, Andes L, et al. Secondhand smoke exposure at home among one billion children in 21 countries: findings from the Global Adult Tobacco Survey (GATS). *Tobacco control* 2016;25(e2):e95-e100.
8. China Center of Disease Control and Prevention. Global Adult Tobacco Survey Fact Sheet - China 2018 [cited 2020 Feb 20]. Available from: https://www.who.int/docs/default-source/wpro---documents/countries/china/2018-gats-china-factsheet-cn-en.pdf?sfvrsn=3f4e2da9_2.
9. Nan Y, Xi Z, Yang Y, et al. The 2015 China Adult Tobacco Survey: exposure to second-hand smoke among adults aged 15 and above and their support to policy on banning smoking in public places. *Zhonghua liu xing bing xue za zhi= Zhonghua liuxingbingxue zazhi* 2016;37(6):810-15.
10. Fong GT, Sansone G, Yan M, et al. Evaluation of smoke-free policies in seven cities in China, 2007–2012. *Tobacco control* 2015;24(Suppl 4):iv14-iv20.
11. Ye X, Yao Z, Gao Y, et al. Second-hand smoke exposure in different types of venues: before and after the implementation of smoke-free legislation in Guangzhou, China. *BMJ open* 2014;4(2)
12. Yang G. Tobacco Control in China: Springer 2018.
13. Chinese Center for Disease Control and Prevention. 2015 China Adult Tobacco Survey Report 2016 [Available from: <http://www.tcrc.org.cn/UploadFiles/2016-03/318/201603231215175500.pdf> accessed March 28 2020.
14. Lin H, Chang C, Liu Z, et al. Subnational smoke-free laws in China. *Tobacco induced diseases* 2019;17
15. Wan X, Stillman F, Liu H, et al. Development of policy performance indicators to assess the implementation of protection from exposure to secondhand smoke in China. *Tobacco control* 2013;22(suppl 2):ii9-ii15.
16. Koplan J, Redmon P, Duan Y, et al. The role of cities in reducing smoking in China. *Annals of Global Health* 2015;1(81):36.
17. Sansone G, Fong GT, Yan M, et al. Secondhand smoke exposure and support for smoke-free policies in cities and rural areas of China from 2009 to 2015: a population-based cohort study (the ITC China Survey). *BMJ open* 2019;9(12)

18. Yu S, Duan Z, Redmon PB, et al. mHealth intervention is effective in creating smoke-free homes for newborns: A randomized controlled trial study in China. *Scientific Reports* 2017;7(1):1-9.
19. Yang L, Tong EK, Mao Z, et al. A clustered randomized controlled trial to reduce secondhand smoke exposure among nonsmoking pregnant women in Sichuan Province, China. *Nicotine & Tobacco Research* 2016;18(5):1163-70.
20. Stillman F, Navas-Acien A, Ma J, et al. Second-hand tobacco smoke in public places in urban and rural China. *Tobacco control* 2007;16(4):229-34.
21. Xia C, Zheng R, Zeng H, et al. Provincial-level cancer burden attributable to active and second-hand smoking in China. *Tobacco control* 2019;28(6):669-75.
22. Global Adult Tobacco Survey Collaborative Group. Tobacco questions for surveys: A subset of key questions from the Global Adult Tobacco Survey (GATS): Centers for Disease Control and Prevention. Atlanta, GA, 2011.
23. The Global Adult Tobacco Survey (GATS): sample design and related methods. Proceedings of the Section on Survey Methods, Joint Statistical Meetings Alexandria: American Statistical Association; 2010.
24. Huang J, Duan Z, Wang Y, et al. Use of Electronic Nicotine Delivery Systems (ENDS) in China: Evidence from Citywide Representative Surveys from Five Chinese Cities in 2018. *International Journal of Environmental Research and Public Health* 2020;17(7):2541.
25. Redmon P, Huang J, Duan Z, et al. Secondhand Smoke (SHS) Exposure and Perceived Health Risks of Tobacco Use among Urban Residents in Five Cities in China. *Annals of Global Health* 2017;1(83):113-14.
26. Peugh JL, Enders CK. Missing data in educational research: A review of reporting practices and suggestions for improvement. *Review of educational research* 2004;74(4):525-56.
27. US Centers for Disease Control and Prevention. Global Tobacco Surveillance System Data (GTSSData) [Available from: <https://www.cdc.gov/tobacco/global/gtss/gtssdata/index.html> accessed Nov 5 2020.
28. Adda J, Cornaglia F. The effect of bans and taxes on passive smoking. *American Economic Journal: Applied Economics* 2010;2(1):1-32.
29. Ho SY, Wang MP, Lo WS, et al. Comprehensive smoke-free legislation and displacement of smoking into the homes of young children in Hong Kong. *Tobacco Control* 2010;19(2):129-33.
30. Yao T, Sung H-Y, Mao Z, et al. Secondhand smoke exposure at home in rural China. *Economics of Tobacco Control in China: From Policy Research to Practice: World Scientific* 2016:29-42.
31. Jin Y, Wang L, Lu B, et al. Secondhand smoke exposure, indoor smoking bans and smoking-related knowledge in China. *International journal of environmental research and public health* 2014;11(12):12835-47.
32. Abdullah AS, Hua F, Xia X, et al. Second - hand smoke exposure and household smoking bans in Chinese families: a qualitative study. *Health & social care in the community* 2012;20(4):356-64.
33. Ji M, Ding D, Hovell MF, et al. Home smoking bans in an urbanizing community in China. *American journal of preventive medicine* 2009;37(2):132-36.
34. Yang T, Jiang S, Barnett R, et al. Individual and city-level determinants of secondhand smoke exposure in China. *International journal of health geographics* 2015;14(1):36.
35. Yao T, Sung H-Y, Mao Z, et al. Secondhand smoke exposure at home in rural China. *Cancer Causes & Control* 2012;23(1):109-15.
36. World Health Organization. Tobacco in China [Available from: <https://www.who.int/china/health-topics/tobacco> accessed Feb 20 2020.

- 1
- 2
- 3 37. World Health Organization. WHO framework convention on tobacco control: World Health
- 4 Organization 2003.
- 5 38. Coughlin SS. Recall bias in epidemiologic studies. *Journal of clinical epidemiology*
- 6 1990;43(1):87-91.
- 7 39. Grimm P. Social desirability bias. *Wiley international encyclopedia of marketing* 2010
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31
- 32
- 33
- 34
- 35
- 36
- 37
- 38
- 39
- 40
- 41
- 42
- 43
- 44
- 45
- 46
- 47
- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

For peer review only

Funding

This work was supported by Pfizer, Inc. through a grant from the China Tobacco Control Partnership (grant numbers CON009013). The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. The content is solely the responsibility of the authors and does not necessarily represent the official view of Pfizer, Inc. or the China Tobacco Control Partnership.

Conflict of Interest

The authors declare no conflicts of interest.

Authors' Contributions

Conceptualization, J.H. and P.B.R.; methodology, J.H., Z.D. and Y.W.; data collection, P.B.R.; formal analysis, Z.D. and Y.W.; writing—original draft preparation, Z.D. and Y.W.; writing—review and editing, J.H., Z.D., Y.W. and P.B.R.; project administration, M.E. and P.B.R.; funding acquisition, M.P.E. and P.B.R. All authors have read and agreed to the published version of the manuscript.

Data availability statement

De-identified study data can be accessed through a written request to the TFC initiative.

Acknowledgements

Technical assistance was provided by China CDC, Chengdu Institute of Health Education, Wuhan Institute of Health Education, Xiamen CDC, Xi'an Institute of Health Education, the ThinkTank Research Center for Health Development, and RTI International.

Supplemental Table 1. Description of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative and city-specific activities implemented from 2015 to 2018

City, (Population, GDP)	Smoke-Free Policy Goal (n or adoption date)	Policy Inspection Frequency	# of Media Mentions	Health Education/Mass Media Campaigns	Cessation Interventions
Chengdu (16 million, 1.39 trillion yuan)	SF government worksites (n=21) SF business worksites (n=15)	Every 2 months	110	WNTD and CNY mass media campaigns; PSAs on subways; city educational events	Cessation training for healthcare workers
Chongqing (30.75 million, 1.95 trillion yuan)	SF government worksites (n=1500) SF business worksites (n=2)	Twice per year	132	WNTD and CNY mass media campaigns; PSAs on TV and outdoor media outlets	Cessation counseling at two large businesses
Wuhan (10.89 million, 1.34 trillion yuan)	SF government worksites (n=106) SF business worksites (190) SF campus (n=38)	Monthly	102	WNTD and CNY mass media campaigns; PSAs on subways; city educational websites; knowledge competitions via WeChat	Citywide cessation completion; cessation hotline
Xi'an (9.06 million, 746.69 billion)	SF public places (August 2018); effective November 2018 SF business (n=65) SF homes (n=2200) SF government worksites (n=33)	Quarterly	263	WNTD and CNY mass media campaigns; PSAs on subways; citywide “no butts fall to the ground, Xian is beautiful” campaign	Free cessation clinics; citywide cessation competition
Xiamen (4.1 million, 435 billion yuan)	SF business worksites (n=86) SF scenery districts, including a UNESCO site(n=3)	Twice per year	116	WNTD and CNY mass media campaigns; SF business awards ceremonies	Cessation services provided to SF government and business workers

Abbreviations: World No Tobacco Day (WNTD); Chinese New Year (CNY); Public Service Announcements (PSA)

Supplemental Table 2. Sample size, response rate, and survey date for each of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative, 2015 and 2018

Locations	Number of Interviews			Response Rate ¹	Survey Date
	Overall	Male	Female		
Year 2015 (N=10,184)					
Chengdu	1,946	903	1,043	89.6%	Feb 2016 - Mar 2016
Chongqing	1,852	843	1,009	79.8%	Oct 2015 - Nov 2015
Wuhan	2,163	1,018	1,145	98.3%	Oct 2015 - Dec 2015
Xiamen	2,174	1,055	1,119	92.5%	Oct 2015 - Jan 2016
Xi'an	2,049	962	1,087	89.4%	Nov 2015 - Feb 2016
2018 (N=10,233)					
Chengdu	1,914	876	1,038	93.5%	Feb 2018 - April 2018
Chongqing	1,829	837	992	90.8%	Sep 2017 - Nov 2017
Wuhan	2,251	1,158	1,093	97.8%	Dec 2017 - Jan 2018
Xiamen	2,116	1,121	995	89.7%	April 2018 - May 2018
Xi'an	2,123	1,092	1,031	87.2%	June 2018 - July 2018

¹ Overall response rate is a product of household response rate and individual response rate

Supplemental Table 3. Demographic characteristics of adult urban residents in all five Chinese cities participated in the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Demographic Characteristics	2015 (N=10,184)		2018 (N=10,233)	
	n	%	n	%
Sex				
Male	4781	51.58	4897	50.75
Female	5403	48.42	5336	49.25
Age (Years)				
15-24	940	18.97	840	20.37
25-44	4222	40.84	4124	39.44
45-64	3354	29.73	3539	29.72
65 and above	1668	10.45	1730	10.47
Education Level				
Primary school completed or below	1626	10.86	1325	9.39
Junior high school completed	2317	22.12	2265	20.51
Senior high school completed	2825	30.08	2821	28.15
College degree or above	3304	36.95	3759	41.95
Occupation				
Government employee, teacher, healthcare provider	972	10.69	1080	11.47
Factory, business, service industry employee	4358	45.63	3795	37.84
Not in the labor force ¹	4773	43.68	5231	50.69
Current smoking status				
Yes	2275	22.75	2339	23.36
No	7909	77.25	7885	76.64

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 4. Subgroup analysis by gender: adjusted ORs¹ for SHS exposure in indoor workplaces in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Male		Female	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.72	0.56 - 0.91	0.70	0.55 - 0.90
<i>Age Group</i>				
15-24	1.52	0.59 - 3.90	1.92	0.44 - 8.44
25-34	1.40	0.57 - 3.44	1.73	0.41 - 7.40
35-64	1.70	0.71 - 4.08	1.83	0.42 - 7.96
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.80	0.46 - 1.38	0.62	0.40 - 0.95
Senior high school completed	0.85	0.50 - 1.44	0.51	0.34 - 0.77
College degree or above	0.70	0.41 - 1.18	0.40	0.26 - 0.63
<i>Occupation</i>				
Government employee, teacher, healthcare provider	Ref.		Ref.	
Factory, business, service industry employee	1.79	1.45 - 2.21	1.33	1.03 - 1.71
<i>Current smoking status</i>				
Yes	2.23	1.84 - 2.71	2.14	1.18 - 3.87
No	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 5. Subgroup analysis by gender: adjusted ORs¹ for SHS exposure in the home in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Male		Female	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.57	0.46 - 0.71	0.68	0.55 - 0.84
<i>Age Group</i>				
15-24	1.15	0.83 - 1.59	1.16	0.85 - 1.56
25-34	1.21	0.93 - 1.57	1.44	1.11 - 1.86
35-64	1.33	1.01 - 1.75	1.39	1.09 - 1.76
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	1.06	0.75 - 1.51	0.99	0.77 - 1.27
Senior high school completed	1.01	0.72 - 1.41	0.87	0.68 - 1.13
College degree or above	0.97	0.69 - 1.36	0.88	0.67 - 1.16
<i>Occupation</i>				
Government employee, teacher, healthcare provider	0.95	0.73 - 1.23	1.07	0.84 - 1.36
Factory, business, service industry employee	1.19	0.97 - 1.47	1.15	0.97 - 1.37
Not in the labor force ²	Ref.		Ref.	
<i>Current smoking status</i>				
Yes	1.84	1.54 - 2.19	2.64	1.76 - 3.96
No	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 6. Subgroup analysis by gender: adjusted ORs¹ for SHS exposure in the restaurant in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Male		Female	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.82	0.63 - 1.05	0.72	0.59 - 0.88
<i>Age Group</i>				
15-24	2.89	2.13 - 3.93	1.44	1.09 - 1.91
25-34	1.00	0.76 - 1.30	1.35	1.08 - 1.68
35-64	0.91	0.73 - 1.14	1.43	1.20 - 1.71
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.68	0.53 - 0.87	0.91	0.75 - 1.11
Senior high school completed	0.68	0.54 - 0.85	0.85	0.69 - 1.05
College degree or above	0.49	0.37 - 0.64	0.56	0.45 - 0.70
<i>Occupation</i>				
Government employee, teacher, healthcare provider	0.87	0.64 - 1.18	1.23	0.99 - 1.52
Factory, business, service industry employee	0.92	0.73 - 1.15	1.09	0.86 - 1.39
Not in the labor force force ^	Ref.		Ref.	
<i>Current smoking status</i>				
Yes	13.53	11.12 - 15.46	9.87	6.55 - 14.89
No	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 7. Subgroup analysis by current smoking status: adjusted ORs¹ for SHS exposure in the workplace in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Current smoker		Current non-smoker	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.65	0.47 - 0.90	0.73	0.58 - 0.91
<i>Gender</i>				
Male	1.42	0.75 - 2.70	1.54	1.33 - 1.79
Female	Ref.		Ref.	
<i>Age Group</i>				
15-24	0.96	0.28 - 3.29	2.09	0.70 - 6.30
25-34	1.16	0.36 - 3.76	1.82	0.62 - 5.35
35-64	1.84	0.59 - 5.72	1.80	0.62 - 5.23
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.89	0.42 - 1.89	0.60	0.40 - 0.89
Senior high school completed	0.83	0.39 - 1.77	0.57	0.39 - 0.82
College degree or above	0.73	0.34 - 1.60	0.44	0.29 - 0.66
<i>Occupation</i>				
Government employee, teacher, healthcare provider	Ref.		Ref.	
Factory, business, service industry employee	1.73	1.20 - 2.50	1.52	1.22 - 1.89

¹ Controlling gender, age, education, occupation, and current smoking status

Supplemental Table 8. Subgroup analysis by current smoking status: adjusted ORs¹ for SHS exposure in the home in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Current smoker		Current non-smoker	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.57	0.42 - 0.79	0.63	0.53 - 0.76
<i>Gender</i>				
Male	0.90	0.61 - 1.33	1.26	1.12 - 1.42
Female	Ref.		Ref.	
<i>Age Group</i>				
15-24	1.47	0.84 - 2.59	1.10	0.86 - 1.41
25-34	1.33	0.84 - 2.10	1.32	1.08 - 1.62
35-64	1.81	1.17 - 2.80	1.25	1.02 - 1.54
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.75	0.43 - 1.29	1.11	0.88 - 1.40
Senior high school completed	0.73	0.43 - 1.24	0.99	0.78 - 1.26
College degree or above	0.79	0.45 - 1.38	0.95	0.74 - 1.22
<i>Occupation</i>				
Government employee, teacher, healthcare provider	0.66	0.45 - 0.99	1.10	0.89 - 1.36
Factory, business, service industry employee	1.11	0.83 - 1.49	1.18	1.02 - 1.37
Not in the labor force ²	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 9. Subgroup analysis by current smoking status: adjusted ORs¹ for SHS exposure in the restaurant in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Current smoker		Current non-smoker	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.86	0.65 - 1.13	0.74	0.60 - 0.90
<i>Gender</i>				
Male	0.73	0.48 - 1.10	0.58	0.50 - 0.67
Female	Ref.		Ref.	
<i>Age Group</i>				
15-24	1.72	1.06 - 2.78	2.12	1.67 - 2.69
25-34	1.03	0.72 - 1.46	1.31	1.07 - 1.59
35-64	1.07	0.76 - 1.50	1.23	1.05 - 1.44
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.57	0.41 - 0.81	0.87	0.72 - 1.05
Senior high school completed	0.56	0.40 - 0.78	0.82	0.67 - 0.99
College degree or above	0.37	0.25 - 0.55	0.55	0.45 - 0.69
<i>Occupation</i>				
Government employee, teacher, healthcare provider	1.08	0.82 - 1.42	1.18	0.98 - 1.42
Factory, business, service industry employee	1.13	0.82 - 1.57	1.19	0.99 - 1.48
Not in the labor force ²	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 10. Adjusted ORs¹ for SHS exposure in the workplace by city and in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Chengdu		Chongqing		Wuhan		Xiamen		Xi'an		Overall	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>												
2015	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
2018	0.82	0.54 - 1.26	0.73	0.45 - 1.19	0.60	0.39 - 0.92	0.61	0.38 - 0.96	0.73	0.45 - 1.18	0.71	0.58 - 0.88
<i>Gender</i>												
Male	1.64	1.26 - 2.14	1.53	1.09 - 2.16	1.36	0.98 - 1.88	1.64	1.19 - 2.26	1.61	1.17 - 2.22	1.53	1.32 - 1.76
Female	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Age Group</i>												
15-24	1.42	0.27 - 7.51	3.37	0.73 - 15.49	0.63	0.15 - 2.72	1.05	0.30 - 3.66	2.69	0.42 - 17.09	1.77	0.79 - 3.98
25-34	0.98	0.19 - 5.13	3.03	0.68 - 13.58	0.92	0.20 - 4.14	1.21	0.39 - 3.77	2.27	0.36 - 14.14	1.62	0.73 - 3.60
35-64	1.23	0.23 - 6.57	2.47	0.54 - 11.24	1.06	0.27 - 4.13	1.79	0.63 - 5.14	2.69	0.45 - 16.20	1.85	0.84 - 4.07
65 and above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Education</i>												
Primary school completed	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Junior high school completed	0.33	0.13 - 0.81	0.66	0.31 - 1.43	0.89	0.33 - 2.38	0.64	0.43 - 0.95	2.11	0.70 - 6.35	0.65	0.45 - 0.95
Senior high school completed	0.19	0.08 - 0.43	0.58	0.26 - 1.29	0.94	0.31 - 2.81	0.90	0.59 - 1.37	1.46	0.53 - 4.03	0.62	0.44 - 0.89
College degree or above	0.17	0.07 - 0.41	0.47	0.20 - 1.10	0.73	0.25 - 2.11	0.58	0.34 - 1.01	1.17	0.43 - 3.15	0.50	0.34 - 0.74
<i>Occupation</i>												
Government employee, teacher, healthcare provider	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Factory, business, service industry employee	1.64	1.12 - 2.41	1.66	1.18 - 2.35	1.50	1.05 - 2.13	1.32	0.83 - 2.09	1.53	1.09 - 2.13	1.56	1.32 - 1.85
<i>Current smoking status</i>												
Yes	2.15	1.51 - 3.06	1.87	1.20 - 2.92	3.35	2.30 - 4.86	2.20	1.57 - 3.10	2.00	1.30 - 3.10	2.21	1.84 - 2.65
No	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

Supplemental Table 11. Adjusted ORs¹ for SHS exposure in the home by city and in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Chengdu		Chongqing		Wuhan		Xiamen		Xi'an		Overall	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>												
2015	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
2018	0.80	0.54 - 1.20	0.65	0.45 - 0.95	0.86	0.54 - 1.40	0.73	0.42 - 1.28	0.78	0.54 - 1.13	0.76	0.63 - 0.93
<i>Gender</i>												
Male	0.50	0.38 - 0.66	0.61	0.45 - 0.81	0.54	0.33 - 0.90	0.62	0.47 - 0.81	0.67	0.53 - 0.83	0.59	0.51 - 0.68
Female	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Age Group</i>												
15-24	1.71	1.09 - 2.68	1.15	0.76 - 1.76	1.91	1.15 - 3.17	3.03	2.02 - 4.56	3.27	2.13 - 5.02	2.06	1.67 - 2.55
25-34	1.20	0.83 - 1.73	1.00	0.73 - 1.36	1.00	0.65 - 1.53	2.11	1.43 - 3.11	1.37	0.90 - 2.08	1.25	1.04 - 1.50
35-64	1.20	0.90 - 1.59	1.10	0.81 - 1.49	0.94	0.71 - 1.23	1.50	1.10 - 2.05	1.46	1.07 - 1.99	1.21	1.05 - 1.40
65 and above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Education</i>												
Primary school completed	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Junior high school completed	0.85	0.59 - 1.23	1.00	0.75 - 1.34	1.27	0.86 - 1.85	0.37	0.28 - 0.50	0.80	0.55 - 1.19	0.82	0.69 - 0.96
Senior high school completed	0.72	0.50 - 1.04	1.05	0.80 - 1.38	1.18	0.84 - 1.64	0.35	0.24 - 0.52	0.74	0.49 - 1.13	0.77	0.65 - 0.91
College degree or above	0.55	0.38 - 0.79	0.77	0.55 - 1.08	0.62	0.41 - 0.94	0.21	0.13 - 0.33	0.51	0.33 - 0.80	0.52	0.43 - 0.63
<i>Occupation</i>												
Government employee, teacher, healthcare provider	0.94	0.58 - 1.52	0.94	0.62 - 1.42	0.82	0.55 - 1.23	0.94	0.63 - 1.41	0.70	0.47 - 1.05	0.86	0.71 - 1.04
Factory, business, service industry employee	0.98	0.73 - 1.31	1.01	0.79 - 1.30	1.12	0.81 - 1.55	0.83	0.61 - 1.12	0.96	0.70 - 1.31	0.98	0.86 - 1.13
Not in the labor force [^]	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Current smoking status</i>												
Yes	17.36	12.69 - 23.77	10.34	7.55 - 14.15	11.28	7.1 - 17.92	8.68	6.19 - 12.18	10.83	8.06 - 14.57	11.27	9.62 - 13.20
No	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 12. Adjusted ORs¹ for SHS exposure in the restaurant by city and in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Chengdu		Chongqing		Wuhan		Xiamen		Xi'an		Overall	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>												
2015	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
2018	0.65	0.42 - 0.98	0.55	0.37 - 0.80	0.76	0.51 - 1.15	0.62	0.45 - 0.86	0.60	0.40 - 0.88	0.63	0.52 - 0.75
<i>Gender</i>												
Male	1.09	0.87 - 1.36	1.21	0.96 - 1.53	1.14	0.91 - 1.41	1.83	1.28 - 2.62	1.31	1.03 - 1.68	1.24	1.11 - 1.38
Female	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Age Group</i>												
15-24	1.33	0.78 - 2.27	1.10	0.69 - 1.75	1.18	0.77 - 1.81	1.96	1.20 - 3.21	1.42	0.92 - 2.22	1.15	0.91 - 1.45
25-34	1.04	0.68 - 1.60	1.69	1.14 - 2.50	1.37	0.97 - 1.94	2.11	1.26 - 3.53	1.51	1.08 - 2.11	1.31	1.08 - 1.59
35-64	1.18	0.78 - 1.78	1.54	0.98 - 2.42	1.51	1.06 - 2.14	1.56	0.97 - 2.49	1.33	0.91 - 1.94	1.35	1.10 - 1.65
65 and above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Education</i>												
Primary school completed	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Junior high school completed	1.05	0.68 - 1.64	0.83	0.55 - 1.26	1.18	0.65 - 2.18	1.06	0.74 - 1.52	1.50	0.87 - 2.58	1.02	0.82 - 1.26
Senior high school completed	1.01	0.61 - 1.65	0.74	0.49 - 1.14	1.37	0.78 - 2.40	0.97	0.60 - 1.57	1.06	0.61 - 1.83	0.93	0.75 - 1.16
College degree or above	0.90	0.56 - 1.46	0.90	0.59 - 1.37	1.25	0.70 - 2.25	1.00	0.64 - 1.56	0.96	0.57 - 1.63	0.91	0.73 - 1.14
<i>Occupation</i>												
Government employee, teacher, healthcare provider	0.87	0.57 - 1.32	0.73	0.48 - 1.11	1.07	0.71 - 1.62	1.36	0.87 - 2.14	1.36	0.95 - 1.95	1.01	0.83 - 1.23
Factory, business, service industry employee	1.12	0.87 - 1.43	1.01	0.71 - 1.42	1.01	0.75 - 1.35	1.53	1.13 - 2.07	1.50	1.07 - 2.12	1.17	1.02 - 1.35
Not in the labor force ²	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Current smoking status</i>												
Yes	1.82	1.35 - 2.46	1.93	1.35 - 2.75	2.27	1.71 - 3.03	1.84	1.20 - 2.83	1.68	1.1 - 2.56	1.88	1.59 - 2.21
No	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5, 6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6, 7
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6, 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7
		(e) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	8,9,10,11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8,9,10,11,12,13
		(b) Report category boundaries when continuous variables were categorized	8,9,10,11,12,13
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13,14,15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities (TFC) initiative in five Chinese cities: a pooled cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044570.R2
Article Type:	Original research
Date Submitted by the Author:	03-Dec-2020
Complete List of Authors:	Duan, Zongshuan; Georgia State University, School of Public Health Wang, Yu; Georgia State University, School of Public Health Huang, Jidong; Georgia State University, School of Public Health Redmon, Pamela; Emory University, Global Health Institute Eriksen, Michael ; Georgia State University, School of Public Health
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health policy, Epidemiology, Smoking and tobacco
Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 **Secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities**
4 **(TFC) initiative in five Chinese cities: a pooled cross-sectional study**
5

6
7 Zongshuan Duan¹, Yu Wang¹, Jidong Huang^{1*}, Pamela B. Redmon², Michael P. Eriksen¹
8

9 ¹ School of Public Health, Georgia State University, Atlanta, GA, 30303, USA

10 ² Global Health Institutes, Emory University, Atlanta, GA, 30322, USA
11
12
13
14
15
16
17
18

19 *Corresponding Author:

20 Jidong Huang, Ph.D. Associate Professor

21 Department of Health Policy & Behavioral Sciences

22 School of Public Health

23 Georgia State University

24 Urban Life Building, Suite 859

25 140 Decatur Street, Atlanta, GA 30303

26 Email: jhuang17@gsu.edu

27 Office Phone: 404-413-9337
28
29
30
31
32

33 Type of Submission: Original research

34 Word Count: 4,247

35 Number of Tables/Figures: 5

36 Number of Supplemental Tables: 12
37
38
39
40
41
42

43 **Keywords:** secondhand smoke exposure, SHS, Tobacco Free Cities, TFC, tobacco control, China, city
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Objectives: To assess the levels of secondhand smoke (SHS) exposure before and after the implementation of the Tobacco Free Cities (TFC) initiative.

Design: Citywide representative, cross-sectional surveys (Tobacco Questions for Surveys, TQS) were conducted in each participating city before and after the implementation of TFC.

Setting: Five large Chinese cities (Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an) participated in the TFC initiative.

Participants: A total of 10,184 adults participated in the 2015 TQS survey, and 10,233 adults participated in the 2018 TQS survey, respectively.

Interventions: The TFC initiative, which included targeted media campaigns, educational programs, implementing citywide smoke-free policies, and providing cessation interventions, was implemented in these five cities between 2015-2018.

Main outcome: Self-reported past-30-day (P30D) SHS exposure in indoor workplaces, restaurants, and homes.

Data analysis: The pre- and post-TFC SHS exposure levels were compared among all residents and among certain population subgroups. Multivariate logistic regressions were used to estimate the adjusted associations between P30D SHS exposure and individual characteristics.

Results Across all five cities, the overall rate of self-reported P30D SHS exposure declined in indoor workplaces (from 49.6% (95% CI: 46.4%-52.8%) to 41.2% (95% CI: 37.7%-44.7%)), restaurants (from 72.4% (95% CI: 69.8%-74.9%) to 61.7% (95% CI: 58.7%-64.7%)), and homes (from 39.8% (95% CI: 36.9%-42.7%) to 34.7% (95% CI: 31.5%-37.8%)) from 2015 to 2018. These declines were statistically significant after controlling for individual characteristics. The P30D SHS exposure was associated with sex, age, education level, occupation, and current smoking status. The associations varied by venues.

Conclusions Our analysis showed that compared with the nationwide SHS exposure levels reported in concurrent national surveys, the declines in P30D SHS exposure in five Chinese cities implemented the TFC initiative were larger in indoor workplaces and restaurants. Our findings suggest that the TFC initiative was effective in reducing SHS exposure in Chinese cities.

Strengths and limitations of this study

- Multistage sampling method was applied to select a citywide representative sample of adults (aged 15 and above) for each of the five Chinese cities that participated in the Tobacco Free Cities (TFC) initiative.
- The Tobacco Questions for Surveys (TQS) were administered to the study sample in each city to assess the levels of secondhand exposure (SHS) in workplaces, restaurants, and homes before and after the implementation of the TFC initiative.
- The pre- and post-TFC SHS exposure levels were compared among all adult city residents, as well as among certain population subgroups, using multivariate logistic regressions controlling for individual characteristics.
- Limitations of this study included self-reported smoking status and SHS exposure, which may be subject to recall bias and social desirability bias, and the inability to estimate the SHS exposure changes before and after the implementation of the TFC initiative at the individual level using pooled cross-sectional surveys.
- The associations between SHS exposure and individual level characteristics reported in this study may not be generalized to other cities or rural areas in China.

Introduction

Secondhand smoke (SHS) exposure is a major preventable cause of diseases for infants, children, and nonsmoking adults.¹⁻³ It has been well documented that there is no risk-free level of exposure to SHS.² As the largest tobacco consumption country globally, China has more than 300 million smokers, exposing an estimated 740 million people to harmful environmental tobacco smoke.⁴ According to the findings from a cross-country comparison of past-30-day (P30D) SHS exposure among adults in 14 countries (Bangladesh, Brazil, China, Egypt, India, Mexico, Philippines, Poland, Russia, Thailand, Turkey, Ukraine, Uruguay, and Vietnam), China had the highest rates of P30D SHS exposure in indoor workplaces (63.3%) and restaurants (88.5%) in 2010.^{5,6} In addition, the rate of P30D exposure to SHS at home in China (67.3%) was the second highest among these 14 countries,⁵ resulting in more than 164 million children being exposed to SHS at home in 2010.⁷

Recent nationwide surveys showed that exposure to SHS had been declining in China over the last decade. For example, the China Adult Tobacco Survey (CATS) found that from 2015 to 2018, the P30D SHS exposure in indoor places had declined, particularly in homes (57.1% to 44.9%), workplaces (54.3% to 50.9%), government buildings (38.1% to 31.1%), healthcare facilities (36.8% to 24.4%), restaurants (76.3% to 73.3%), and public transportation (16.4% to 12.9%).^{8,9} Previous studies indicated that the decline in SHS exposure in China was likely due to the implementation of smoke-free air policies in public places in recent years.^{10,11} In 2013, the Chinese Central government issued a notice prohibiting government officials smoking in public to set an example for all to follow.^{4,12} In 2014, the Ministry of Education and the National Health Commission (now National Health and Family Planning Commission) issued directives for all schools and healthcare facilities in China to become 100% smoke-free.^{4,12} To date, more than 20 largest Chinese cities, including Beijing, Shanghai, Shenzhen, and Xi'an, have adopted citywide smoke-free air policies.⁸

Despite progress in smoke-free legislation and tobacco control efforts, to date, there is still no comprehensive smoke-free air laws at the national level in China. The 2015 CATS estimated that more than half (54.3%) of adults who worked indoors were still exposed to tobacco smoke at their workplaces, and more than 500 million adults were exposed to SHS at home.¹³ Even in cities where smoke-free air policies have been adopted, the strengths and enforcement of these policies varied significantly at the local level.^{14,15} To support Chinese cities to develop effective, comprehensive and sustainable tobacco control programs, researchers from Georgia State University (GSU) and China Centers for Disease Control and Prevention (China CDC) selected five Chinese cities to participate in the Tobacco Free Cities (TFC) initiative in 2015. The TFC initiative was a three-year program aimed to achieve the goal of creating cities where no tobacco use is the norm, by providing grant funds and experts' support to help the

1
2
3 cities implement best practice interventions, including adoption of tobacco-free policies, communication
4 strategies to increase knowledge on harms of tobacco use, and provision of cessation services.¹⁶ The
5 research team in GSU collaborated with the ThinkTank Research Center for Health Development, a
6 China-based non-governmental organization, the China CDC, and the National Health Commission to
7 identify a non-random sample of 10 potential cities for the TFC initiative in 2015. Five metropolitan cities
8 were selected based on population size, societal influence in China, local government support for tobacco
9 control efforts, and stage of readiness to take action to change social norms of tobacco use in their city.
10 These five cities selected were Chengdu, Chongqing, Wuhan, Xiamen, and Xi'an. None of these five
11 cities had citywide smoke-free air policies at the time of selection. The population size of these five
12 participating cities ranged from about 4 million in Xiamen to about 30 million in Chongqing (see the
13 Supplemental Table 1 for detail).
14
15
16
17
18
19
20

21 This study aims to conduct a preliminary assessment of the effectiveness of the TFC initiative in
22 reducing SHS exposure in indoor areas. Studies using the International Tobacco Control (ITC) data
23 indicated that partial smoke-free air policies had minimal impact on reducing SHS exposure in indoor
24 workplaces, restaurants, and bars in China.^{10 17} Although a few small randomized controlled trials had
25 demonstrated the effectiveness of tobacco control intervention programs in reducing SHS exposure in
26 China,^{18 19} the evidence on the effectiveness of citywide tobacco control activities in reducing SHS
27 exposure in China is scarce. In addition, because smoking behavior and its determinants may differ
28 considerably between urban and rural areas in China, the overall SHS exposure status at the national level
29 may mask the differences across regions and population subgroups.^{20 21} Importantly, due in part to a lack
30 of representative, citywide data on SHS exposure in China, very little is known about SHS exposure in
31 large cities, where the population is more concentrated than small cities and rural areas, and SHS
32 exposure may be more pronounced. One study using the ITC data from seven cities and five rural areas of
33 China found that from 2009 to 2015, there were no significant differences in SHS exposure between
34 smokers and nonsmokers except that SHS exposure among smokers was higher than among nonsmokers
35 in rural workplaces.¹⁷
36
37
38
39
40
41
42
43
44

45 This study is designed to enrich the literature by examining the level of SHS exposure in indoor
46 workplaces, indoor areas of restaurants, and at home in five large Chinese cities before and after the
47 implementation of the TFC initiative in those cities. This study also investigates the potential differences
48 in SHS exposure across population subgroups. It was hypothesized that the decline in SHS exposure at
49 workplaces, restaurants, and homes between 2015 and 2018 would be more pronounced in these five
50 cities with the TFC initiative, compared with the nationwide trend. In addition, the SHS exposure was
51
52
53
54
55
56
57
58
59
60

1
2
3 hypothesized to vary among population subgroups characterized by socio-demographic factors and
4 smoking status.
5

6 **Methods**

7 **Study design and survey participants**

8
9
10
11 The TFC initiative was implemented in the five selected cities, i.e. Chengdu, Chongqing, Wuhan,
12 Xiamen, and Xi'an, from 2015 to 2018.¹⁶ During this period, these cities executed activities, including
13 implementing citywide and sector-wide smoke-free policies, launching health education interventions and
14 mass media campaigns, and providing cessation interventions for smokers who want to quit (see the
15 Supplemental Table 1 for a detailed list of tobacco control activities in each city). Two citywide
16 representative household surveys were conducted in each city, one before the TFC initiative and the
17 second one after the TFC initiative, by the local municipal health department under the supervision of the
18 China CDC. The surveys assessed tobacco use, exposure to secondhand smoke (SHS) and knowledge,
19 attitudes, and beliefs towards various tobacco and nicotine products, using the Tobacco Questions for
20 Surveys (TQS) questionnaire. TQS was a subset of key questions adapted from the Global Adult Tobacco
21 Survey (GATS), developed by the World Health Organization (WHO) and the US Centers for Disease
22 Control and Prevention (US CDC).²²
23
24
25
26
27
28
29

30
31 The first TQS survey was conducted from October 2015 to March 2016 (data were collected
32 mainly in 2015, referred to as TQS 2015 below). The second TQS survey was conducted from November
33 2017 to March 2018 (data were collected mainly in 2018, referred to as TQS 2018 below) (see a detailed
34 timeline in Supplemental Table 2). Participants were recruited using a household-based, multistage cluster
35 sampling scheme designed to represent non-institutionalized adults (defined as age 15 and above at the
36 survey time) residing in urban areas of these five cities, based on the principles outlined in the GATS
37 Sample Design Manual.²³ Detailed sampling procedures and weight calculations were described in
38 previously published studies.^{24 25} The household surveys were conducted through indoor face-to-face
39 interviews using handheld computer-assisted devices to reduce measurement errors. These surveys were
40 approved by the local IRB of each city's municipal health department. Written informed consent was
41 obtained from all participants. A total of 10,184 participants completed the household survey in
42 2015/2016, and 10,233 participants completed the survey in 2017/2018. The response rate and sample
43 size overall and for each city were listed in Supplemental Table 2. Secondary data analyses were
44 approved by the GSU IRB.
45
46
47
48
49
50
51
52

53 **Measures and variables**

54 *Outcomes*

1
2
3 The primary outcome variables in this study were self-reported P30D SHS exposure status in
4 indoor areas of workplaces, restaurants, and homes. All study participants were asked whether they
5 usually worked indoors. Participants who responded “yes” were then asked whether they had noticed
6 anyone (including themselves) smoking in indoor areas of workplaces in the past 30 days. In addition, all
7 participants were asked whether they had visited any restaurants in the past 30 days, and if so, whether
8 they had observed anyone (including themselves) smoking inside any of the restaurants they visited in the
9 past 30 days. Finally, all participants were asked whether anyone (including themselves) had smoked in
10 their homes in the past 30 days.
11
12
13
14
15

16 *Current tobacco smoking status*

17
18 Participants were asked whether they were currently using any smoking tobacco products,
19 including cigarettes, cigars, and pipes, daily, occasionally, or not at all. Participants who were currently
20 using smoking tobacco products daily or occasionally were categorized as current smokers. Participants
21 who were not using any smoking tobacco products at all were categorized as current nonsmokers.
22
23
24

25 *Demographic characteristics*

26
27 Demographic variables included biological sex, age, highest education level, and occupation type.
28 Age was categorized into 15-24, 25-44, 45-64, and 65 years and older. Education was categorized into
29 primary school completed or below, junior high school completed, senior high school completed, and
30 college degree or above. The occupation was categorized into “government employee, teacher, healthcare
31 provider,” “factory, business, agriculture, and service industry employee,” and “not in the labor force,”
32 which included the unemployed, students, homemakers, and retired. The TQS survey grouped
33 “Government employee, teacher, healthcare provider” into one single category because most schools and
34 hospitals in China are government-owned. On the contrary, “factory, business, agriculture, and service
35 industry employees” are generally considered working in the private sector in China. The rationale for
36 this grouping method was because existing smoke-free policies in China were generally implemented in
37 government buildings, schools, and hospitals.¹⁶ The categorization of individual characteristics and the
38 grouping method for occupation were consistent with the method used in other national-level surveys in
39 China, such as the 2015 and 2018 China Adult Tobacco Survey (CATS).^{8 13}
40
41
42
43
44
45
46
47

48 *Data Analyses*

49
50 SAS® 9.4 (SAS Institute, Cary, NC, USA) was used for data analyses. Complex sampling
51 procedures were accounted for in analyses by using the survey procedures in SAS. Invalid answers, i.e.,
52 “I don’t know” and “Refused”, were coded as missing. The main resources of missing data were outcome
53 variables (about 2% of respondents with missing values for SHS exposure at each venue) and self-
54
55
56
57
58
59
60

1
2
3 reported occupation types (about 1% of respondents with missing values). The proportion of respondents
4 with missing values on any key variable included in data analyses for each venue was less than 5%. We
5 assumed that missing was at random (MCR) and used pairwise deletion to handle missing values.²⁶ We
6 estimated the percentages and 95% confidence intervals (CIs) of urban adult residents who had been
7 exposed to SHS in the past 30 days at selected venues, in total and by demographic characteristics,
8 including biologic sex, age, education, occupation, and current smoking status. The Rao-Scott Chi-Square
9 test was used to check the unadjusted associations between P30D SHS exposure and survey years in total
10 and by demographic characteristics. In addition, multivariate logistic regression was used to estimate the
11 adjusted associations between P30D SHS exposure and survey years, controlling for demographic
12 characteristics, including age, gender, education, occupational status, and smoking status.
13
14
15
16
17
18

19 Patient and public involvement

20
21 This study was done without patient involvement. The target population of TQS was non-
22 institutionalized adults residing in urban areas of the five participating Chinese cities.
23
24
25
26

27 Results

28 Demographic characteristics and smoking status

29
30 Among urban adult residents in all five participating cities, in 2015, about 11% of them
31 completed primary school or below, and 37% had a college degree or above. Approximately 11% worked
32 as government employees, teachers, or healthcare providers, and 44% were not in the labor force. In
33 2018, approximately 9% completed primary school or below, and 42% had a college degree or above.
34 There were about 11% of adult residents working as government employees, teachers, or healthcare
35 providers, and more than half of them (51%) were not in the labor force. Approximately 23% of them
36 were current smokers in 2015 and 2018. (Supplemental Table 3)
37
38
39
40
41
42

43 P30D SHS exposure in indoor workplaces

44
45 As shown in Table 1, 4,710 and 5,011 respondents usually worked indoors and reported P30D
46 SHS exposure status in 2015 and 2018, respectively. The overall P30D SHS exposure in indoor
47 workplaces decreased from 49.6% (95% CI: 46.4%-52.8%) in 2015 to 41.2% (95% CI: 37.7%-44.7%) in
48 2018 ($p=0.0003$). In 2015, 58.3% (95% CI: 54.5%-62.0%) of men and 39.2% (95% CI: 35.8%-42.7%) of
49 women reported P30D SHS exposure, while 49.2% (95% CI: 45.1%-53.2%) of men and 32.2% (95% CI:
50 28.4%-36.0%) reported P30D SHS exposure in their indoor workplaces in 2018 ($p=0.0007$ and $p=0.0055$
51 for men and women, respectively). Regarding age, the rate of P30D SHS exposure was the highest among
52
53
54
55
56
57
58
59
60

adults aged 45 to 64 years old in 2015 and 2018. From 2015 to 2018, the decline in P30D SHS exposure was statistically significant for adults aged 25 to 44 years old (47.9%, 95% CI: 44.4%-51.4% vs. 41.2%, 95% CI: 37.4%-45.0%, $p=0.0086$) and 45 to 64 years old (58.6%, 95% CI: 53.9%-63.3% vs. 46.9%, 95% CI: 42.0%-51.8%, $p=0.0005$). Exposure to SHS followed a gradient, i.e., exposure decreases as education levels increase, in both 2015 and 2018 surveys. The decline in P30D SHS exposure was statistically significant for people with senior high school completed or above (51.5%, 95% CI: 46.8%-56.2% vs. 44.6%, 95% CI: 40.0%-49.1%, $p=0.0356$) and college degree or above (45.8%, 95% CI: 42.3%-49.3% vs. 37.2%, 95% CI: 33.1%-41.4%, $p=0.0012$). A significant decrease in the self-reported P30D SHS exposure was observed for both government employees, teachers, or healthcare providers and factory, business, and service industry employees. In 2015, 70.7% (95% CI: 66.0%-75.3%) of smokers and 42.8% (95% CI: 39.4%-46.1%) of nonsmokers reported exposed to SHS at their indoor workplace in the past 30 days, and the corresponding rates in 2018 significantly decreased to 63.6% (95% CI: 59.1%-68.1%) and 34.6% (95% CI: 31.0%-38.2%) for smokers and nonsmokers, respectively.

Table 1: P30D Secondhand smoke (SHS) exposure in indoor workplaces before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=4,710)		Year 2018 (N=5,011)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	49.61	46.37 - 52.85	41.24	37.74 - 44.74	0.0003
<i>Sex</i>					
Male	58.25	54.52 - 61.98	49.15	45.13 - 53.18	0.0007
Female	39.23	35.8 - 42.66	32.21	28.39 - 36.03	0.0055
<i>Age (Years)</i>					
15-24	44.83	39.31 - 50.35	37.34	31.34 - 43.34	0.0717
25-44	47.88	44.4 - 51.35	41.21	37.41 - 45.01	0.0086
45-64	58.58	53.87 - 63.3	46.88	42.01 - 51.75	0.0005
65 and above	41.66	20.05 - 63.26	25.39	16.05 - 34.74	0.1183
<i>Education Level</i>					
Primary school completed or below	64.16	54.51 - 73.8	52.85	42.17 - 63.53	0.1071
Junior high school completed	56.33	50.59 - 62.06	48.05	41.63 - 54.46	0.0511
Senior high school completed	51.47	46.76 - 56.17	44.57	40.02 - 49.11	0.0356
College degree or above	45.81	42.33 - 49.29	37.25	33.05 - 41.44	0.0012
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	39.39	33.96 - 44.82	30.43	24.89 - 35.97	0.0304
Factory, business, service industry employee	52.22	49.02 - 55.42	44.08	40.21 - 47.95	0.0003
<i>Current smoking status</i>					
Yes	70.65	65.99 - 75.31	63.59	59.06 - 68.12	0.0313

No	42.76	39.39 - 46.14	34.59	30.97 - 38.22	0.0007
----	-------	---------------	-------	---------------	--------

P30D SHS exposure in indoor areas of restaurants

As shown in Table 2, 6,576 and 6,878 respondents had visited any indoor areas of restaurants in the past 30 days and reported SHS exposure status in 2015 and 2018, respectively. The overall P30D SHS exposure in indoor areas of restaurants decreased significantly from 72.4% (95% CI: 69.8%-74.9%) in 2015 to 61.7% (95% CI: 58.7%-64.7%) in 2018 ($p<0.0001$). Both men and women reported significantly less exposure to SHS from 2015 to 2018 (for men, 77.4%, 95% CI: 74.8%-80.0% vs. 66.0%, 95% CI: 62.6%-69.4%, $p<0.0001$; for women: 66.3%, 95% CI: 63.0%-69.6% vs. 56.9%, 95% CI: 53.4%-60.3%, $p<0.0001$). In addition, the rate of reporting P30D SHS exposure in indoor areas of restaurants had declined significantly for people in age groups below 65 years old but remained the same (59.4%) for residents who were 65 years old or above from 2015 to 2018. In 2015, adults with primary school completed or below had the lowest rate (64.6%, 95% CI: 58.6%-70.7%) of reporting P30D SHS exposure in indoor areas of restaurants in 2015. However, this group reported the highest rate (69.9%, 95% CI: 64.0%-75.8%) in 2018. The rate of reporting P30D SHS exposure declined significantly in another three education level groups. In addition, respondents in all three occupation categories had experienced a significant decline in P30D SHS exposure in indoor areas of restaurants. In 2015, 83.6% (95% CI: 80.5%-86.6%) of current smokers and 68.6% (95% CI: 65.8%-71.4%) of current nonsmokers reported P30D SHS exposure in indoor areas of restaurants, and the rates significantly decreased to 74.3% (95% CI: 70.1%-78.5%) and 57.40% (95% CI: 54.2%-60.6%) in 2018 for current smokers and nonsmokers, respectively ($p<0.0001$ and $p=0.0002$, respectively).

Table 2: P30D Secondhand smoke (SHS) exposure in indoor areas of restaurants before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=6,576)		Year 2018 (N=6,878)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	72.37	69.81 - 74.92	61.70	58.66 - 64.74	<.0001
<i>Sex</i>					
Male	77.37	74.76 - 79.98	66.00	62.57 - 69.43	<.0001
Female	66.27	62.99 - 69.55	56.88	53.44 - 60.31	<.0001
<i>Age (Years)</i>					
15-24	71.56	67.35 - 75.76	55.37	50.74 - 59.99	<.0001

25-44	73.00	69.98 - 76.03	63.47	60.12 - 66.82	<.0001
45-64	74.56	71.21 - 77.91	64.80	60.21 - 69.38	0.0004
65 and above	59.40	54.2 - 64.59	59.36	52.74 - 65.98	0.9931
<i>Education Level</i>					
Primary school completed or below	64.63	58.59 - 70.67	69.92	64.04 - 75.79	0.2197
Junior high school completed	73.59	70.44 - 76.75	64.95	59.17 - 70.74	0.0074
Senior high school completed	73.37	70.03 - 76.7	61.10	57.44 - 64.75	<.0001
College degree or above	72.15	69.05 - 75.25	60.04	56.52 - 63.57	<.0001
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	71.71	66.38 - 77.04	58.8	52.5 - 65.11	0.0010
Factory, business, service industry employee	74.96	72.35 - 77.58	64.92	61.5 - 68.33	<.0001
Not in the labor force ¹	69.22	65.5 - 72.93	60.09	56.2 - 63.98	0.0008
<i>Current smoking status</i>					
Yes	83.55	80.48 - 86.62	74.33	70.13 - 78.54	<.0001
No	68.57	65.77 - 71.38	57.40	54.23 - 60.57	0.0002

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

P30D SHS exposure at home

As shown in Table 3, 9,943 and 10,086 respondents reported P30D SHS exposure status at home in 2015 and 2018, respectively. The overall exposure to SHS in the past 30 days at home decreased significantly from 39.8% (95% CI: 36.9%-42.7%) in 2015 to 34.6% (95% CI: 31.5%-37.8%) in 2018 ($p=0.0178$). The decline was only significant for women (34.7%, 95% CI: 31.6%-37.8% vs. 27.7%, 95% CI: 24.8%-30.6%, $p=0.0009$), not for men. Regarding age, the rate of self-reported P30D SHS exposure at home was found to be declining in all age groups, but the decline was statistically significant only among 25 to 44 years old age group (37.4%, 95% CI: 34.1%-40.7% vs. 31.9%, 95% CI: 28.0%-35.8%, $p=0.0327$). The rate of reporting P30D SHS exposure at home was found declining among urban residents of all education levels, but the decline was statistically significant only among residents with a college degree or above (33.8%, 95% CI: 30.4%-37.3% vs. 27.7%, 95% CI: 24.9%-30.5%, $p=0.0052$). The rate of self-reported P30D SHS exposure at home was lowest among government employees, teachers, or healthcare providers, and did not change significantly from 2015 to 2018 ($p=0.7085$). A significant decrease in the rate of reporting P30D SHS exposure at home was observed for adults working in factory, business, and service industry (41.6%, 95% CI: 38.2%-45.1% vs. 36.0%, 95% CI: 32.0%-39.9%, $p=0.0299$), and who were not in the labor force (40.0%, 95% CI: 37.0%-42.9% vs. 34.6%, 95% CI: 31.0%-38.3%, $p=0.0288$) from 2015 to 2018. During the same period, there was a statistically significant decline of reported P30D SHS exposure at home for current nonsmokers (29.4%, 95% CI: 26.6%-32.1% vs. 23.2%, 95% CI: 20.5%-25.8%, $p=0.0015$), the decline was not significant for current smokers.

Table 3: P30D Secondhand smoke (SHS) exposure at home before and after the implementation of the Tobacco Free Cities (TFC) initiative in all five participating Chinese cities in 2015 and 2018

Demographic Characteristics	Year 2015 (N=9,943)		Year 2018 (N=10,086)		P value
	Percent	95% CI	Percent	95% CI	
<i>Total</i>	39.80	36.89 - 42.71	34.65	31.49 - 37.81	0.0178
<i>Sex</i>					
Male	44.58	41.19 - 47.97	41.36	37.37 - 45.35	0.2293
Female	34.73	31.65 - 37.8	27.70	24.82 - 30.58	0.0009
<i>Age (Years)</i>					
15-24	42.70	37.81 - 47.6	37.56	32.86 - 42.26	0.1412
25-44	37.40	34.06 - 40.73	31.87	27.97 - 35.78	0.0327
45-64	43.30	39.87 - 46.72	38.33	34.37 - 42.28	0.0627
65 and above	33.94	30.51 - 37.37	28.79	24.65 - 32.93	0.0612
<i>Education Level</i>					
Primary school completed or below	43.35	38.55 - 48.14	39.85	33.74 - 45.97	0.3936
Junior high school completed	43.10	39.26 - 46.93	40.09	35.62 - 44.56	0.3224
Senior high school completed	43.78	40.23 - 47.32	39.24	35.22 - 43.27	0.0974
College degree or above	33.81	30.35 - 37.26	27.71	24.87 - 30.54	0.0052
<i>Occupation</i>					
Gov. employee, teacher, healthcare provider	31.63	26.29 - 36.98	30.81	26.11 - 35.51	0.7085
Factory, business, service industry employee	41.63	38.18 - 45.08	35.96	32.03 - 39.9	0.0299
Not in the labor force ¹	39.96	36.97 - 42.95	34.64	30.97 - 38.30	0.0288
<i>Current smoking status</i>					
Yes	74.61	71.09 - 78.12	72.07	68.01 - 76.12	0.3518
No	29.38	26.63 - 32.13	23.15	20.45 - 25.85	0.0015

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

Adjusted odds ratios (ORs) of P30D SHS exposure at workplaces, restaurants, and homes

Table 4 presented adjusted odds ratios between SHS exposure and survey year, socio-demographic characteristics, and smoking status using multivariate logistic regressions. Urban adult residents from all five cities were significantly less likely to report P30D SHS exposure in indoor workplaces (aOR=0.70, 95% CI: 0.57-0.86), indoor areas of restaurants (aOR=0.63, 95% CI: 0.52-0.75), and at home (aOR=0.76, 95% CI: 0.63-0.93) in 2018 compared to in 2015. Men were more likely to report P30D SHS exposure in indoor workplaces (aOR=1.52, 95% CI: 1.32-1.76) and indoor areas of restaurants (aOR=1.24, 95% CI: 1.11-1.38), but less likely to report P30D SHS exposure at home (aOR=0.59, 95% CI: 0.51-0.68) than women. Compared with adults aged 65 years or above, adults in

1
2
3 younger age groups were more likely to report P30D SHS exposure in indoor areas of restaurants and at
4 home. In addition, adults with higher education levels were less likely to report P30D SHS exposure in
5 restaurants and homes compared to adults with primary school completed or below. Compared with
6 government employees, teachers, or healthcare providers, people who worked in factories, businesses,
7 and service industries were more likely to be exposed to workplace SHS in the past 30 days (aOR=1.49,
8 95% CI: 1.26-1.77). In addition, current smokers were found significantly more likely to be exposed to
9 SHS than their nonsmoking counterparts in indoor workplaces (aOR=2.20, 95% CI: 1.83-2.63), indoor
10 areas of restaurants (aOR=1.88, 95% CI: 1.59-2.21), and at home (aOR=11.27, 95% CI: 9.62-13.20) in
11 the past 30 days. Subgroup analyses results by sex and current smoking status were presented in
12 Supplemental Tables 4-9. Generally, there were no significant differences in SHS exposure changes
13 between men and women, and between current smokers and nonsmokers, controlling for other covariates.
14 City-specific analyses results were presented in Supplemental Tables 10-12. Again, no significant
15 differences were found across cities in terms of SHS exposure changes between 2015 and 2018.
16
17
18
19
20
21
22
23
24
25

26 Table 4: Adjusted¹ odds ratios (ORs) between P30D secondhand smoke (SHS) exposure and survey year,
27 socio-demographic characteristics, and smoking status in indoor workplaces, indoor areas of restaurants,
28 and homes in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and
29 2018
30

Indicators	Workplaces (n=9,587)		Restaurants (n=13,239)		Home (n=19,712)	
	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>						
2015	Ref.		Ref.		Ref.	
2018	0.71	0.58 - 0.88	0.63	0.52 - 0.75	0.76	0.63 - 0.93
<i>Sex</i>						
Male	1.53	1.32 - 1.76	1.24	1.11 - 1.38	0.59	0.51 - 0.68
Female	Ref.		Ref.		Ref.	
<i>Age Group</i>						
15-24	1.77	0.79 - 3.98	1.15	0.91 - 1.45	2.06	1.67 - 2.55
25-44	1.62	0.73 - 3.60	1.31	1.08 - 1.59	1.25	1.04 - 1.50
45-64	1.85	0.84 - 4.07	1.35	1.10 - 1.65	1.21	1.05 - 1.40
65 and above	Ref.		Ref.		Ref.	
<i>Education</i>						
Primary school completed or below	Ref.		Ref.		Ref.	
Junior high school completed	0.65	0.45 - 0.95	1.02	0.82 - 1.26	0.82	0.69 - 0.96
Senior high school completed	0.62	0.44 - 0.89	0.93	0.75 - 1.16	0.77	0.65 - 0.91
College degree or above	0.50	0.34 - 0.74	0.91	0.73 - 1.14	0.52	0.43 - 0.63
<i>Occupation</i>						
Gov. employee, teacher, healthcare provider	Ref.		1.01	0.83 - 1.23	0.86	0.71 - 1.04

Factory, business, service industry employee	1.56	1.32 - 1.85	1.17	1.02 - 1.35	0.98	0.86 - 1.13
Not in the labor force ²			Ref.		Ref.	
<i>Current smoking status</i>						
Yes	2.21	1.84 - 2.65	1.88	1.59 - 2.21	11.27	9.62 - 13.20
No	Ref.		Ref.		Ref.	

¹ Multivariate logistic regression models were used to estimate the adjusted ORs, controlling survey year, sex, age, education, occupation, and current smoking status.

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work.

Discussion

This study analyzed data from two citywide representative household surveys conducted before and after the implementation of the TFC initiative in five participating Chinese cities. Our study results showed that across all five Chinese cities, the rates of P30D SHS exposure declined significantly in indoor workplaces, indoor areas of restaurants, and homes from 2015 to 2018. In addition, compared with the overall levels of P30D SHS exposure reported in the nationwide surveys over the same time period,^{8 13} the decline of P30D SHS exposure in indoor workplaces and indoor areas of restaurants was significantly larger in these five TFC cities (see Table 5), indicating the potential effectiveness of the TFC initiative in reducing SHS exposure in public indoor areas in large Chinese cities. The decline in SHS exposure in workplaces, restaurants, and homes in China was similar to those observed in other Asian countries that have adopted smoke-free policies over the past decade.²⁷ It is notable that the decrease in SHS exposure at home in our five study cities (from 39.8% to 34.7%) was less than that at the national level (from 57.1% to 44.9%) between 2015 and 2018, and that smoking prevalence did not change in these five cities from 2015 to 2018 despite the TFC initiative. Although these results were consistent with the hypothesis of substitution of smoking in public indoor places with home smoking because of the implementation of smoke-free policies at public indoor places,^{28 29} individual level longitudinal data are needed to examine whether prohibiting smoking in public indoor places had the unintended consequences of increasing smoking at home.

Table 5. Secondhand smoke (SHS) exposure in indoor workplaces, indoor areas of restaurants and homes in 2015 and 2018 nationwide in China and in the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative

	Indoor workplace			Indoor Restaurants			Home		
	2015	2018	% change	2015	2018	% change	2015	2018	% change
CATS ¹	54.3	50.9	6.3%	76.3	73.3	3.9%	57.1	44.9	21.4%

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

TQS ²	49.6	41.2	16.9%	72.4	61.7	14.7%	39.8	34.7	12.9%
------------------	------	------	-------	------	------	-------	------	------	-------

¹ CATS, China Adult Tobacco Survey, conducted in 2015 and 2018, consisted of a representative sample of adults in China.

² TQS, Tobacco Questions for Survey, conducted in 2015 and 2018 in the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative consisted of a representative sample of adult urban residents in these five cities.

Our results also showed that the change of P30D SHS exposure between 2015 and 2018 varied across population subgroups characterized by demographic and socioeconomic characteristics and smoking status. For example, although the P30D SHS exposure in indoor areas of restaurants did not change among adult urban residents with primary school completed or below between 2015 and 2018, it decreased significantly for those with higher education levels during the same period. Given that education level was positively correlated with socioeconomic status (SES), respondents with higher SES may be more likely to dine in restaurants that were more likely to have smoke-free air policies, or the policies were better implemented/enforced. The subgroup analysis in our study revealed important variations in P30D SHS exposure that were not reported by previous national surveys, which only reported P30D SHS exposure at the national level.

In addition, our study found that the associations between P30D SHS exposure and individual characteristics varied by venue, which contributes to the existing literature that has so far focused primarily on SHS exposure in homes and in overall public indoor areas in China. Consistent with previous findings, our study also found that, in general, being younger, having lower levels of education, and being current smokers were associated with higher rates of SHS exposure.^{11 30 31} As discussed previously, age and education level were usually positively associated with income, or SES, therefore, younger respondents or respondents having lower levels of education may be more likely to work, dine, or live in places that had higher rates of smoking, hence more likely to be exposed to SHS. Smokers may be more likely to have peers who smoke, therefore exposing themselves to the SHS produced by their smoking peers. In addition, smokers would be exposed to SHS if they themselves smoked in workplaces, restaurants, and their homes. Our study further revealed that the strengths of the associations varied by venue. For example, the association between smoking status and SHS exposure at home was much stronger than in restaurants (aOR: 11.27 vs. 1.88). This may be due to the fact that home smoking restrictions are not common in China.^{32 33}

Furthermore, our study found that men were significantly more likely to be exposed to SHS than women in workplaces and restaurants, but less likely to be exposed at home, controlling for survey year and other individual characteristics. Previous studies also indicated that men were more likely to be exposed to SHS generally,³⁴ but women were more likely to be exposed to SHS at home.³⁵ Given the

1
2
3 disproportional high smoking prevalence among men in China (about 50% for men and 2% for women),⁸
4 these findings suggested that many married women in China were exposed to SHS at home because of
5 their smoking husbands. A decline in SHS exposure at home could be expected if more Chinese male
6 smokers quit smoking as China further strengthens its tobacco control policies.
7
8
9

10 It is worth noting that compared with people who were government employees, teachers, and
11 healthcare providers, people who worked in factories, businesses, and service industries were found to be
12 more likely to be exposed to SHS at workplaces, controlling for the survey year and other individual
13 characteristics. This difference, which was not identified by previous studies, could be partially attributed
14 to the implementation of national-level smoke-free policies in government buildings, healthcare facilities,
15 and schools.^{4 8 13}
16
17
18
19

20 Our study provided important evidence to support the implementation of tobacco control
21 interventions, such as the TFC initiative, which included implementing smoke-free policies, health
22 education/mass media campaigns, and cessation interventions. Our results show that these interventions
23 have the potential to reduce SHS exposure in indoor public places, such as workplaces and restaurants.
24 Although SHS exposure had decreased in China from 2015 to 2018, the prevalence of smoking among
25 men and SHS exposure of all population subgroups are still alarmingly high in China. China ratified the
26 WHO Framework Convention on Tobacco Control (FCTC) in 2005,³⁶ which required universal protection
27 of SHS exposure in public indoor places.³⁷ Unfortunately, to date, China still does not have a nationwide
28 comprehensive smoke-free air policy to prevent SHS exposure in public indoor areas. In Chinese cities
29 where smoke-free policies have been adopted, the strengths of policies and the enforcement of such
30 policies varied significantly.^{14 15} The findings of our study indicated that, in the absence of a national level
31 smoke-free policy, cities can play an important role in local tobacco control and protect their residents
32 from the harm of SHS through adoption of comprehensive, strong, and well-enforced citywide tobacco
33 control policies and programs.
34
35
36
37
38
39
40
41
42

43 Our study has limitations. First, the associations between SHS exposure and individual level
44 characteristics were estimated based on data from surveys conducted in five participating cities, therefore,
45 our results may not be generalized to other cities or rural areas in China. Second, smoking status and SHS
46 exposure at three venues were self-reported, which may suffer from recall bias and social desirability
47 bias.^{38 39} In addition, since the data we used were from pooled cross-sectional surveys, we were not able to
48 estimate changes of SHS exposure before and after the implementation of the TFC initiative at the
49 individual level.
50
51
52
53
54
55
56
57
58
59
60

Conclusion

The P30D SHS exposure in indoor workplaces, restaurants, and homes decreased significantly in five large Chinese cities that implemented the TFC initiative between 2015 and 2018. The TFC initiative activities include citywide smoke-free policies in public indoor venues, targeted media and education campaigns, and cessation interventions effort to help smokers quit. Exposure to SHS in China can be further reduced by expanding the TFC initiative to other Chinese cities without comprehensive tobacco control policies/programs.

For peer review only

References

1. US Department of Health and Human Services. The health consequences of smoking—50 years of progress: a report of the Surgeon General: Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, 2014.
2. US Department of Health and Human Services. The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General: Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, 2006.
3. Prevention and Health Promotion (US), Office on Smoking and Health (US). How tobacco smoke causes disease: the biology and behavioral basis for smoking-attributable disease: a report of the Surgeon General: US Government Printing Office 2010.
4. Yang G, Wang Y, Wu Y, et al. The road to effective tobacco control in China. *The Lancet* 2015;385(9972):1019-28.
5. King BA, Mirza SA, Babb SD. A cross-country comparison of secondhand smoke exposure among adults: findings from the Global Adult Tobacco Survey (GATS). *Tobacco control* 2013;22(4):e5-e5.
6. Asma S. The GATS atlas: global adult tobacco survey. 2015
7. Mbulo L, Palipudi KM, Andes L, et al. Secondhand smoke exposure at home among one billion children in 21 countries: findings from the Global Adult Tobacco Survey (GATS). *Tobacco control* 2016;25(e2):e95-e100.
8. China Center of Disease Control and Prevention. Global Adult Tobacco Survey Fact Sheet - China 2018 [cited 2020 Feb 20]. Available from: https://www.who.int/docs/default-source/wpro---documents/countries/china/2018-gats-china-factsheet-cn-en.pdf?sfvrsn=3f4e2da9_2.
9. Nan Y, Xi Z, Yang Y, et al. The 2015 China Adult Tobacco Survey: exposure to second-hand smoke among adults aged 15 and above and their support to policy on banning smoking in public places. *Zhonghua liu xing bing xue za zhi= Zhonghua liuxingbingxue zazhi* 2016;37(6):810-15.
10. Fong GT, Sansone G, Yan M, et al. Evaluation of smoke-free policies in seven cities in China, 2007–2012. *Tobacco control* 2015;24(Suppl 4):iv14-iv20.
11. Ye X, Yao Z, Gao Y, et al. Second-hand smoke exposure in different types of venues: before and after the implementation of smoke-free legislation in Guangzhou, China. *BMJ open* 2014;4(2)
12. Yang G. Tobacco Control in China: Springer 2018.
13. Chinese Center for Disease Control and Prevention. 2015 China Adult Tobacco Survey Report 2016 [Available from: <http://www.tcrc.org.cn/UploadFiles/2016-03/318/201603231215175500.pdf> accessed March 28 2020.
14. Lin H, Chang C, Liu Z, et al. Subnational smoke-free laws in China. *Tobacco induced diseases* 2019;17
15. Wan X, Stillman F, Liu H, et al. Development of policy performance indicators to assess the implementation of protection from exposure to secondhand smoke in China. *Tobacco control* 2013;22(suppl 2):ii9-ii15.
16. Koplan J, Redmon P, Duan Y, et al. The role of cities in reducing smoking in China. *Annals of Global Health* 2015;1(81):36.
17. Sansone G, Fong GT, Yan M, et al. Secondhand smoke exposure and support for smoke-free policies in cities and rural areas of China from 2009 to 2015: a population-based cohort study (the ITC China Survey). *BMJ open* 2019;9(12)

18. Yu S, Duan Z, Redmon PB, et al. mHealth intervention is effective in creating smoke-free homes for newborns: A randomized controlled trial study in China. *Scientific Reports* 2017;7(1):1-9.
19. Yang L, Tong EK, Mao Z, et al. A clustered randomized controlled trial to reduce secondhand smoke exposure among nonsmoking pregnant women in Sichuan Province, China. *Nicotine & Tobacco Research* 2016;18(5):1163-70.
20. Stillman F, Navas-Acien A, Ma J, et al. Second-hand tobacco smoke in public places in urban and rural China. *Tobacco control* 2007;16(4):229-34.
21. Xia C, Zheng R, Zeng H, et al. Provincial-level cancer burden attributable to active and second-hand smoking in China. *Tobacco control* 2019;28(6):669-75.
22. Global Adult Tobacco Survey Collaborative Group. Tobacco questions for surveys: A subset of key questions from the Global Adult Tobacco Survey (GATS): Centers for Disease Control and Prevention. Atlanta, GA, 2011.
23. The Global Adult Tobacco Survey (GATS): sample design and related methods. Proceedings of the Section on Survey Methods, Joint Statistical Meetings Alexandria: American Statistical Association; 2010.
24. Huang J, Duan Z, Wang Y, et al. Use of Electronic Nicotine Delivery Systems (ENDS) in China: Evidence from Citywide Representative Surveys from Five Chinese Cities in 2018. *International Journal of Environmental Research and Public Health* 2020;17(7):2541.
25. Redmon P, Huang J, Duan Z, et al. Secondhand Smoke (SHS) Exposure and Perceived Health Risks of Tobacco Use among Urban Residents in Five Cities in China. *Annals of Global Health* 2017;1(83):113-14.
26. Peugh JL, Enders CK. Missing data in educational research: A review of reporting practices and suggestions for improvement. *Review of educational research* 2004;74(4):525-56.
27. US Centers for Disease Control and Prevention. Global Tobacco Surveillance System Data (GTSSData) [Available from: <https://www.cdc.gov/tobacco/global/gtss/gtssdata/index.html> accessed Nov 5 2020.
28. Adda J, Cornaglia F. The effect of bans and taxes on passive smoking. *American Economic Journal: Applied Economics* 2010;2(1):1-32.
29. Ho SY, Wang MP, Lo WS, et al. Comprehensive smoke-free legislation and displacement of smoking into the homes of young children in Hong Kong. *Tobacco Control* 2010;19(2):129-33.
30. Yao T, Sung H-Y, Mao Z, et al. Secondhand smoke exposure at home in rural China. *Economics of Tobacco Control in China: From Policy Research to Practice: World Scientific* 2016:29-42.
31. Jin Y, Wang L, Lu B, et al. Secondhand smoke exposure, indoor smoking bans and smoking-related knowledge in China. *International journal of environmental research and public health* 2014;11(12):12835-47.
32. Abdullah AS, Hua F, Xia X, et al. Second - hand smoke exposure and household smoking bans in Chinese families: a qualitative study. *Health & social care in the community* 2012;20(4):356-64.
33. Ji M, Ding D, Hovell MF, et al. Home smoking bans in an urbanizing community in China. *American journal of preventive medicine* 2009;37(2):132-36.
34. Yang T, Jiang S, Barnett R, et al. Individual and city-level determinants of secondhand smoke exposure in China. *International journal of health geographics* 2015;14(1):36.
35. Yao T, Sung H-Y, Mao Z, et al. Secondhand smoke exposure at home in rural China. *Cancer Causes & Control* 2012;23(1):109-15.
36. World Health Organization. Tobacco in China [Available from: <https://www.who.int/china/health-topics/tobacco> accessed Feb 20 2020.

- 1
- 2
- 3 37. World Health Organization. WHO framework convention on tobacco control: World Health
- 4 Organization 2003.
- 5 38. Coughlin SS. Recall bias in epidemiologic studies. *Journal of clinical epidemiology*
- 6 1990;43(1):87-91.
- 7 39. Grimm P. Social desirability bias. *Wiley international encyclopedia of marketing* 2010
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31
- 32
- 33
- 34
- 35
- 36
- 37
- 38
- 39
- 40
- 41
- 42
- 43
- 44
- 45
- 46
- 47
- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

For peer review only

Funding

This work was supported by Pfizer, Inc. through a grant from the China Tobacco Control Partnership (grant numbers CON009013). The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. The content is solely the responsibility of the authors and does not necessarily represent the official view of Pfizer, Inc. or the China Tobacco Control Partnership.

Conflict of Interest

The authors declare no conflicts of interest.

Authors' Contributions

Conceptualization, J.H. and P.B.R.; methodology, J.H., Z.D. and Y.W.; data collection, P.B.R.; formal analysis, Z.D. and Y.W.; writing—original draft preparation, Z.D. and Y.W.; writing—review and editing, J.H., Z.D., Y.W. and P.B.R.; project administration, M.E. and P.B.R.; funding acquisition, M.P.E. and P.B.R. All authors have read and agreed to the published version of the manuscript.

Data availability statement

De-identified study data can be accessed through a written request to the TFC initiative.

Acknowledgements

Technical assistance was provided by China CDC, Chengdu Institute of Health Education, Wuhan Institute of Health Education, Xiamen CDC, Xi'an Institute of Health Education, the ThinkTank Research Center for Health Development, and RTI International.

Supplemental Table 1. Description of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative and city-specific activities implemented from 2015 to 2018

City, (Population, GDP)	Smoke-Free Policy Goal (n or adoption date)	Policy Inspection Frequency	# of Media Mentions	Health Education/Mass Media Campaigns	Cessation Interventions
Chengdu (16 million, 1.39 trillion yuan)	SF government worksites (n=21) SF business worksites (n=15)	Every 2 months	110	WNTD and CNY mass media campaigns; PSAs on subways; city educational events	Cessation training for healthcare workers
Chongqing (30.75 million, 1.95 trillion yuan)	SF government worksites (n=1500) SF business worksites (n=2)	Twice per year	132	WNTD and CNY mass media campaigns; PSAs on TV and outdoor media outlets	Cessation counseling at two large businesses
Wuhan (10.89 million, 1.34 trillion yuan)	SF government worksites (n=106) SF business worksites (190) SF campus (n=38)	Monthly	102	WNTD and CNY mass media campaigns; PSAs on subways; city educational websites; knowledge competitions via WeChat	Citywide cessation completion; cessation hotline
Xi'an (9.06 million, 746.69 billion)	SF public places (August 2018); effective November 2018 * SF business (n=65) SF homes (n=2200) SF government worksites (n=33)	Quarterly	263	WNTD and CNY mass media campaigns; PSAs on subways; citywide "no butts fall to the ground, Xian is beautiful" campaign	Free cessation clinics; citywide cessation competition
Xiamen (4.1 million, 435 billion yuan)	SF business worksites (n=86) SF scenery districts, including a UNESCO site(n=3)	Twice per year	116	WNTD and CNY mass media campaigns; SF business awards ceremonies	Cessation services provided to SF government and business workers

Abbreviations: World No Tobacco Day (WNTD); Chinese New Year (CNY); Public Service Announcements (PSA)

* Xi'an implemented their city-wide smoke-free law after the Wave 2 survey was conducted

Supplemental Table 2. Sample size, response rate, and survey date for each of the five Chinese cities participated in the Tobacco Free Cities (TFC) initiative, 2015 and 2018

Locations	Number of Interviews			Response Rate ¹	Survey Date
	Overall	Male	Female		
Year 2015 (N=10,184)					
Chengdu	1,946	903	1,043	89.6%	Feb 2016 - Mar 2016
Chongqing	1,852	843	1,009	79.8%	Oct 2015 - Nov 2015
Wuhan	2,163	1,018	1,145	98.3%	Oct 2015 - Dec 2015
Xiamen	2,174	1,055	1,119	92.5%	Oct 2015 - Jan 2016
Xi'an	2,049	962	1,087	89.4%	Nov 2015 - Feb 2016
2018 (N=10,233)					
Chengdu	1,914	876	1,038	93.5%	Feb 2018 - April 2018
Chongqing	1,829	837	992	90.8%	Sep 2017 - Nov 2017
Wuhan	2,251	1,158	1,093	97.8%	Dec 2017 - Jan 2018
Xiamen	2,116	1,121	995	89.7%	April 2018 - May 2018
Xi'an	2,123	1,092	1,031	87.2%	June 2018 - July 2018

¹ Overall response rate is a product of household response rate and individual response rate

Supplemental Table 3. Demographic characteristics of adult urban residents in all five Chinese cities participated in the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Demographic Characteristics	2015 (N=10,184)		2018 (N=10,233)	
	n	%	n	%
Sex				
Male	4781	51.58	4897	50.75
Female	5403	48.42	5336	49.25
Age (Years)				
15-24	940	18.97	840	20.37
25-44	4222	40.84	4124	39.44
45-64	3354	29.73	3539	29.72
65 and above	1668	10.45	1730	10.47
Education Level				
Primary school completed or below	1626	10.86	1325	9.39
Junior high school completed	2317	22.12	2265	20.51
Senior high school completed	2825	30.08	2821	28.15
College degree or above	3304	36.95	3759	41.95
Occupation				
Government employee, teacher, healthcare provider	972	10.69	1080	11.47
Factory, business, service industry employee	4358	45.63	3795	37.84
Not in the labor force ¹	4773	43.68	5231	50.69
Current smoking status				
Yes	2275	22.75	2339	23.36
No	7909	77.25	7885	76.64

¹ Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 4. Subgroup analysis by gender: adjusted ORs¹ for SHS exposure in indoor workplaces in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Male		Female	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.72	0.56 - 0.91	0.70	0.55 - 0.90
<i>Age Group</i>				
15-24	1.52	0.59 - 3.90	1.92	0.44 - 8.44
25-34	1.40	0.57 - 3.44	1.73	0.41 - 7.40
35-64	1.70	0.71 - 4.08	1.83	0.42 - 7.96
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.80	0.46 - 1.38	0.62	0.40 - 0.95
Senior high school completed	0.85	0.50 - 1.44	0.51	0.34 - 0.77
College degree or above	0.70	0.41 - 1.18	0.40	0.26 - 0.63
<i>Occupation</i>				
Government employee, teacher, healthcare provider	Ref.		Ref.	
Factory, business, service industry employee	1.79	1.45 - 2.21	1.33	1.03 - 1.71
<i>Current smoking status</i>				
Yes	2.23	1.84 - 2.71	2.14	1.18 - 3.87
No	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 5. Subgroup analysis by gender: adjusted ORs¹ for SHS exposure in the home in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Male		Female	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.57	0.46 - 0.71	0.68	0.55 - 0.84
<i>Age Group</i>				
15-24	1.15	0.83 - 1.59	1.16	0.85 - 1.56
25-34	1.21	0.93 - 1.57	1.44	1.11 - 1.86
35-64	1.33	1.01 - 1.75	1.39	1.09 - 1.76
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	1.06	0.75 - 1.51	0.99	0.77 - 1.27
Senior high school completed	1.01	0.72 - 1.41	0.87	0.68 - 1.13
College degree or above	0.97	0.69 - 1.36	0.88	0.67 - 1.16
<i>Occupation</i>				
Government employee, teacher, healthcare provider	0.95	0.73 - 1.23	1.07	0.84 - 1.36
Factory, business, service industry employee	1.19	0.97 - 1.47	1.15	0.97 - 1.37
Not in the labor force ²	Ref.		Ref.	
<i>Current smoking status</i>				
Yes	1.84	1.54 - 2.19	2.64	1.76 - 3.96
No	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 6. Subgroup analysis by gender: adjusted ORs¹ for SHS exposure in the restaurant in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Male		Female	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.82	0.63 - 1.05	0.72	0.59 - 0.88
<i>Age Group</i>				
15-24	2.89	2.13 - 3.93	1.44	1.09 - 1.91
25-34	1.00	0.76 - 1.30	1.35	1.08 - 1.68
35-64	0.91	0.73 - 1.14	1.43	1.20 - 1.71
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.68	0.53 - 0.87	0.91	0.75 - 1.11
Senior high school completed	0.68	0.54 - 0.85	0.85	0.69 - 1.05
College degree or above	0.49	0.37 - 0.64	0.56	0.45 - 0.70
<i>Occupation</i>				
Government employee, teacher, healthcare provider	0.87	0.64 - 1.18	1.23	0.99 - 1.52
Factory, business, service industry employee	0.92	0.73 - 1.15	1.09	0.86 - 1.39
Not in the labor force force ^	Ref.		Ref.	
<i>Current smoking status</i>				
Yes	13.53	11.12 - 15.46	9.87	6.55 - 14.89
No	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 7. Subgroup analysis by current smoking status: adjusted ORs¹ for SHS exposure in the workplace in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Current smoker		Current non-smoker	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.65	0.47 - 0.90	0.73	0.58 - 0.91
<i>Gender</i>				
Male	1.42	0.75 - 2.70	1.54	1.33 - 1.79
Female	Ref.		Ref.	
<i>Age Group</i>				
15-24	0.96	0.28 - 3.29	2.09	0.70 - 6.30
25-34	1.16	0.36 - 3.76	1.82	0.62 - 5.35
35-64	1.84	0.59 - 5.72	1.80	0.62 - 5.23
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.89	0.42 - 1.89	0.60	0.40 - 0.89
Senior high school completed	0.83	0.39 - 1.77	0.57	0.39 - 0.82
College degree or above	0.73	0.34 - 1.60	0.44	0.29 - 0.66
<i>Occupation</i>				
Government employee, teacher, healthcare provider	Ref.		Ref.	
Factory, business, service industry employee	1.73	1.20 - 2.50	1.52	1.22 - 1.89

¹ Controlling gender, age, education, occupation, and current smoking status

Supplemental Table 8. Subgroup analysis by current smoking status: adjusted ORs¹ for SHS exposure in the home in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Current smoker		Current non-smoker	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.57	0.42 - 0.79	0.63	0.53 - 0.76
<i>Gender</i>				
Male	0.90	0.61 - 1.33	1.26	1.12 - 1.42
Female	Ref.		Ref.	
<i>Age Group</i>				
15-24	1.47	0.84 - 2.59	1.10	0.86 - 1.41
25-34	1.33	0.84 - 2.10	1.32	1.08 - 1.62
35-64	1.81	1.17 - 2.80	1.25	1.02 - 1.54
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.75	0.43 - 1.29	1.11	0.88 - 1.40
Senior high school completed	0.73	0.43 - 1.24	0.99	0.78 - 1.26
College degree or above	0.79	0.45 - 1.38	0.95	0.74 - 1.22
<i>Occupation</i>				
Government employee, teacher, healthcare provider	0.66	0.45 - 0.99	1.10	0.89 - 1.36
Factory, business, service industry employee	1.11	0.83 - 1.49	1.18	1.02 - 1.37
Not in the labor force ²	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 9. Subgroup analysis by current smoking status: adjusted ORs¹ for SHS exposure in the restaurant in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Current smoker		Current non-smoker	
	OR	95% CI	OR	95% CI
<i>Year</i>				
2015	Ref.		Ref.	
2018	0.86	0.65 - 1.13	0.74	0.60 - 0.90
<i>Gender</i>				
Male	0.73	0.48 - 1.10	0.58	0.50 - 0.67
Female	Ref.		Ref.	
<i>Age Group</i>				
15-24	1.72	1.06 - 2.78	2.12	1.67 - 2.69
25-34	1.03	0.72 - 1.46	1.31	1.07 - 1.59
35-64	1.07	0.76 - 1.50	1.23	1.05 - 1.44
65 and above	Ref.		Ref.	
<i>Education</i>				
Primary school completed or below	Ref.		Ref.	
Junior high school completed	0.57	0.41 - 0.81	0.87	0.72 - 1.05
Senior high school completed	0.56	0.40 - 0.78	0.82	0.67 - 0.99
College degree or above	0.37	0.25 - 0.55	0.55	0.45 - 0.69
<i>Occupation</i>				
Government employee, teacher, healthcare provider	1.08	0.82 - 1.42	1.18	0.98 - 1.42
Factory, business, service industry employee	1.13	0.82 - 1.57	1.19	0.99 - 1.48
Not in the labor force ²	Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 10. Adjusted ORs¹ for SHS exposure in the workplace by city and in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Chengdu		Chongqing		Wuhan		Xiamen		Xi'an		Overall	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>												
2015	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
2018	0.82	0.54 - 1.26	0.73	0.45 - 1.19	0.60	0.39 - 0.92	0.61	0.38 - 0.96	0.73	0.45 - 1.18	0.71	0.58 - 0.88
<i>Gender</i>												
Male	1.64	1.26 - 2.14	1.53	1.09 - 2.16	1.36	0.98 - 1.88	1.64	1.19 - 2.26	1.61	1.17 - 2.22	1.53	1.32 - 1.76
Female	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Age Group</i>												
15-24	1.42	0.27 - 7.51	3.37	0.73 - 15.49	0.63	0.15 - 2.72	1.05	0.30 - 3.66	2.69	0.42 - 17.09	1.77	0.79 - 3.98
25-34	0.98	0.19 - 5.13	3.03	0.68 - 13.58	0.92	0.20 - 4.14	1.21	0.39 - 3.77	2.27	0.36 - 14.14	1.62	0.73 - 3.60
35-64	1.23	0.23 - 6.57	2.47	0.54 - 11.24	1.06	0.27 - 4.13	1.79	0.63 - 5.14	2.69	0.45 - 16.20	1.85	0.84 - 4.07
65 and above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Education</i>												
Primary school completed	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Junior high school completed	0.33	0.13 - 0.81	0.66	0.31 - 1.43	0.89	0.33 - 2.38	0.64	0.43 - 0.95	2.11	0.70 - 6.35	0.65	0.45 - 0.95
Senior high school completed	0.19	0.08 - 0.43	0.58	0.26 - 1.29	0.94	0.31 - 2.81	0.90	0.59 - 1.37	1.46	0.53 - 4.03	0.62	0.44 - 0.89
College degree or above	0.17	0.07 - 0.41	0.47	0.20 - 1.10	0.73	0.25 - 2.11	0.58	0.34 - 1.01	1.17	0.43 - 3.15	0.50	0.34 - 0.74
<i>Occupation</i>												
Government employee, teacher, healthcare provider	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Factory, business, service industry employee	1.64	1.12 - 2.41	1.66	1.18 - 2.35	1.50	1.05 - 2.13	1.32	0.83 - 2.09	1.53	1.09 - 2.13	1.56	1.32 - 1.85
<i>Current smoking status</i>												
Yes	2.15	1.51 - 3.06	1.87	1.20 - 2.92	3.35	2.30 - 4.86	2.20	1.57 - 3.10	2.00	1.30 - 3.10	2.21	1.84 - 2.65
No	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

¹Controlling gender, age, education, occupation, and current smoking status

Supplemental Table 11. Adjusted ORs¹ for SHS exposure in the home by city and in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Chengdu		Chongqing		Wuhan		Xiamen		Xi'an		Overall	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>												
2015	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
2018	0.80	0.54 - 1.20	0.65	0.45 - 0.95	0.86	0.54 - 1.40	0.73	0.42 - 1.28	0.78	0.54 - 1.13	0.76	0.63 - 0.93
<i>Gender</i>												
Male	0.50	0.38 - 0.66	0.61	0.45 - 0.81	0.54	0.33 - 0.90	0.62	0.47 - 0.81	0.67	0.53 - 0.83	0.59	0.51 - 0.68
Female	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Age Group</i>												
15-24	1.71	1.09 - 2.68	1.15	0.76 - 1.76	1.91	1.15 - 3.17	3.03	2.02 - 4.56	3.27	2.13 - 5.02	2.06	1.67 - 2.55
25-34	1.20	0.83 - 1.73	1.00	0.73 - 1.36	1.00	0.65 - 1.53	2.11	1.43 - 3.11	1.37	0.90 - 2.08	1.25	1.04 - 1.50
35-64	1.20	0.90 - 1.59	1.10	0.81 - 1.49	0.94	0.71 - 1.23	1.50	1.10 - 2.05	1.46	1.07 - 1.99	1.21	1.05 - 1.40
65 and above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Education</i>												
Primary school completed	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Junior high school completed	0.85	0.59 - 1.23	1.00	0.75 - 1.34	1.27	0.86 - 1.85	0.37	0.28 - 0.50	0.80	0.55 - 1.19	0.82	0.69 - 0.96
Senior high school completed	0.72	0.50 - 1.04	1.05	0.80 - 1.38	1.18	0.84 - 1.64	0.35	0.24 - 0.52	0.74	0.49 - 1.13	0.77	0.65 - 0.91
College degree or above	0.55	0.38 - 0.79	0.77	0.55 - 1.08	0.62	0.41 - 0.94	0.21	0.13 - 0.33	0.51	0.33 - 0.80	0.52	0.43 - 0.63
<i>Occupation</i>												
Government employee, teacher, healthcare provider	0.94	0.58 - 1.52	0.94	0.62 - 1.42	0.82	0.55 - 1.23	0.94	0.63 - 1.41	0.70	0.47 - 1.05	0.86	0.71 - 1.04
Factory, business, service industry employee	0.98	0.73 - 1.31	1.01	0.79 - 1.30	1.12	0.81 - 1.55	0.83	0.61 - 1.12	0.96	0.70 - 1.31	0.98	0.86 - 1.13
Not in the labor force ²	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Current smoking status</i>												
Yes	17.36	12.69 - 23.77	10.34	7.55 - 14.15	11.28	7.1 - 17.92	8.68	6.19 - 12.18	10.83	8.06 - 14.57	11.27	9.62 - 13.20
No	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

Supplemental Table 12. Adjusted ORs¹ for SHS exposure in the restaurant by city and in all five Chinese cities participating the Tobacco Free Cities (TFC) initiative in 2015 and 2018

Indicators	Chengdu		Chongqing		Wuhan		Xiamen		Xi'an		Overall	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<i>Year</i>												
2015	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
2018	0.65	0.42 - 0.98	0.55	0.37 - 0.80	0.76	0.51 - 1.15	0.62	0.45 - 0.86	0.60	0.40 - 0.88	0.63	0.52 - 0.75
<i>Gender</i>												
Male	1.09	0.87 - 1.36	1.21	0.96 - 1.53	1.14	0.91 - 1.41	1.83	1.28 - 2.62	1.31	1.03 - 1.68	1.24	1.11 - 1.38
Female	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Age Group</i>												
15-24	1.33	0.78 - 2.27	1.10	0.69 - 1.75	1.18	0.77 - 1.81	1.96	1.20 - 3.21	1.42	0.92 - 2.22	1.15	0.91 - 1.45
25-34	1.04	0.68 - 1.60	1.69	1.14 - 2.50	1.37	0.97 - 1.94	2.11	1.26 - 3.53	1.51	1.08 - 2.11	1.31	1.08 - 1.59
35-64	1.18	0.78 - 1.78	1.54	0.98 - 2.42	1.51	1.06 - 2.14	1.56	0.97 - 2.49	1.33	0.91 - 1.94	1.35	1.10 - 1.65
65 and above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Education</i>												
Primary school completed	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Junior high school completed	1.05	0.68 - 1.64	0.83	0.55 - 1.26	1.18	0.65 - 2.18	1.06	0.74 - 1.52	1.50	0.87 - 2.58	1.02	0.82 - 1.26
Senior high school completed	1.01	0.61 - 1.65	0.74	0.49 - 1.14	1.37	0.78 - 2.40	0.97	0.60 - 1.57	1.06	0.61 - 1.83	0.93	0.75 - 1.16
College degree or above	0.90	0.56 - 1.46	0.90	0.59 - 1.37	1.25	0.70 - 2.25	1.00	0.64 - 1.56	0.96	0.57 - 1.63	0.91	0.73 - 1.14
<i>Occupation</i>												
Government employee, teacher, healthcare provider	0.87	0.57 - 1.32	0.73	0.48 - 1.11	1.07	0.71 - 1.62	1.36	0.87 - 2.14	1.36	0.95 - 1.95	1.01	0.83 - 1.23
Factory, business, service industry employee	1.12	0.87 - 1.43	1.01	0.71 - 1.42	1.01	0.75 - 1.35	1.53	1.13 - 2.07	1.50	1.07 - 2.12	1.17	1.02 - 1.35
Not in the labor force ²	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<i>Current smoking status</i>												
Yes	1.82	1.35 - 2.46	1.93	1.35 - 2.75	2.27	1.71 - 3.03	1.84	1.20 - 2.83	1.68	1.1 - 2.56	1.88	1.59 - 2.21
No	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

¹ Controlling gender, age, education, occupation, and current smoking status

² Respondents who were not in the labor force included students, homemakers, retired and unemployed residents either able or unable to work

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5, 6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6, 7
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6, 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7
		(e) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	8,9,10,11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8,9,10,11,12,13
		(b) Report category boundaries when continuous variables were categorized	8,9,10,11,12,13
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	13,14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13,14,15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.