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Frequency-risk relationships between second-hand smoke exposure and respiratory symptoms among adolescents in Guangzhou, China

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4 **1 Frequency-risk relationships between second-hand smoke exposure and**
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6 **2 respiratory symptoms among adolescents in Guangzhou, China**
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3 20 **ABSTRACT**

4 21 **Objectives:** Although previous studies have suggested an association between second-hand smoke
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7 22 (SHS) exposure and respiratory symptoms, current evidence is inconsistent. Additionally, it
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10 23 remains unclear whether there are frequency-risk relationships between SHS exposure and
11
12 24 respiratory symptoms among adolescents.

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14 25 **Methods:** A cross-sectional survey was conducted using a stratified cluster sampling method to
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16
17 26 obtain representative students. The univariable and multivariable logistic regression models were
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19
20 27 fitted to explore the potential frequency-risk relationships between SHS exposure and respiratory
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22 28 symptoms.

23
24 29 **Results:** Among 3575 students, the prevalence of SHS exposure was 49.5% in indoor public
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27 30 places, 34.5% in homes, 22.7% in indoor campuses, and 29.2% in outdoor campuses. There were
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29
30 31 significantly increased risks of respiratory symptoms corresponding to SHS exposure in public
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32 32 places (odds ratio [OR]=1.60, 95% CI 1.30-1.95), in homes (OR=1.53, 95% CI 1.25-1.87), in
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34 33 indoor campuses (OR = 1.43, 95% CI 1.14-1.79) and in outdoor campuses (OR = 1.37, 95% CI
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36 34 1.10-1.69) using no exposure as reference. Notably, we also observed monotonically
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38 35 frequency-risk relationships between setting-specific (e.g., homes, public places, and campuses)
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41 36 SHS exposure and respiratory symptoms.

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43
44 37 **Conclusion:** Our findings suggest that setting-specific SHS exposure is associated with a
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46 38 significant, dose-dependent increase in risk of respiratory symptoms.
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4 **40 Strengths and limitations of this study**

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6 41 ■ SHS exposure in indoor and outdoor campuses is at a high level, which suggests poor
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8 42 compliance with the full smoke-free ban in schools and supports growing concern about SHS
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11 43 exposure in campuses.

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13 44 ■ The most striking findings from this study were that there were monotonically increasing
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15 45 frequency-risk relationships between SHS exposure and respiratory symptoms.

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18 46 ■ The findings highlight the need for further longitudinal studies to establish the causal
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20 47 relationship and its biological mechanisms.
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49 INTRODUCTION

50 It is well established that inhaling second-hand smoke (SHS) is harmful and that no
51 scientific evidence establishes a risk-free level of exposure.^{1,2} To note, a retrospective
52 analysis of data from 192 countries revealed that 40% of children (including 35% of
53 female non-smokers and 33% of male non-smokers) were exposed to SHS, which
54 results in an annual estimate of 603000 deaths attributable to SHS.³ Global youth
55 tobacco surveillance also reported that nearly half the adolescents worldwide were
56 exposed to SHS at home (42.5%) and in public places (55.1%), which constitutes a
57 substantial public health threat and demands urgent intervention.⁴ In recent years,
58 much attention has been focused on SHS exposure in public places and in homes, but
59 there is limited information in published reports regarding SHS exposure in indoor
60 and outdoor campuses among adolescents.

61 Increasing epidemiological studies of adolescents have demonstrated the
62 relations between SHS exposure and respiratory symptoms (such as nose irritation,
63 coughing, and sore throat),⁵⁻⁸ but current evidence is inconsistent. Some studies
64 demonstrated significant positive associations in adolescents,^{9,10} while the report from
65 Malaysian adolescents revealed no association.¹¹ To note, it was unclear whether there
66 are dose-response relationships between SHS exposure and respiratory symptoms.
67 Furthermore, SHS exposure occurs in varying amounts in public places, homes, and
68 other indoor spaces, but few studies have differentiated SHS exposure in indoor and
69 outdoor to make the setting-specific relations between SHS exposure and respiratory
70 symptoms clearer. Of particular concern is that little is known about the effects of

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4 71 SHS exposure from indoor and outdoor campuses on respiratory symptoms, although
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6 72 a significant body of literature has associated indoor SHS exposure with respiratory
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8 73 symptoms. This study builds on previous literature to explore setting-specific (e.g.,
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11 74 public places, homes, and campuses) and frequency-risk relationships between SHS
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13 75 exposure and respiratory symptoms among adolescents.
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18 77 **METHODS**

19 20 78 **Ethics statement**

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23 79 The study was approved by the Ethics Committee of Guangdong Pharmaceutical
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25 80 University, and it was performed in accordance with the approved guidelines. This
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28 81 survey was qualified as involving no risks to participants. All participants provided an
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30 82 informed consent regarding the goals of the study and the willingness to participate.
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35 84 **Study design and data collection**

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38 85 This cross-sectional study was conducted in Guangzhou city, China, from March to
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40 86 April 2016. The target population was high school students in Guangzhou city. A
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42 87 stratified cluster sampling process was used to obtain a representative sample. In the
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45 88 first stage, all high schools were divided into two categories (prestigious or
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47 89 non-prestigious schools) according to level of education and the education quality.
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50 90 Three high schools were randomly sampled from prestigious schools, and four high
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52 91 schools were randomly sampled from non-prestigious schools, with the probability of
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55 92 selection proportional to the number of the schools. In the second stage, classes in the
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4 93 selected schools were randomly sampled with proportional to school enrollment size,
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6 94 and all students in sampled classes were eligible to participate.
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8 95 All interviewers in each school were centrally trained to ensure that the survey
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10 96 was carried out according to the protocol and that operation procedures were identical
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12 97 across all areas. After obtaining informed consent, eligible students were asked to
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14 98 complete a face-to-face survey by trained interviewers. A total of 3833 participants
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16 99 were enrolled in the study, and the effective response rate was 95.4% (3657/3833). To
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18 100 note, only non-smokers were included in the analyses and a total of 3575 non-smokers
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21 101 were included in this study.
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28 103 **Study variables**

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30 104 The main outcome variable was self-reported respiratory symptoms. The respiratory
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32 105 symptoms were defined as persistent coughed or sputum for 3 consecutive months in
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34 106 a row during the past 12 months, as had been used in previous studies.¹²⁻¹⁴ The main
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37 107 independent variable of respiratory symptoms was self-reported SHS exposure, which
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39 108 was defined as non-smokers' inhalation of the smoke exhaled from smokers on ≥ 1 day
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41 109 a week for at least the last six months.¹ SHS exposure was asked separately in indoor
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44 110 public places, in homes, in indoor campuses and in outdoor campuses. Frequency of
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47 111 SHS exposure was continuous data (days/week), and was also categorized into three
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49 112 groups: <1 day/week (no exposure), '1-4 days/week' and '5-7 days/week'. Smoking
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51 113 status was classified as non-smokers and smokers (defined as 'has smoked over 100
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54 114 cigarettes in their lifetime').
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4 115 Covariates including potential mediators and confounders were chosen a priori
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6 116 on the basis of literature review. Potential covariates in our study included age (year),
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8 117 gender (male or female), grade (4-5 or 1-2), only-child (yes or no), monthly pocket
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10 118 money ($<¥100$, $¥100-399$, or $\geq ¥400$), prestigious school (yes or no), father's
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12 119 education (primary school, middle school, or university and above), mother's
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14 120 education (primary school, middle school, or university and above), and asthma
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16 121 history (yes or no).
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23 **Data analysis**

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25 124 All data were entered in duplicate into EpiData version 3.1 database (The EpiData
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27 125 Association, Odense Denmark). The univariable and multivariable logistic regression
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29 126 models were fitted to calculate the odds ratios (ORs) and 95% confidence intervals
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31 127 (CIs) for evaluating the frequency-risk relationships between SHS exposure
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33 128 (including ordinal and continuous variables) and respiratory symptoms. Linear trends
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35 129 of SHS exposure were assessed by modeling exposure as continuous variables
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37 130 (arithmetic or logarithmic scale) or ordinal variables in multivariable models.
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39 131 Two-sided p-value of ≤ 0.05 was regarded as being of statistical significance. All
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41 132 statistical analyses were conducted using Stata version 14.0 (StataCorp LP, College
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43 133 Station, Texas, USA).
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51 **RESULTS**

52 **Characteristics of the sample**

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4 137 Sample characteristics are given in [Table 1](#). A total of 3575 non-smoking students
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6 138 were interviewed, of whom 477 (13.3%) were classified as having respiratory
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8 139 symptoms. Participants' mean age was 15.0 ± 1.8 years, and 50.9% were male
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11 140 students. About 62.2% of the students were the only child in their family and 63.4%
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13 141 from prestigious schools. The prevalence of SHS exposure in indoor public places,
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15 142 homes, indoor campuses, and outdoor campuses was 49.5%, 34.5%, 22.7% and
16
17 143 29.2%, respectively.
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22 23 145 **Relation between binary SHS exposure and respiratory symptoms**

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25 146 [Table 2](#) shows the relations between binary SHS exposure and respiratory symptoms.
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27
28 147 The prevalence of respiratory symptoms was significantly higher in students with
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30 148 SHS exposure (OR=1.60, 95% CI 1.30-1.95, for SHS in indoor public places;
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32 149 OR=1.53, 95% CI 1.25-1.87, for SHS in homes; OR = 1.43, 95% CI 1.14-1.79, for
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34 150 SHS in indoor campuses) than in those with no exposure. Similar positive
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37 151 associations were observed among students with SHS exposure in indoor campuses
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39 152 from smoking teachers (OR =1.34, 95% CI 1.05-1.71) or from smoking classmates
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41 153 (OR = 1.54, 95% CI 1.15-2.06). To note, the effects of SHS exposure in outdoor
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43 154 campuses cannot be ignored. Students with SHS exposure in outdoor campuses had
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45 155 significantly higher rates of respiratory symptoms (OR = 1.37, 95% CI 1.10-1.69) as
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47 156 compared with unexposed students, and there were similar positive associations
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49 157 between respiratory symptoms and SHS exposure in outdoor campuses from smoking
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51 158 teachers (OR =1.38, 95% CI 1.09-1.75) or from smoking classmates (OR = 1.33, 95%

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4 159 CI 1.03-1.71).

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9 161 **Relation between ordinal SHS exposure and respiratory symptoms**

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11 162 [Table 3](#) indicates the relations between ordinal frequency of SHS exposure and
12
13 163 respiratory symptoms. Compared with no SHS exposure, ordinal frequency of SHS
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15 164 exposure was associated with respiratory symptoms in a increasing manner (SHS in
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17 165 public places: OR=1 for no exposure, OR=1.50 for 1-4 days/week, OR=1.87 for 5-7
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19 166 days/week, p for linear trend <0.001; SHS in indoor campuses: OR=1 for no exposure,
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21 167 OR=1.24 for 1-4 days/week, OR=1.84 for 5-7 days/week, p for linear trend <0.001).

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23 168 When examining the relations by source of exposure, significant increasing trends
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25 169 were observed for SHS exposure in indoor campuses from smoking teachers (p for
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27 170 linear trend =0.001) and from smoking classmates (p for linear trend =0.005).

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29 171 Additionally, there was a significantly increasing relation between ordinal frequency
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31 172 of SHS exposure in outdoor campuses and respiratory symptoms (OR=1 for no
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33 173 exposure, OR=1.28 for 1-4 days/week, OR=1.56 for 5-7 days/week, p for linear trend
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35 174 =0.007), and similar increasing trends were observed for SHS exposure in outdoor
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37 175 campuses from smoking teachers (p for linear trend =0.004) and from smoking
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39 176 classmates (p for linear trend =0.006). However, no increasing trend was observed for
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41 177 SHS exposure in homes.

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46 179 **Relation between continuous SHS exposure and respiratory symptoms**

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48 180 [Table 4](#) presents the relations between continuous frequency of SHS exposure and
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4 181 respiratory symptoms. There are significant frequency-risk relationships between
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6 182 indoor SHS exposure and respiratory symptoms (OR = 2.30, 95% CI: 1.67-3.16, for
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8 183 SHS in indoor public places; OR = 1.64, 95% CI: 1.23-2.20, for SHS in homes; OR =
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10 184 2.09, 95% CI: 1.42-3.07, for SHS in indoor campuses; OR = 1.70, 95% CI: 1.18-2.47,
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12 185 for SHS in outdoor campuses). When examining the relations by source of exposure,
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14 186 there were similar frequency-risk relationships for SHS exposure in indoor or outdoor
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16 187 campuses from smoking teachers or from smoking classmates. Additionally, we
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18 188 observed a monotonically increasing frequency-risk trend for SHS exposure in indoor
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20 189 public places (Figure 1A), in homes (Figure 1B), in indoor campuses (Figure 2A) or
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22 190 in outdoor campuses (Figure 2B). When examining these trends by source of
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24 191 exposure, there were similar increasing frequency-risk trends for SHS exposure from
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26 192 smoking teachers (Figure 3A for indoor SHS and Figure 3B for outdoor SHS) and
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28 193 from smoking classmates (Figure 4A for indoor SHS and Figure 4B for outdoor SHS).

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37 195 **DISCUSSION**

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39 196 This observational study showed that non-smoking students with setting-specific
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41 197 (public places, homes, or campuses) SHS exposure experienced significantly higher
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43 198 risks of respiratory symptoms than those with no exposure. The most striking findings
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45 199 from this study were that there were monotonically increasing frequency-risk
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47 200 relationships between setting-specific SHS exposure and respiratory symptoms. When
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49 201 examining these relations by source of exposure, there were similar monotonically
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51 202 increasing frequency-risk relationships for SHS exposure from smoking teachers and
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4 203 from smoking classmates.
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6 204 It is well known that there is no risk-free level of exposure to SHS. According to
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8 205 the partial smoke-free legislation implemented in Guangzhou on 1 September 2010,
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10 206 full smoke-free ban covered indoor campuses, outdoor campuses and most indoor
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12 207 public places, but did not cover homes. It is disappointing that SHS exposure or
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14 208 smoking behaviors in schools were not eliminated, and were still at a high level
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16 209 (22.7% for SHS exposure in indoor campuses; 29.2% for SHS exposure in outdoor
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18 210 campuses). This observation may be due to poor compliance with the full smoke-free
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20 211 ban in campuses, since we observed that SHS exposure among students was mainly
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22 212 from smoking teachers (indoor SHS: 17.8%; outdoor SHS: 18.4%) and smoking
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24 213 classmates (indoor SHS: 11.9%; outdoor SHS:19.6%) in both indoor and outdoor
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26 214 campuses. Similarly, a recent population-based study in Tehran showed that 29.3%
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28 215 and 29.2% non-smoker students have been exposed to SHS from smoking teachers in
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30 216 indoor and outdoor campuses, respectively, and another survey of Chinese college
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32 217 students reported that 37% of non-smokers had SHS exposure from smoking teachers.
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34 218 ^{15,16} More disappointing was that SHS exposure in indoor public places among
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36 219 students was remarkably high in 49.5% in this study, which is similar to the latest
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38 220 study on adult SHS exposure in Guangzhou (50.3%) and the Global Youth Tobacco
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40 221 Survey (47.8%).^{17,18} However, very few respondents (1-2%) reported smoking in
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42 222 enclosed public places in England after the implementation of comprehensive
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44 223 smoke-free legislation covering all enclosed public places and workplaces.¹⁹ These
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46 224 findings point out the urgent need for a comprehensive smoke-free legislation
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4 225 covering all public places in Guangzhou to protect the public from SHS hazards.
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6 226 A few published studies have indicated that SHS exposure may be a risk factor of
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8 227 respiratory symptoms, but the potential relation for setting-specific exposure was still
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10 228 unclear.²⁰⁻²³ Recent studies of Chinese adolescents indicated that there was a positive
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13 229 relation between household SHS exposure and respiratory symptoms, but the relation
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15 230 for SHS exposure in workplaces or in schools was unknown.^{20,21} In addition, the
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18 231 surveys of London casino workers and Shanghai workers revealed that there was an
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20 232 association between SHS exposure at work and respiratory symptoms, but the
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22 233 association for SHS exposure in homes or in schools was unknown.^{22,23} To note, the
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24 234 influence of SHS exposure from indoor campuses on respiratory symptoms is still
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27 235 unclear, and the potential dose-response association between frequency of SHS
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29 236 exposure and respiratory symptoms is also uncertain. Our study builds on previous
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31 237 literature by exploring the potential dose-response relationships and differentiating
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33 238 SHS exposure in homes, public places, and campuses to make exposure and potential
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35 239 relations clearer. We found that there were positive relations and frequency-risk
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37 240 relationships between setting-specific (public places, homes, or campuses) SHS
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39 241 exposure and respiratory symptoms. When examining the relations by source of
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41 242 exposure, there was still evidence of similar dose-response relationships for SHS
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43 243 exposure in indoor campuses from smoking teachers and smoking classmates. These
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45 244 findings provided new evidence of dose-response relationships between
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47 245 setting-specific SHS exposure and respiratory symptoms among adolescents, and
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49 246 further research is needed to establish the causal relationship and its biological
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4 247 mechanisms.

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6 248 Globally, outdoor smoking restrictions are uncommon, though the
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8 249 outdoor-campus smoking bans implemented in Guangzhou City on 1 September 2010.
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10 250 A few published studies have indicated that smoking increases PM_{2.5} concentrations in
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12 251 outdoor areas to levels that are potentially hazardous to health,^{24,25} but research
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14 252 linking SHS exposures from outdoor environments to health effects is still limit.
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16 253 Notably, the potential relation between outdoor SHS exposure and respiratory
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18 254 symptoms is still unclear. To our knowledge, this is the first study to reveal the
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20 255 relation between SHS exposure in outdoor campuses and respiratory symptoms
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22 256 among adolescents, and found that outdoor SHS exposure was positively associated
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24 257 with respiratory symptoms in a monotonically increasing trend. When examining the
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26 258 relations by source of exposure, there were still similar frequency-risk relationships
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28 259 for SHS exposure in outdoor campuses from smoking teachers and smoking
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30 260 classmates. These findings provide more evidence for the adverse effects of outdoor
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32 261 SHS exposure on human respiratory symptoms, and also support growing concern
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34 262 about SHS exposure in outdoor campuses.
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42 263 The most meaningful advantage of this study is that we contributes additionally
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44 264 to the literature by exploring the potential frequency-risk relationships and
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46 265 differentiating SHS exposure in specific settings (e.g., indoor or outdoor; public
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48 266 places, homes, or campuses) and specific sources (e.g., from smoking teachers or
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50 267 from smoking classmates) to make exposure and potential relations clearer. There are
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52 268 also some potential limitations in this study. First, all data were self-reported,
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4 269 including SHS exposure and respiratory symptoms. For SHS exposure, although
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6 270 biochemical measures can give objective measurements, the biomarkers cannot
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8 271 distinguish the sources of exposure, the key factors in this study. Previous survey has
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10 272 found that school children are capable of reporting their health conditions reliably,²⁶
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12 273 and the presence of frequent cough and phlegm was quite obvious to the students and
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14 274 explicit in the question to avoid measurement error. Second, causal association
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16 275 between SHS exposure and respiratory symptoms could not be ascertained due to the
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18 276 cross-sectional design. However, the notion of reverse causation that students with
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20 277 respiratory symptoms deliberately increased their exposure to noxious SHS seems
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22 278 improbable. The strong association observed in other studies also supported our data
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24 279 validity and provided support for the deduction of causation.^{20,27,28} Finally, few people
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26 280 would be completely unexposed to SHS in densely populated Guangzhou even now,
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28 281 when smoking was still allowed in public places such as amusement parks, restaurants,
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30 282 workplaces, and so on. Therefore, the control groups who reported no SHS exposure
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32 283 have probably underestimated their exposure, and the risk for respiratory symptoms in
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34 284 these groups would also be underestimated.

35
36 285 In conclusion, SHS exposure in indoor and outdoor campuses is still at a high
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38 286 level, which suggests poor compliance with the full smoke-free ban in schools and
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40 287 supports growing concern about SHS exposure in campuses. Additionally, this study
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42 288 contributes to the literature by finding monotonically increasing frequency-risk
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44 289 relationships between SHS exposure and respiratory symptoms among adolescents in
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46 290 addition to differentiating SHS exposure in specific settings and specific sources to
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4 291 make these relationships clearer. Future longitudinal studies are needed to establish
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6 292 the causal relationship and its biological mechanisms.
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11 294 **Contributors**

12
13 295 CZ, LG, LS, JT, XB, CJ and YX were involved in the design of the study, data
14
15 296 analysis and writing of the draft of the manuscript. All the authors read and approved
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17 297 the final version of the manuscript.
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23 299 **Competing interests None.**

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28 301 **Ethics approval**

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30 302 The Ethics Committee of Guangdong Pharmaceutical University.
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4 376 **Figure Legends**

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6 377 **Figure 1.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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8 378 exposure (A: exposure in indoor public places; B: exposure in homes).
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13 380 **Figure 2.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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15 381 exposure in campuses (A: exposure in indoor campuses; B: exposure in outdoor
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17 382 campuses).
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23 384 **Figure 3.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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25 385 exposure from smoking teachers (A: exposure in indoor campuses; B: exposure in
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27 386 outdoor campuses).
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33 388 **Figure 4.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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35 389 exposure from smoking classmates (A: exposure in indoor campuses; B: exposure in
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37 390 outdoor campuses).
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392 **Table 1.** Demographic characteristics of the study participants

Characteristics	<i>n</i>	%	Characteristics	<i>n</i>	%
Respiratory symptoms			Grade		
No	3098	86.7	1-2	2329	65.2
Yes	477	13.3	4-5	1246	34.8
SHS exposure in indoor public places			Only-child		
No	1806	50.5	No	1353	37.8
Yes	1769	49.5	Yes	2222	62.2
SHS exposure in homes			Prestigious school		
No	2342	65.5	No	1307	36.6
Yes	1233	34.5	Yes	2268	63.4
SHS exposure in indoor campuses			Pocket money monthly(¥)		
No	2763	77.3	<100	2039	57.0
Yes	812	22.7	100-399	1125	31.5
SHS exposure in outdoor campuses			≥400	411	11.5
No	2532	70.8	Father's education		
Yes	1043	29.2	Primary school	838	23.4
Gender			Middle school	1215	34.0
Male	1818	50.9	University and above	1522	42.6
Female	1757	49.1	Mother's education		
Asthma history			Primary school	978	27.4
No	3514	98.3	Middle school	1165	32.6
Yes	61	1.7	University and above	1432	40.1

393 *n*, number of participants; %, the proportion of participants.

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395

396 **Table 2.** Relation between binary SHS exposure and respiratory symptoms

SHS exposure	<i>n</i>	Respiratory symptoms (%)	Unadjusted OR(95%CI)	Adjusted OR(95%CI) ^a
SHS exposure in indoor public places				
No	1806	200(11.1)	1.00	1.00
Yes	1769	277(15.7)	1.49(1.23-1.81)	1.60(1.30-1.95)
SHS exposure in homes				
No	2342	275(11.7)	1.00	1.00
Yes	1233	202(16.4)	1.47(1.21-1.79)	1.53(1.25-1.87)
SHS exposure in indoor campuses				
No	2763	338(12.2)	1.00	1.00
Yes	812	139(17.1)	1.48(1.19-1.84)	1.43(1.14-1.79)
SHS exposure in indoor campuses from smoking teachers				
No	2940	369(12.6)	1.00	1.00
Yes	635	108(17.0)	1.43(1.13-1.80)	1.34(1.05-1.71)
SHS exposure in indoor campuses from smoking classmates				
No	3149	399(12.7)	1.00	1.00
Yes	426	78(18.3)	1.54(1.18-2.02)	1.54(1.15-2.06)
SHS exposure in outdoor campuses				
No	2532	309(12.2)	1.00	1.00
Yes	1043	168(16.1)	1.38(1.13-1.69)	1.37(1.10-1.69)
SHS exposure in outdoor campuses from smoking teachers				
No	2917	362(12.4)	1.00	1.00
Yes	658	115(17.5)	1.49(1.19-1.88)	1.38(1.09-1.75)
SHS exposure in outdoor campuses from smoking classmates				
No	2873	366(12.7)	1.00	1.00
Yes	702	111(15.8)	1.29(1.02-1.62)	1.33(1.03-1.71)

397 *n*, number of participants; SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.398 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
399 history (yes vs no).

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401 **Table 3.** Relation between ordinal frequency of SHS exposure and respiratory symptoms

Frequency of SHS exposure	<i>n</i>	Respiratory symptoms (%)	Unadjusted OR(95%CI)	Adjusted OR(95%CI) ^a
SHS exposure in indoor public places				
No exposure	1806	200(11.1)	1.00	1.00
1-4 days/week	1242	184(14.8)	1.40(1.13-1.73)	1.50(1.20-1.86)
5-7 days/week	527	93(17.7)	1.72(1.32-2.25)	1.87(1.41-2.46)
p for linear trend			<0.001	<0.001
SHS exposure in homes				
No exposure	2342	275(11.7)	1.00	1.00
1-4 days/week	570	97(17.0)	1.54(1.20-1.98)	1.62(1.25-2.09)
5-7 days/week	663	105(15.8)	1.41(1.11-1.80)	1.45(1.13-1.87)
p for linear trend			^b	^b
SHS exposure in indoor campuses				
No exposure	2763	338(12.2)	1.00	1.00
1-4 days/week	539	81(15.0)	1.27(0.98-1.65)	1.24(0.95-1.63)
5-7 days/week	273	58(21.3)	1.94(1.42-2.64)	1.84(1.32-2.56)
p for linear trend			<0.001	<0.001
SHS exposure in indoor campuses from smoking teachers				
No exposure	2940	369(12.6)	1.00	1.00
1-4 days/week	412	59(14.3)	1.16(0.87-1.57)	1.13(0.84-1.53)
5-7 days/week	223	49(22.0)	1.96(1.40-2.74)	1.78(1.25-2.53)
p for linear trend			<0.001	0.001
SHS exposure in indoor campuses from smoking classmates				
No exposure	3149	399(12.7)	1.00	1.00
1-4 days/week	271	45(16.6)	1.37(0.98-1.92)	1.38(0.97-1.97)
5-7 days/week	155	33(21.3)	1.86(1.25-2.78)	1.84(1.20-2.82)
p for linear trend			<0.001	0.005
SHS exposure in outdoor campuses				
No exposure	2532	309(12.2)	1.00	1.00
1-4 days/week	704	105(14.9)	1.26(0.99-1.60)	1.28(1.01-1.64)
5-7 days/week	339	63(18.6)	1.64(1.22-2.21)	1.56(1.13-2.15)
p for linear trend			<0.001	0.007
SHS exposure in outdoor campuses from smoking teachers				
No exposure	2917	362(12.4)	1.00	1.00
1-4 days/week	456	71(15.6)	1.30(0.99-1.72)	1.24(0.94-1.64)
5-7 days/week	202	44(21.8)	1.97(1.38-2.79)	1.74(1.20-2.50)
p for linear trend			<0.001	0.004
SHS exposure in outdoor campuses from smoking classmates				
No exposure	2873	366(12.7)	1.00	1.00
1-4 days/week	451	62(13.8)	1.09(0.82-1.46)	1.16(0.86-1.57)
5-7 days/week	251	49(19.5)	1.66(1.19-2.31)	1.66(1.16-2.39)
p for linear trend			<0.001	0.006

402 *n*, number of participants; SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.403 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
404 history (yes vs no).405 ^b: No estimate of *p* value for linear trend is provide since no linear trend was observed.

406 **Table 4.** Relation between continuous frequency of SHS exposure and respiratory symptoms

Frequency of SHS exposure (days/week, logarithmic scale)	β	SE	Z	p-value	OR(95% CI)
SHS exposure in indoor public places					
Univariable regression	0.73	0.16	4.68	<0.001	2.06(1.52-2.80)
Multivariable regression ^a	0.83	0.16	5.11	<0.001	2.30(1.67-3.16)
SHS exposure in homes					
Univariable regression	0.45	0.14	3.14	0.002	1.56(1.18-2.07)
Multivariable regression ^a	0.49	0.15	3.32	0.001	1.64(1.23-2.20)
SHS exposure in indoor campuses					
Univariable regression	0.78	0.18	4.30	<0.001	2.19(1.53-3.12)
Multivariable regression ^a	0.74	0.20	3.77	<0.001	2.09(1.42-3.07)
SHS exposure in indoor campuses from smoking teachers					
Univariable regression	0.82	0.20	4.16	<0.001	2.27(1.54-3.33)
Multivariable regression ^a	0.72	0.21	3.47	0.001	2.06(1.37-3.09)
SHS exposure in indoor campuses from smoking classmates					
Univariable regression	0.71	0.23	3.11	0.002	2.04(1.30-3.20)
Multivariable regression ^a	0.69	0.25	2.77	0.006	2.00(1.22-3.26)
SHS exposure in outdoor campuses					
Univariable regression	0.58	0.17	3.32	0.001	1.79(1.27-2.51)
Multivariable regression ^a	0.53	0.19	2.82	0.005	1.70(1.18-2.47)
SHS exposure in outdoor campuses from smoking teachers					
Univariable regression	0.93	0.20	4.65	<0.001	2.53(1.71-3.74)
Multivariable regression ^a	0.78	0.21	3.72	<0.001	2.20(1.45-3.33)
SHS exposure in outdoor campuses from smoking classmates					
Univariable regression	0.44	0.20	2.22	0.027	1.55(1.05-2.30)
Multivariable regression ^a	0.45	0.22	2.08	0.037	1.58(1.03-2.42)

407 SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.

408 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
409 history (yes vs no).

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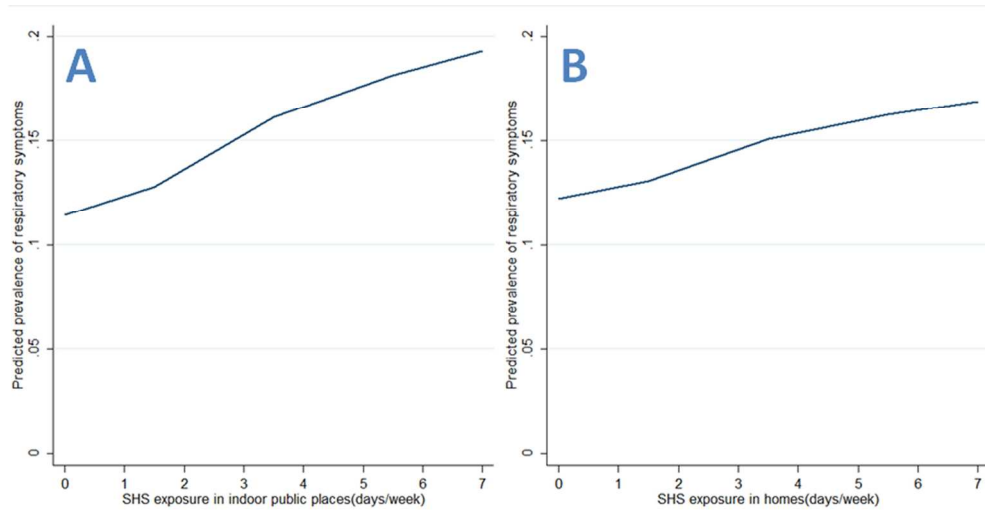


Figure 1. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure (A: exposure in indoor public places; B: exposure in homes).

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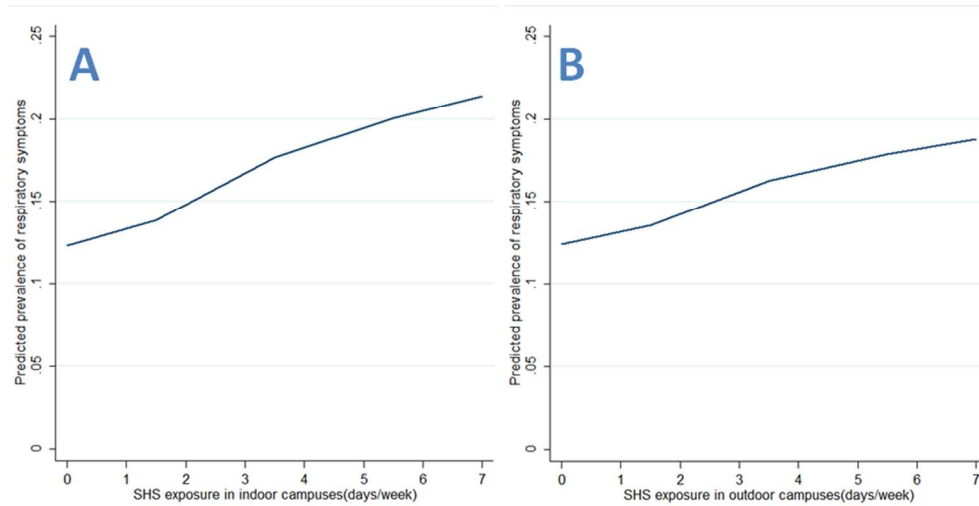


Figure 2. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure in campuses (A: exposure in indoor campuses; B: exposure in outdoor campuses).

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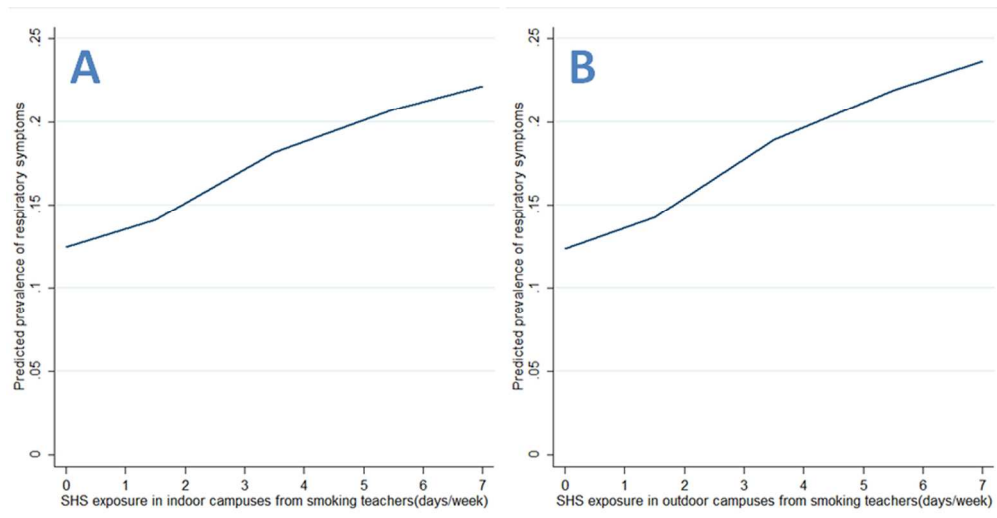


Figure 3. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure from smoking teachers (A: exposure in indoor campuses; B: exposure in outdoor campuses).

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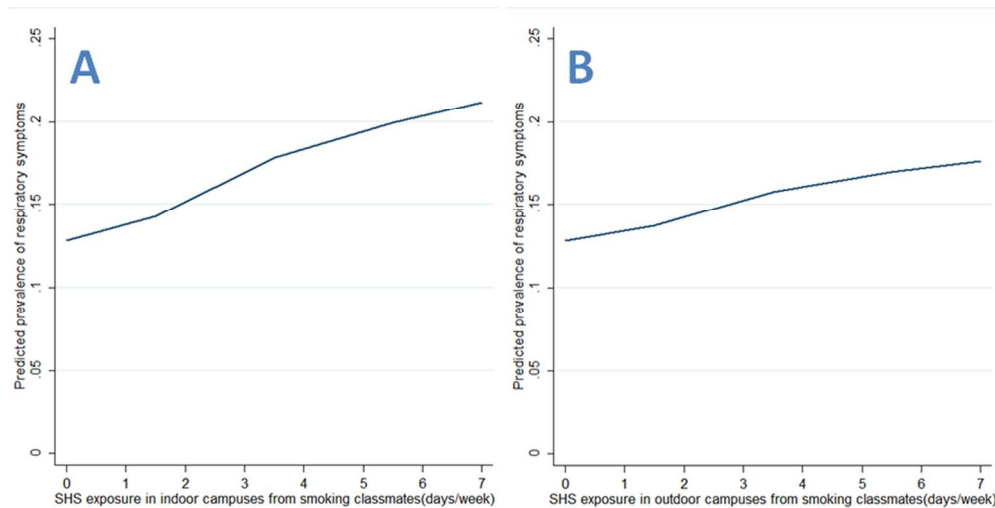


Figure 4. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure from smoking classmates (A: exposure in indoor campuses; B: exposure in outdoor campuses).

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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	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
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
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	6-7
Study size	10	Explain how the study size was arrived at	5-6
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	No missing data
		(d) If applicable, describe analytical methods taking account of sampling strategy	No applicable
		(e) Describe any sensitivity analyses	7
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	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	No applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	8
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	8-10
		(b) Report category boundaries when continuous variables were categorized	8-10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
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	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
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	No funding

*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

Frequency-risk relationships between second-hand smoke exposure and respiratory symptoms among adolescents: a cross-sectional study in South China

Journal:	<i>BMJ Open</i>
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Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Epidemiology, Public health, Respiratory medicine, Smoking and tobacco
Keywords:	second-hand smoke exposure, respiratory symptoms, adolescents

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4 **1 Frequency-risk relationships between second-hand smoke exposure and**
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6 **2 respiratory symptoms among adolescents: a cross-sectional study in South China**
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9 3 Zhiyao Chen MPH ^{1,#}, Guocong Liu MPH ^{2,#}, Shunming Li MPH ¹, Ting Jiang BS ², Bin Xu MPH ²,
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13 [#] These authors contributed equally to this work.

15 **Word counts** of the manuscript (excluding references): 2587

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3 20 **ABSTRACT**

4 21 **Objectives:** Although previous studies have suggested an association between second-hand smoke
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7 22 (SHS) exposure and respiratory symptoms, current evidence is inconsistent. Additionally, it
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10 23 remains unclear whether there are frequency-risk relationships between SHS exposure and
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12 24 respiratory symptoms among adolescents.

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14 25 **Methods:** A cross-sectional survey was conducted using a stratified cluster sampling method to
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17 26 obtain a representative sample of high school students in Guangzhou, China. The respiratory
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19 27 symptoms were defined as persistent cough or sputum for 3 consecutive months during the past 12
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21 28 months. Self-reported SHS exposure was defined as non-smokers' inhalation of the smoke exhaled
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23 29 from smokers on ≥ 1 day a week in the past 7 days. The univariable and multivariable logistic
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25 30 regression models were fitted to explore the potential frequency-risk relationships between SHS
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27 31 exposure and respiratory symptoms.

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29 32 **Results:** Among 3575 students, the overall prevalence of SHS exposure was 69.2%, including
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31 33 49.5% in public places, 34.5% in homes, 22.7% in indoor campuses, and 29.2% in outdoor
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33 34 campuses. There were significantly increased risks of having respiratory symptoms corresponding
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35 35 to SHS exposure in public places (odds ratio [OR]=1.60, 95% CI 1.30-1.95), in homes (OR=1.53,
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37 36 95% CI 1.25-1.87), in indoor campuses (OR = 1.43, 95% CI 1.14-1.79) and in outdoor campuses
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39 37 (OR = 1.37, 95% CI 1.10-1.69) using no exposure as reference. Notably, we observed
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41 38 monotonically frequency-risk relationships between setting-specific (e.g., homes, public places,
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43 39 and campuses) SHS exposure and respiratory symptoms.

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45 40 **Conclusion:** Our findings suggest that setting-specific SHS exposure is associated with a
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4 43 **Strengths and limitations of this study**
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6 44 ■ This study contributes additionally to the literature by exploring the potential frequency-risk
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8 45 relationship between SHS exposure and respiratory symptoms.

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11 46 ■ This study differentiates SHS exposure in specific settings and specific sources to make
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13 47 exposure and potential relations clearer.

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15 48 ■ SHS exposure and respiratory symptoms were self-reported, which is a limitation.

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18 49 ■ Cross-sectional studies do not establish causal relationships but only depict associations. Our
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20 50 findings highlight the need for further longitudinal studies to establish the causal relationship
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22 51 and its biological mechanisms.
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53 INTRODUCTION

54 It is well established that inhaling second-hand smoke (SHS) is harmful and that no
55 scientific evidence establishes a risk-free level of exposure.^{1,2} Notably, a retrospective
56 analysis of data from 192 countries revealed that 40% of children (including 35% of
57 non-smoking women and 33% of non-smoking men) were exposed to SHS, and this
58 exposure is estimated to result in an annual estimate of 603000 deaths attributable to
59 SHS.³ Global youth tobacco surveillance also reported that nearly half the adolescents
60 worldwide were exposed to SHS at home (42.5%) and in public places (55.1%),
61 which constitutes a substantial public health threat and demands urgent intervention.⁴
62 China is the world's largest producer and consumer of tobacco. The 2010 Global
63 Adult Tobacco Survey reported and 2014 Chinese adolescents Tobacco Survey
64 reported that 72.4% adult and 72.9% adolescents in China were exposed to SHS,
65 suggesting that the tremendous burden from tobacco-induced diseases makes tobacco
66 prevention an essential health priority in China.^{5,6} In recent years, much attention has
67 been focused on SHS exposure in public places and in homes, but there is limited
68 reports on SHS exposure in indoor and outdoor campuses among adolescents.

69 Epidemiological studies of adolescents have explored the relations between SHS
70 exposure and respiratory symptoms (such as nose irritation, coughing, and sore throat)
71 or infection,⁷⁻¹¹ but current evidence is inconsistent. Some studies demonstrated
72 significantly positive associations,^{12,13} while the report from Malaysia revealed no
73 association.¹⁴ Recent Chinese studies indicated that there was a positive relation
74 between household SHS exposure and respiratory symptoms in adolescents, but the

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4 75 relation for SHS exposure in public places or in schools was unknown.^{15,16} SHS
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6 76 exposure occurs in varying amounts in public places, homes, and other indoor spaces,
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8 77 but few studies have differentiated SHS exposure in indoor and outdoor to make the
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10 78 setting-specific relations between SHS exposure and respiratory symptoms clearer. Of
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12 79 particular concern is that little is known about the effects of campus SHS exposure on
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14 80 respiratory symptoms. Furthermore, it was unclear whether there are dose-response
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16 81 relationships between SHS exposure and respiratory symptoms. This study builds on
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18 82 previous literature to explore setting-specific (e.g., public places, homes, and
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20 83 campuses) and frequency-risk relationships between SHS exposure and respiratory
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22 84 symptoms among adolescents.
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30 **METHODS**

31 **Ethics statement**

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34 35 The study was approved by the Ethics Committee of Guangdong Pharmaceutical
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37 38 University, and it was performed in accordance with the approved guidelines. The
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40 41 goals of the study were given to study participants and they should express their
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43 44 willingness to participate. Before participating, written informed consents were
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46 47 obtained from their parents or guardians.
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50 **Study design and data collection**

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52 53 This cross-sectional study was conducted in Guangzhou, China, from March to April
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55 56 2016. The target population was high school students. A stratified cluster sampling
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4 97 process was used to obtain a representative sample. Notably, middle schools in most
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6 98 part of China are generally rated by the Bureau of Education as key schools (or
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8 99 prestigious schools) and ordinary schools (or non-prestigious schools) according to
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11 100 level of education and the education quality. In the first stage, all high schools were
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13 101 divided into two categories (prestigious or non-prestigious schools). Three high
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15 102 schools were randomly sampled from prestigious schools, and four high schools were
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17 103 randomly sampled from non-prestigious schools, with the probability of selection
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19 104 proportional to the number of the schools. In the second stage, classes in the selected
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21 105 schools were randomly sampled with proportional to school enrollment size, and all
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23 106 students in sampled classes were eligible to participate.
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28 107 All interviewers in each school were centrally trained to ensure that the survey
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30 108 was carried out according to the protocol and operation procedures were identical
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32 109 across all areas. After obtaining informed consent, eligible students were asked to
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34 110 complete a face-to-face survey by trained interviewers. A total of 3833 participants
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36 111 were enrolled in the study, and the effective response rate was 95.4% (3657/3833).
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38 112 Only non-smokers were included in the analyses and a total of 3575 non-smokers
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40 113 were included in this study.
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46 115 **Study variables**

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48 116 The main outcome variable was self-reported respiratory symptoms. The respiratory
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50 117 symptoms were defined as persistent cough or sputum for 3 consecutive months
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52 118 during the past 12 months.¹⁷⁻¹⁹ The main independent variable of respiratory
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4 119 symptoms was self-reported SHS exposure, which was defined as non-smokers'
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6 120 inhalation of the smoke exhaled from smokers on ≥ 1 day a week in the past 7 days for
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8 121 at least 6 months (first question: "In the past 7 days, how many days did you breathe
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10 122 in SHS in homes (or indoor public places, indoor campuses, outdoor campuses)");
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12 123 second question for those having SHS exposure: "Did you breathe in SHS in this
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14 124 venue for at least 6 months?"). In order to recall SHS exposure for at least 6 months,
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16 125 we use both curriculum schedules and calendars as an assistive device to facilitate
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18 126 recall the time. Frequency of SHS exposure was continuous data (days/week), and
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20 127 was also categorized into three groups: < 1 day/week (no exposure), '1-4 days/week'
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22 128 and '5-7 days/week'. Smoking status was classified as non-smokers and smokers
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24 129 (defined as 'has smoked over 100 cigarettes in their lifetime').
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31 130 Covariates including potential mediators and confounders were chosen a priori
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33 131 on the basis of literature review. Potential covariates in our study included age (year),
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35 132 gender (male or female), grade (4-5 or 1-2), only-child (yes or no), monthly pocket
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37 133 money ($< ¥100$, $¥100-399$, or $\geq ¥400$), prestigious school (yes or no), father's
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39 134 education (primary school, middle school, or university and above), mother's
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41 135 education (primary school, middle school, or university and above), and asthma
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43 136 history (yes or no).
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50 138 **Data analysis**

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52 139 All data were entered in duplicate into EpiData version 3.1 database (The EpiData
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54 140 Association, Odense Denmark). The univariable and multivariable logistic regression
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4 141 models were fitted to calculate the odds ratios (ORs) and 95% confidence intervals
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6 142 (CIs) for evaluating the frequency-risk relationships between SHS exposure
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8 143 (including ordinal and continuous variables) and respiratory symptoms. Linear trends
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11 144 of SHS exposure were assessed by modeling exposure as continuous variables
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13 145 (arithmetic or logarithmic scale) or ordinal variables in multivariable models.
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16 146 Two-sided p-value of <0.05 was regarded as being of statistical significance. All
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18 147 statistical analyses were conducted using Stata version 14.0(StataCorp LP, College
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21 148 Station, Texas, USA).

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24 25 150 **RESULTS**

26 27 151 **Characteristics of the sample**

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30 152 A total of 3575 non-smoking students were interviewed, of whom 477 (13.3%) were
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32 153 classified as having respiratory symptoms. Participants' mean age was 15.0 ± 1.8
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34 154 years, and 50.9% were male students. About 62.2% of the students were the only child
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36 155 in their family and 63.4% from prestigious schools. The overall prevalence of SHS
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38 156 exposure was 69.2%, including 49.5% in indoor public places, 34.5% in homes,
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40 157 22.7% in indoor campuses, and 29.2% in outdoor campuses (Table 1).

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46 47 159 **Relation between binary SHS exposure and respiratory symptoms**

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50 160 The prevalence of respiratory symptoms was significantly higher in students with
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52 161 SHS exposure (OR=1.72, 95% CI 1.35-2.17, for SHS in general; OR=1.60, 95% CI
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54 162 1.30-1.95, for SHS in indoor public places; OR=1.53, 95% CI 1.25-1.87, for SHS in

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4 163 homes; OR = 1.43, 95% CI 1.14-1.79, for SHS in indoor campuses) than in those with
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6 164 no exposure (Table 2). Similar positive associations were observed in students with
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8 165 SHS exposure in indoor campuses from smoking teachers (OR =1.34, 95% CI
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10 166 1.05-1.71) or from smoking classmates (OR = 1.54, 95% CI 1.15-2.06). Notably, the
11
12 167 effects of SHS exposure in outdoor campuses cannot be ignored. Students with SHS
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14 168 exposure in outdoor campuses had significantly higher rates of respiratory symptoms
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16 169 (OR = 1.37, 95% CI 1.10-1.69) as compared with unexposed students, and there were
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18 170 similar positive associations between respiratory symptoms and SHS exposure in
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20 171 outdoor campuses from smoking teachers (OR =1.38, 95% CI 1.09-1.75) or from
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22 172 smoking classmates (OR = 1.33, 95% CI 1.03-1.71).

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29 30 174 **Relation between ordinal SHS exposure and respiratory symptoms**

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32 175 Compared with no SHS exposure, ordinal frequency of SHS exposure was associated
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34 176 with respiratory symptoms in an increasing manner (SHS in public places: OR=1 for
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36 177 no exposure, OR=1.50 for 1-4 days/week, OR=1.87 for 5-7 days/week, *p* for linear
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38 178 trend <0.001; SHS in indoor campuses: OR=1 for no exposure, OR=1.24 for 1-4
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40 179 days/week, OR=1.84 for 5-7 days/week, *p* for linear trend <0.001; Table 3). When
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42 180 examining these relations by source of exposure, significant increasing trends were
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44 181 observed for SHS exposure in indoor campuses from smoking teachers (*p* for linear
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46 182 trend =0.001) and from smoking classmates (*p* for linear trend =0.005). Additionally,
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48 183 there was a significantly increasing relation between ordinal frequency of SHS
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50 184 exposure in outdoor campuses and respiratory symptoms (OR=1 for no exposure,
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4 185 OR=1.28 for 1-4 days/week, OR=1.56 for 5-7 days/week, p for linear trend =0.007;
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6 186 [Table 3](#)), and similar increasing trends were observed for SHS exposure in outdoor
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8 187 campuses from smoking teachers (p for linear trend =0.004) and from smoking
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10 188 classmates (p for linear trend =0.006). However, no increasing trend was observed for
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13 189 SHS exposure in homes.
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18 191 **Relation between continuous SHS exposure and respiratory symptoms**

19 192 As to continuous SHS exposure, there were significant frequency-risk relationships
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21 193 between indoor SHS exposure and respiratory symptoms (OR = 2.30, 95% CI:
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23 194 1.67-3.16, for SHS in indoor public places; OR = 1.64, 95% CI: 1.23-2.20, for SHS in
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25 195 homes; OR = 2.09, 95% CI: 1.42-3.07, for SHS in indoor campuses; OR = 1.70, 95%
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27 196 CI: 1.18-2.47, for SHS in outdoor campuses; [Table 3](#)). When examining these
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29 197 relations by source of exposure, there were similar frequency-risk relationships for
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31 198 SHS exposure in indoor or outdoor campuses ([Table 3](#)). Additionally, we observed a
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33 199 monotonically increasing frequency-risk trend for SHS exposure in indoor public
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35 200 places ([Figure 1A](#)), in homes ([Figure 1B](#)), in indoor campuses ([Figure 2A](#)) or in
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37 201 outdoor campuses ([Figure 2B](#)). When examining these trends by source of exposure,
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39 202 there were similar increasing frequency-risk trends for SHS exposure from smoking
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41 203 teachers ([Figure 3A](#) for indoor SHS and [Figure 3B](#) for outdoor SHS) and from
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43 204 smoking classmates ([Figure 4A](#) for indoor SHS and [Figure 4B](#) for outdoor SHS).
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55 206 **DISCUSSION**

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4 207 This observational study showed that non-smoking students with setting-specific
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6 208 SHS exposure experienced significantly higher risks of respiratory symptoms than
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8 209 those with no exposure. The most striking findings from this study were that there
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11 210 were monotonically increasing frequency-risk relationships between setting-specific
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13 211 SHS exposure and respiratory symptoms. When examining these relations by source
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16 212 of exposure, there were similar monotonically increasing frequency-risk relationships
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18 213 for SHS exposure from smoking teachers and from smoking classmates.

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21 214 It is well known that there is no risk-free level of exposure to SHS. Although
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23 215 previous studies have focused on SHS exposure among Chinese adolescents,^{15,16,20}
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25 216 there is limited reports regarding SHS exposure in specific settings and specific
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28 217 sources to make exposure clearer. According to the partial smoke-free legislation
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31 218 implemented in Guangzhou on 1 September 2010, full smoke-free ban covered indoor
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33 219 campuses, outdoor campuses and most indoor public places, but did not cover homes.
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35 220 It is disappointing that SHS exposure in schools was not eliminated, and was still at a
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38 221 high level (22.7% for SHS exposure in indoor campuses; 29.2% for SHS exposure in
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41 222 outdoor campuses). This observation may be due to poor compliance with the full
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43 223 smoke-free ban in campuses, since we observed that SHS exposure among students
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45 224 was mainly from smoking teachers and smoking classmates in both indoor and
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48 225 outdoor campuses. Similarly, a recent population-based study in Tehran showed that
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51 226 about 30% non-smoking students have been exposed to SHS from smoking teachers
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53 227 in indoor or outdoor campuses,²¹ and another survey of Chinese college students
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55 228 reported that 37% of non-smokers had SHS exposure from smoking teachers.²⁰ More

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4 229 disappointing was that SHS exposure in indoor public places among students was
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6 230 remarkably high in 49.5% in this study, which is similar to the latest study on adult
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8 231 SHS exposure in Guangzhou (50.3%) and the Global Youth Tobacco Survey
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10 232 (47.8%).^{22,23} After the implementation of a smoke-free legislation, very few
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13 233 respondents (1-2%) reported smoking in public places in England,²⁴ but smoking
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15 234 behaviors still remained high in public places in Guangzhou because of unwillingness
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18 235 of the policymakers to implement tougher smoke-free policies and poor compliance
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20 236 with the smoke-free law among smokers.²³ These findings reveal that a partial
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23 237 smoke-free legislation has a weak impact on smoking cessation, but a comprehensive
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25 238 smoke-free legislation can substantially attenuate smoking behaviors, which point out
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28 239 the urgent need for a comprehensive smoke-free legislation covering all public places
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30 240 in Guangzhou to protect the public from SHS hazards.

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33 241 A few published studies have indicated that SHS exposure may be a risk factor of
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35 242 respiratory symptoms, but the potential relation for setting-specific exposure was still
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37 243 unclear.^{15,16,25,26} Recent studies of Chinese adolescents indicated that there was a
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40 244 positive relation between household SHS exposure and respiratory symptoms, but the
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42 245 relation for SHS exposure in public places or in schools was unknown.^{15,16} In addition,
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45 246 the surveys of London casino workers and Shanghai workers revealed that there was
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47 247 an association between SHS exposure at work and respiratory symptoms, but the
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50 248 association for SHS exposure in homes or in public places was unknown.^{25,26} It is
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52 249 noteworthy that the influence of SHS exposure from indoor campuses on respiratory
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55 250 symptoms is still unclear, and the potential dose-response association between

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4 251 frequency of SHS exposure and respiratory symptoms is also uncertain. Our study
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6 252 builds on previous literature by exploring the potential dose-response relationships
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8 253 and differentiating SHS exposure in homes, public places, and campuses to make
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10 254 exposure and potential relations clearer. We found that there were positive relations
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12 255 and frequency-risk relationships between setting-specific SHS exposure and
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14 256 respiratory symptoms. When examining the relations by source of exposure, there was
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16 257 still evidence of similar dose-response relationships for SHS exposure in indoor
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18 258 campuses from smoking teachers and smoking classmates. These findings provided
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20 259 new evidence of dose-response relationships between SHS exposure and respiratory
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22 260 symptoms among adolescents, and support that the future studies should focus more
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24 261 on differentiating these associations in setting-specific and source-specific exposure.
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26 262 Additionally, further research is needed to establish the causal relationship and
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28 263 potential biological mechanisms, and confirm that elimination of SHS exposure (or
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30 264 stricter smoke-free legislation in Guangzhou) will lead to a reduction in respiratory
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32 265 symptoms among adolescents.

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40 266 Globally, outdoor smoking restrictions are uncommon, though the
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42 267 outdoor-campus smoking bans implemented in Guangzhou City on 1 September 2010.
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44 268 A few published studies have indicated that smoking increases PM_{2.5} concentrations in
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46 269 outdoor areas to levels that are potentially hazardous to health,^{27,28} but research
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48 270 linking SHS exposures from outdoor environments to health effects is still rare.
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50 271 Notably, the potential relation between outdoor SHS exposure and respiratory
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52 272 symptoms is still unclear. To our knowledge, this is the first study to reveal the
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4 273 relation between SHS exposure in outdoor campuses and respiratory symptoms
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6 274 among adolescents, and found that outdoor SHS exposure was positively associated
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8 275 with respiratory symptoms in a monotonically increasing trend. When examining the
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10 276 relations by source of exposure, there were still similar frequency-risk relationships
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13 277 for SHS exposure in outdoor campuses from smoking teachers and smoking
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16 278 classmates. Although outdoor SHS is more transient than indoor SHS, evidence from
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18 279 review of the research literature on SHS levels in outdoor hospitality venues
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20 280 suggested that tobacco-generated PM_{2.5} in outdoor setting may occasionally be
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23 281 equivalent to or higher than levels observed in indoor setting when smoking is
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25 282 permitted at close proximity.²⁷ These findings provide more evidence for the adverse
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28 283 effects of outdoor SHS exposure on human respiratory symptoms, and also support
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30 284 growing concern about SHS exposure in outdoor campuses. Future studies on school
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33 285 SHS exposure in adolescents and protective measures against SHS should take
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35 286 outdoor campuses SHS into consideration.

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38 287 The most meaningful advantage of this study is that we contributes additionally
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40 288 to the literature by exploring the potential frequency-risk relationships and
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43 289 differentiating SHS exposure in specific settings and specific sources to make
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45 290 exposure and potential relations clearer. There are also some potential limitations in
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48 291 this study. First, all data was self-reported, including SHS exposure and respiratory
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50 292 symptoms. For SHS exposure, biochemical measures can give objective
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52 293 measurements, but cannot distinguish the sources of exposure, the key factors in this
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55 294 study. Previous survey has found that school children are capable of reporting their

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4 295 health conditions reliably,²⁹ and the presence of frequent cough and phlegm was quite
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6 296 obvious to avoid measurement error. Second, causal association between SHS
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8 297 exposure and respiratory symptoms could not be ascertained due to the cross-sectional
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11 298 design. However, the notion of reverse causation that students with respiratory
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13 299 symptoms deliberately increased their exposure to noxious SHS seems improbable.
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16 300 The strong association observed in other studies also supported our data validity and
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18 301 provided support for the deduction of causation.^{15,30,31} Finally, few people would be
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21 302 completely unexposed to SHS in densely populated Guangzhou even now, when
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23 303 smoking was still allowed in public places (e.g., cafes, bars, night clubs, amusement
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25 304 parks, restaurants, and workplaces). Therefore, the control groups who reported no
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28 305 SHS exposure have probably underestimated their exposure, and the risk for
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31 306 respiratory symptoms in these groups would also be underestimated.

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33 307 In conclusion, SHS exposure in indoor and outdoor campuses is still at a high
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35 308 level, which suggests poor compliance with the full smoke-free ban in schools and
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37 309 supports growing concern about SHS exposure in campuses. Additionally, this study
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40 310 contributes to the literature by finding monotonically increasing frequency-risk
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42 311 relationships between SHS exposure and respiratory symptoms among adolescents in
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45 312 addition to differentiating SHS exposure in specific settings and specific sources to
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47 313 make these relationships clearer. Future longitudinal studies are needed to establish
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50 314 the causal relationship and its biological mechanisms.

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55 316 **Contributors**

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4 317 CZ, LG, LS, JT, XB, CJ and YX were involved in the design of the study, data
5
6 318 analysis and writing of the draft of the manuscript. All the authors read and approved
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8 319 the final version of the manuscript.
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12
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14
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16
17 323 funding line for this study.
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23 325 **Competing interests None.**

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27 327 **Ethics approval**

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29 328 The Ethics Committee of Guangdong Pharmaceutical University.
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35 330 **Data sharing statement**

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37 331 No additional data are available.
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4 414 **Figure Legends**

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6 415 **Figure 1.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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8 416 exposure (A: exposure in indoor public places; B: exposure in homes).

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13 418 **Figure 2.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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15 419 exposure in campuses (A: exposure in indoor campuses; B: exposure in outdoor
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17 420 campuses).

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22 422 **Figure 3.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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24 423 exposure from smoking teachers (A: exposure in indoor campuses; B: exposure in
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26 424 outdoor campuses).

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31 426 **Figure 4.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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33 427 exposure from smoking classmates (A: exposure in indoor campuses; B: exposure in
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35 428 outdoor campuses).

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430 **Table 1.** Demographic characteristics of the study participants

Characteristics	<i>n</i>	%	Characteristics	<i>n</i>	%
Respiratory symptoms			Grade		
No	3098	86.7	1-2	2329	65.2
Yes	477	13.3	4-5	1246	34.8
SHS exposure in general			Only-child		
No	1101	30.8	No	1353	37.8
Yes	2474	69.2	Yes	2222	62.2
SHS exposure in indoor public places			Gender		
No	1806	50.5	Male	1818	50.9
Yes	1769	49.5	Female	1757	49.1
SHS exposure in homes			Pocket money monthly(¥)		
No	2342	65.5	<100	2039	57.0
Yes	1233	34.5	100-399	1125	31.5
SHS exposure in indoor campuses			≥400	411	11.5
No	2763	77.3	Father's education		
Yes	812	22.7	Primary school	838	23.4
SHS exposure in outdoor campuses			Middle school	1215	34.0
No	2532	70.8	University and above	1522	42.6
Yes	1043	29.2	Mother's education		
Asthma history			Primary school	978	27.4
No	3514	98.3	Middle school	1165	32.6
Yes	61	1.7	University and above	1432	40.1

431 *n*, number of participants; %, the proportion of participants.

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434 **Table 2.** Relation between binary SHS exposure and respiratory symptoms

SHS exposure	<i>n</i>	Respiratory symptoms (%)	Unadjusted OR(95%CI)	Adjusted OR(95%CI) ^a
SHS exposure in general				
No	1101	106(9.6)	1.00	1.00
Yes	2474	371(15.0)	1.66(1.32-2.08)	1.72(1.35-2.17)
SHS exposure in indoor public places				
No	1806	200(11.1)	1.00	1.00
Yes	1769	277(15.7)	1.49(1.23-1.81)	1.60(1.30-1.95)
SHS exposure in homes				
No	2342	275(11.7)	1.00	1.00
Yes	1233	202(16.4)	1.47(1.21-1.79)	1.53(1.25-1.87)
SHS exposure in indoor campuses				
No	2763	338(12.2)	1.00	1.00
Yes	812	139(17.1)	1.48(1.19-1.84)	1.43(1.14-1.79)
SHS exposure in indoor campuses from smoking teachers				
No	2940	369(12.6)	1.00	1.00
Yes	635	108(17.0)	1.43(1.13-1.80)	1.34(1.05-1.71)
SHS exposure in indoor campuses from smoking classmates				
No	3149	399(12.7)	1.00	1.00
Yes	426	78(18.3)	1.54(1.18-2.02)	1.54(1.15-2.06)
SHS exposure in outdoor campuses				
No	2532	309(12.2)	1.00	1.00
Yes	1043	168(16.1)	1.38(1.13-1.69)	1.37(1.10-1.69)
SHS exposure in outdoor campuses from smoking teachers				
No	2917	362(12.4)	1.00	1.00
Yes	658	115(17.5)	1.49(1.19-1.88)	1.38(1.09-1.75)
SHS exposure in outdoor campuses from smoking classmates				
No	2873	366(12.7)	1.00	1.00
Yes	702	111(15.8)	1.29(1.02-1.62)	1.33(1.03-1.71)

435 *n*, number of participants; SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.436 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
437 history (yes vs no).

438

439 **Table 3.** Relation between frequency of SHS exposure and respiratory symptoms

Frequency of SHS exposure	<i>n</i>	Respiratory symptoms (%)	Unadjusted OR(95%CI)	Adjusted OR(95%CI) ^a
SHS exposure in indoor public places				
No exposure	1806	200(11.1)	1.00	1.00
1-4 days/week	1242	184(14.8)	1.40(1.13-1.73)	1.50(1.20-1.86)
5-7 days/week	527	93(17.7)	1.72(1.32-2.25)	1.87(1.41-2.46)
Continuous SHS in indoor public places ^b			2.06(1.52-2.80)	2.30(1.67-3.16)
SHS exposure in homes				
No exposure	2342	275(11.7)	1.00	1.00
1-4 days/week	570	97(17.0)	1.54(1.20-1.98)	1.62(1.25-2.09)
5-7 days/week	663	105(15.8)	1.41(1.11-1.80)	1.45(1.13-1.87)
Continuous SHS in homes ^b			1.56(1.18-2.07)	1.64(1.23-2.20)
SHS exposure in indoor campuses				
No exposure	2763	338(12.2)	1.00	1.00
1-4 days/week	539	81(15.0)	1.27(0.98-1.65)	1.24(0.95-1.63)
5-7 days/week	273	58(21.3)	1.94(1.42-2.64)	1.84(1.32-2.56)
Continuous SHS in indoor campuses ^b			2.19(1.53-3.12)	2.09(1.42-3.07)
SHS exposure in indoor campuses from smoking teachers				
No exposure	2940	369(12.6)	1.00	1.00
1-4 days/week	412	59(14.3)	1.16(0.87-1.57)	1.13(0.84-1.53)
5-7 days/week	223	49(22.0)	1.96(1.40-2.74)	1.78(1.25-2.53)
Continuous SHS in indoor campuses from smoking teachers ^b			2.27(1.54-3.33)	2.06(1.37-3.09)
SHS exposure in indoor campuses from smoking classmates				
No exposure	3149	399(12.7)	1.00	1.00
1-4 days/week	271	45(16.6)	1.37(0.98-1.92)	1.38(0.97-1.97)
5-7 days/week	155	33(21.3)	1.86(1.25-2.78)	1.84(1.20-2.82)
Continuous SHS in indoor campuses from smoking classmates ^b			2.04(1.30-3.20)	2.00(1.22-3.26)
SHS exposure in outdoor campuses				
No exposure	2532	309(12.2)	1.00	1.00
1-4 days/week	704	105(14.9)	1.26(0.99-1.60)	1.28(1.01-1.64)
5-7 days/week	339	63(18.6)	1.64(1.22-2.21)	1.56(1.13-2.15)
Continuous SHS exposure in outdoor campuses ^b			1.79(1.27-2.51)	1.70(1.18-2.47)
SHS exposure in outdoor campuses from smoking teachers				
No exposure	2917	362(12.4)	1.00	1.00
1-4 days/week	456	71(15.6)	1.30(0.99-1.72)	1.24(0.94-1.64)
5-7 days/week	202	44(21.8)	1.97(1.38-2.79)	1.74(1.20-2.50)
Continuous SHS in outdoor campuses from smoking teachers ^b			2.53(1.71-3.74)	2.20(1.45-3.33)
SHS exposure in outdoor campuses from smoking classmates				
No exposure	2873	366(12.7)	1.00	1.00
1-4 days/week	451	62(13.8)	1.09(0.82-1.46)	1.16(0.86-1.57)
5-7 days/week	251	49(19.5)	1.66(1.19-2.31)	1.66(1.16-2.39)
Continuous SHS in outdoor campuses from smoking classmates ^b			1.55(1.05-2.30)	1.58(1.03-2.42)

440 *n*, number of participants; SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.441 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
442 history (yes vs no).443 ^b: Use logarithmic exposure (days/week) in the model.

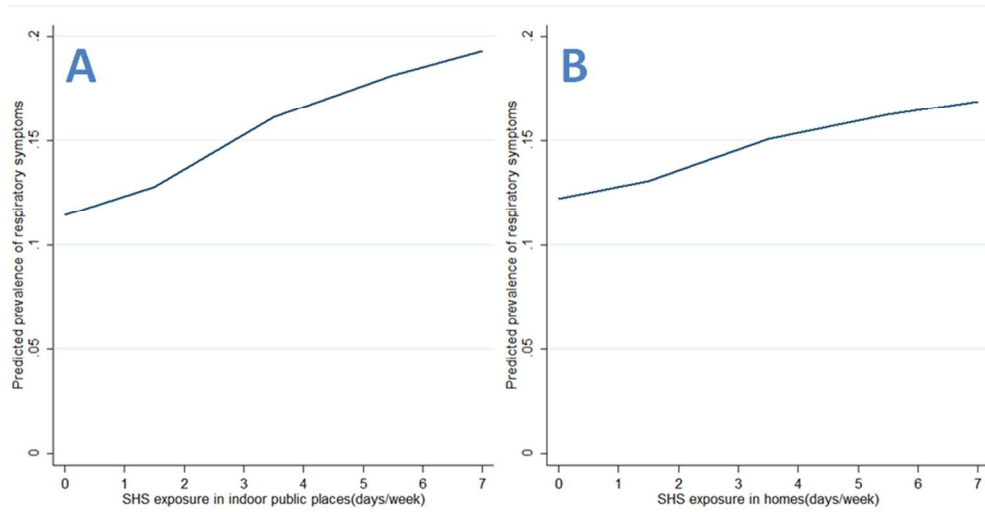


Figure 1. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure (A: exposure in indoor public places; B: exposure in homes).

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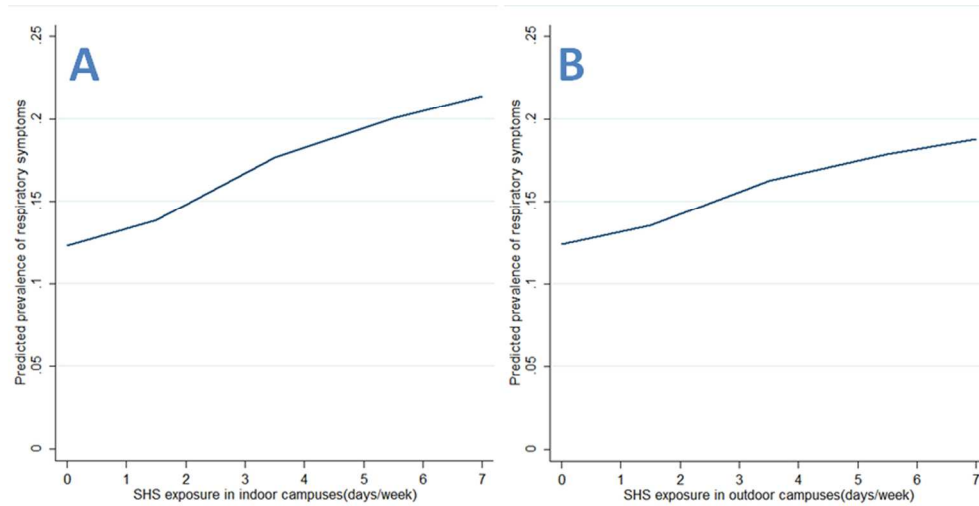


Figure 2. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure in campuses (A: exposure in indoor campuses; B: exposure in outdoor campuses).

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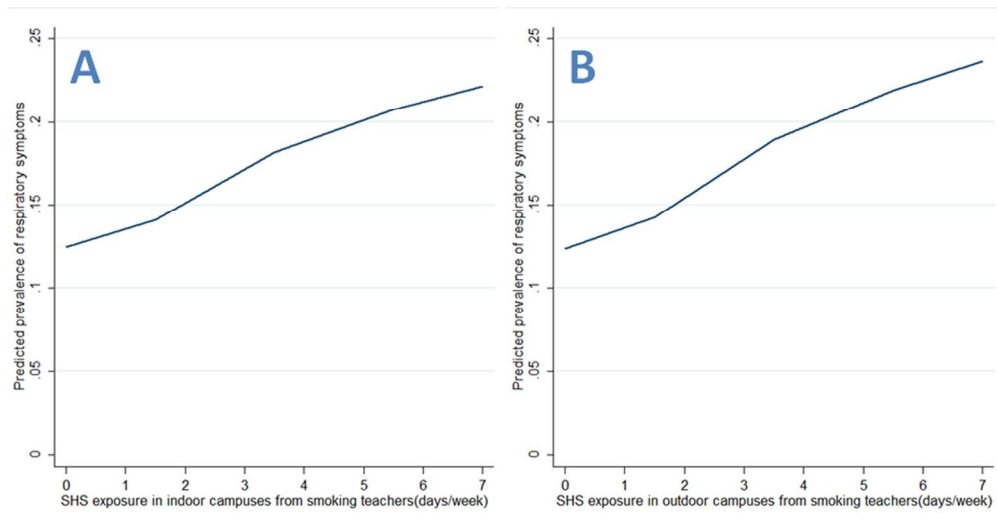


Figure 3. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure from smoking teachers (A: exposure in indoor campuses; B: exposure in outdoor campuses).

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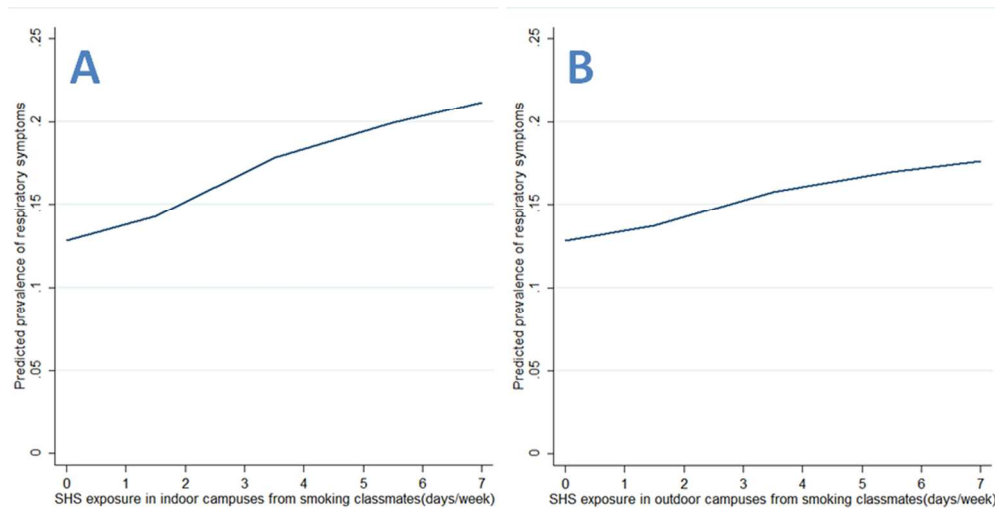


Figure 4. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure from smoking classmates (A: exposure in indoor campuses; B: exposure in outdoor campuses).

124x63mm (300 x 300 DPI)

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	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
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
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	6-7
Study size	10	Explain how the study size was arrived at	5-6
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	No missing data
		(d) If applicable, describe analytical methods taking account of sampling strategy	No applicable
		(e) Describe any sensitivity analyses	7
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	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	No applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	8
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	8-10
		(b) Report category boundaries when continuous variables were categorized	8-10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
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	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
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	No funding

*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

Frequency-risk relationships between second-hand smoke exposure and respiratory symptoms among adolescents: a cross-sectional study in South China

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Keywords:	second-hand smoke exposure, respiratory symptoms, adolescents

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4 **1 Frequency-risk relationships between second-hand smoke exposure and**
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6 **2 respiratory symptoms among adolescents: a cross-sectional study in South China**
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9 3 Zhiyao Chen MPH^{1,#}, Guocong Liu MPH^{2,#}, Jianying Chen BS^{3,#}, Shunming Li MPH¹,

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13 # These authors contributed equally to this work.

15 **Word counts** of the manuscript (excluding references): 2830

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3 20 **ABSTRACT**

4 21 **Objectives:** Although previous studies have suggested an association between second-hand smoke
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7 22 (SHS) exposure and respiratory symptoms, current evidence is inconsistent. Additionally, it
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10 23 remains unclear whether there are frequency-risk relationships between SHS exposure and
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12 24 respiratory symptoms among adolescents.

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14 25 **Methods:** A cross-sectional survey was conducted using a stratified cluster sampling method to
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17 26 obtain a representative sample of high school students in Guangzhou, China. The respiratory
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19 27 symptoms were defined as persistent cough or sputum for 3 consecutive months during the past 12
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21 28 months. Self-reported SHS exposure was defined as non-smokers' inhalation of the smoke exhaled
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23 29 from smokers on ≥ 1 day a week in the past 7 days. The univariable and multivariable logistic
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25 30 regression models were fitted to explore the potential frequency-risk relationships between SHS
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27 31 exposure and respiratory symptoms.

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29 32 **Results:** Among 3575 students, the overall prevalence of SHS exposure was 69.2%, including
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31 33 49.5% for SHS in public places, 34.5% in homes, 22.7% in indoor campuses, and 29.2% in
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33 34 outdoor campuses. There were significantly increased risks of having respiratory symptoms
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35 35 corresponding to SHS exposure in public places (odds ratio [OR]=1.60, 95% CI 1.30-1.95), in
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37 36 homes (OR=1.53, 95% CI 1.25-1.87), in indoor campuses (OR = 1.43, 95% CI 1.14-1.79) and in
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39 37 outdoor campuses (OR = 1.37, 95% CI 1.10-1.69) using no exposure as reference. Notably, we
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41 38 observed monotonically frequency-risk relationships between setting-specific (e.g., homes, public
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43 39 places, and campuses) SHS exposure and respiratory symptoms.

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45 40 **Conclusion:** Our findings suggest that setting-specific SHS exposure is associated with a
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47 41 significant, dose-dependent increase in risk of respiratory symptoms.
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4 43 **Strengths and limitations of this study**

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6 44 ■ This study aims to explore the potential frequency-risk relationship between SHS exposure
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8 45 and respiratory symptoms, and adds to the literature by focusing on Chinese tobacco control
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11 46 and Chinese youth along with its global context.

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13 47 ■ This study differentiates SHS exposure in specific settings and specific sources to make
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16 48 exposure and potential associations clearer.

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18 49 ■ SHS exposure and respiratory symptoms were self-reported, which is a limitation.

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20 50 ■ Cross-sectional studies do not establish causal relationships but only depict associations. Our
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23 51 findings highlight the need for further longitudinal studies to establish the causal relationship
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26 52 and the biological mechanisms for the impact of SHS.

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54 INTRODUCTION

55 It is well established that inhaling second-hand smoke (SHS) is harmful and that no
56 scientific evidence establishes a risk-free level of exposure.^{1,2} Notably, a retrospective
57 analysis of data from 192 countries revealed that 40% of children (including 35% of
58 non-smoking women and 33% of non-smoking men) were exposed to SHS, and this
59 exposure is estimated to result in an annual estimate of 603000 deaths attributable to
60 SHS.³ Global youth tobacco surveillance also reported that nearly half the adolescents
61 worldwide were exposed to SHS at home (42.5%) and in public places (55.1%),
62 which constitutes a substantial public health threat and demands urgent intervention.⁴
63 China is the world's largest producer and consumer of tobacco. The 2010 Global
64 Adult Tobacco Survey revealed that 72.4% adults in China were exposed to SHS, and
65 the 2014 Chinese adolescents Tobacco Survey also reported that 72.9% adolescents in
66 China had SHS exposure, suggesting that the tremendous burden from
67 tobacco-induced diseases makes tobacco prevention an essential health priority in
68 China.^{5,6} In recent years, much attention has been focused on SHS exposure in public
69 places and in homes, but there is limited reports on SHS exposure in indoor and
70 outdoor campuses among adolescents.

71 Epidemiological studies of adolescents have explored the associations between
72 SHS exposure and respiratory symptoms (such as nose irritation, coughing, and sore
73 throat) or infection,⁷⁻¹¹ but current evidence is inconsistent. Some studies
74 demonstrated significantly positive associations,^{12,13} while the report from Malaysia
75 revealed no association.¹⁴ Recent Chinese studies indicated that there were positive

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4 76 associations between household SHS exposure and respiratory symptoms in
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6 77 adolescents, but the association for SHS exposure in public places or in schools was
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8 78 unknown.^{15,16} SHS exposure occurs in varying amounts in public places, homes, and
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11 79 other indoor spaces, but few studies have differentiated SHS exposure in indoor and
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13 80 outdoor to make the setting-specific relationships between SHS exposure and
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15 81 respiratory symptoms clearer. Of particular concern is that little is known about the
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17 82 effects of campus SHS exposure on respiratory symptoms. Furthermore, it was
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19 83 unclear whether there are dose–response relationships between SHS exposure and
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21 84 respiratory symptoms. This study builds on previous literature to explore
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23 85 setting-specific (e.g., public places, homes, and campuses) and frequency-risk
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25 86 relationships between SHS exposure and respiratory symptoms among adolescents.
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33 **METHODS**

34 **Ethics statement**

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37 90 The study was approved by the Ethics Committee of Guangdong Pharmaceutical
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39 91 University, and it was performed in accordance with the approved guidelines. The
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41 92 goals of the study were given to study participants and they should express their
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43 93 willingness to participate. Before participating, written informed consents were
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45 94 obtained from their parents or guardians.
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50 **Study design and data collection**

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53 97 This cross-sectional study was conducted in Guangzhou, China, from March to April
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3 98 2016. The target population was high school students. A stratified cluster sampling
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6 99 process was used to obtain a representative sample. Notably, middle schools in most
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9 100 part of China are generally rated by the Bureau of Education as key schools (or
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11 101 prestigious schools) and ordinary schools (or non-prestigious schools) according to
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13 102 level of education and the education quality. In the first stage, all high schools were
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15 103 divided into two categories (prestigious or non-prestigious schools). Three high
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17 104 schools were randomly sampled from prestigious schools, and four high schools were
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19 105 randomly sampled from non-prestigious schools, with the probability of selection
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21 106 proportional to the number of the schools. In the second stage, classes in the selected
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23 107 schools were randomly sampled with proportional to school enrollment size, and all
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25 108 students in sampled classes were eligible to participate.
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30 109 All interviewers in each school were centrally trained to ensure that the survey
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32 110 was carried out according to the protocol and operation procedures were identical
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34 111 across all areas. After obtaining informed consent, eligible students were asked to
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36 112 complete a face-to-face survey by trained interviewers. A total of 3833 participants
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38 113 were enrolled in this study, and the effective response rate was 95.4% (3657/3833).
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40 114 Only non-smokers were included in the analyses and a total of 3575 non-smokers
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42 115 were included in this study.
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49 117 **Study variables**

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52 118 The main outcome variable was self-reported respiratory symptoms. The respiratory
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54 119 symptoms were defined as persistent cough or sputum for 3 consecutive months
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4 120 during the past 12 months.¹⁷⁻¹⁹ The main independent variable of respiratory
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6 121 symptoms was self-reported SHS exposure, which was defined as non-smokers'
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8 122 inhalation of the smoke exhaled from smokers on ≥ 1 day a week in the past 7 days for
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11 123 at least 6 months (first question: "In the past 7 days, how many days did you breathe
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13 124 in SHS in homes (or indoor public places, indoor campuses, outdoor campuses)";
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16 125 second question for those having SHS exposure: "Did you breathe in SHS in this
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18 126 venue for at least 6 months?"). In order to recall SHS exposure for at least 6 months,
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21 127 we use both curriculum schedules and calendars as an assistive device to facilitate
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23 128 recall the time. Frequency of SHS exposure was continuous data (days/week), and
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26 129 was also categorized into three groups: < 1 day/week (no exposure), '1-4 days/week'
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28 130 and '5-7 days/week'. Smoking status was classified as non-smokers and smokers
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31 131 (defined as 'has smoked over 100 cigarettes in their lifetime').

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33 132 Covariates including potential mediators and confounders were chosen a priori
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35 133 on the basis of literature review. Potential covariates in our study included age (year),
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38 134 gender (male or female), grade (4-5 or 1-2), only-child (yes or no), monthly pocket
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40 135 money ($< \text{¥}100$, $\text{¥}100\text{-}399$, or $\geq \text{¥}400$), prestigious school (yes or no), father's
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43 136 education (primary school, middle school, or university and above), mother's
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45 137 education (primary school, middle school, or university and above), and asthma
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48 138 history (yes or no).

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51 52 140 **Data analysis**

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55 141 All data were entered in duplicate into EpiData version 3.1 database (The EpiData
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4 142 Association, Odense Denmark). The univariable and multivariable logistic regression
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6 143 models were fitted to calculate the odds ratios (ORs) and 95% confidence intervals
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8 144 (CIs) for evaluating the frequency-risk relationships between SHS exposure
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10 145 (including ordinal and continuous variables) and respiratory symptoms. Linear trends
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12 146 of SHS exposure were assessed by modeling exposure as continuous variables
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14 147 (arithmetic or logarithmic scale) or ordinal variables in multivariable models.
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16 148 Two-sided p-value of <0.05 was regarded as being of statistical significance. All
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18 149 statistical analyses were conducted using Stata version 14.0 (StataCorp LP, College
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21 150 Station, Texas, USA).
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27 152 **RESULTS**

28 153 **Characteristics of the sample**

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32 154 A total of 3575 non-smoking students were interviewed, of whom 477 (13.3%) were
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34 155 classified as having respiratory symptoms. Participants' mean age was 15.0 ± 1.8
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36 156 years, and 50.9% were male students. About 62.2% of the students were the only child
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38 157 in their family and 63.4% from prestigious schools. The overall prevalence of SHS
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40 158 exposure was 69.2%, including 49.5% for SHS in indoor public places, 34.5% in
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42 159 homes, 22.7% in indoor campuses, and 29.2% in outdoor campuses ([Table 1](#)).
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49 161 **Relationship between binary SHS exposure and respiratory symptoms**

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52 162 The prevalence of respiratory symptoms was significantly higher in students with
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54 163 SHS exposure (OR=1.72, 95% CI 1.35-2.17, for SHS in general; OR=1.60, 95% CI
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4 164 1.30-1.95, for SHS in indoor public places; OR=1.53, 95% CI 1.25-1.87, for SHS in
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6 165 homes; OR = 1.43, 95% CI 1.14-1.79, for SHS in indoor campuses) than in those with
7
8 166 no exposure (Table 2). Similar positive associations were observed in students with
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10 167 SHS exposure in indoor campuses from smoking teachers (OR =1.34, 95% CI
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12 168 1.05-1.71) or from smoking classmates (OR = 1.54, 95% CI 1.15-2.06). Notably, the
13
14 169 effects of SHS exposure in outdoor campuses cannot be ignored. Students with SHS
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16 170 exposure in outdoor campuses had significantly higher rates of respiratory symptoms
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18 171 (OR = 1.37, 95% CI 1.10-1.69) as compared with unexposed students, and there were
19
20 172 similar positive associations between respiratory symptoms and SHS exposure in
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22 173 outdoor campuses from smoking teachers (OR =1.38, 95% CI 1.09-1.75) or from
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24 174 smoking classmates (OR = 1.33, 95% CI 1.03-1.71).

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33 176 **Relationship between ordinal SHS exposure and respiratory symptoms**

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35 177 Compared with no SHS exposure, ordinal frequency of SHS exposure was associated
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37 178 with respiratory symptoms in an increasing manner (SHS in public places: OR=1 for
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39 179 no exposure, OR=1.50 for 1-4 days/week, OR=1.87 for 5-7 days/week, p for linear
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41 180 trend <0.001; SHS in indoor campuses: OR=1 for no exposure, OR=1.24 for 1-4
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43 181 days/week, OR=1.84 for 5-7 days/week, p for linear trend <0.001; Table 3). When
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45 182 examining these associations by source of exposure, significant increasing trends
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47 183 were observed for SHS exposure in indoor campuses from smoking teachers (p for
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49 184 linear trend =0.001) and from smoking classmates (p for linear trend =0.005).
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55 185 Additionally, there was a significantly increasing relationship between ordinal
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4 186 frequency of SHS exposure in outdoor campuses and respiratory symptoms (OR=1
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6 187 for no exposure, OR=1.28 for 1-4 days/week, OR=1.56 for 5-7 days/week, p for linear
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8 188 trend =0.007; [Table 3](#)), and similar increasing trends were observed for SHS exposure
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11 189 in outdoor campuses from smoking teachers (p for linear trend =0.004) and from
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13 190 smoking classmates (p for linear trend =0.006). However, no increasing trend was
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16 191 observed for SHS exposure in homes.
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21 **Relationship between continuous SHS exposure and respiratory symptoms**

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23 194 As to continuous SHS exposure, there were significant frequency-risk relationships
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25 195 between indoor SHS exposure and respiratory symptoms (OR = 2.30, 95% CI:
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28 196 1.67-3.16, for SHS in indoor public places; OR = 1.64, 95% CI: 1.23-2.20, for SHS in
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31 197 homes; OR = 2.09, 95% CI: 1.42-3.07, for SHS in indoor campuses; OR = 1.70, 95%
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33 198 CI: 1.18-2.47, for SHS in outdoor campuses; [Table 3](#)). When examining these
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35 199 associations by source of exposure, there were similar frequency-risk relationships for
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38 200 SHS exposure in indoor or outdoor campuses ([Table 3](#)). Additionally, we observed a
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41 201 monotonically increasing frequency-risk trend for SHS exposure in indoor public
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43 202 places ([Figure 1A](#)), in homes ([Figure 1B](#)), in indoor campuses ([Figure 2A](#)) or in
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45 203 outdoor campuses ([Figure 2B](#)). When examining these trends by source of exposure,
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47
48 204 there were similar increasing frequency-risk trends for SHS exposure from smoking
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50 205 teachers ([Figure 3A](#) for indoor SHS and [Figure 3B](#) for outdoor SHS) and from
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52 206 smoking classmates ([Figure 4A](#) for indoor SHS and [Figure 4B](#) for outdoor SHS).
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208 **DISCUSSION**

209 This observational study showed that non-smoking students with setting-specific
210 SHS exposure experienced significantly higher risks of respiratory symptoms than
211 those with no exposure. The most striking findings from this study were that there
212 were monotonically increasing frequency-risk relationships between setting-specific
213 SHS exposure and respiratory symptoms. When examining these associations by
214 source of exposure, there were similar monotonically increasing frequency-risk
215 relationships for SHS exposure from smoking teachers and from smoking classmates.

216 It is well known that there is no risk-free level of exposure to SHS. Although
217 previous studies have focused on SHS exposure among Chinese adolescents,^{15,16,20}
218 there is limited reports regarding SHS exposure in specific settings and specific
219 sources. According to the partial smoke-free legislation implemented in Guangzhou
220 on 1 September 2010, full smoke-free ban covered indoor campuses, outdoor
221 campuses and most indoor public places, but did not cover homes. It is disappointing
222 that SHS exposure in schools was not eliminated, and was still at a high level (22.7%
223 for SHS exposure in indoor campuses; 29.2% for SHS exposure in outdoor campuses).
224 This observation may be due to poor compliance with the full smoke-free ban in
225 campuses, since we observed that SHS exposure among students was mainly from
226 smoking teachers and smoking classmates in both indoor and outdoor campuses.
227 Similarly, a recent population-based study in Tehran showed that about 30%
228 non-smoking students have been exposed to SHS from smoking teachers in indoor or
229 outdoor campuses,²¹ and another survey of Chinese college students reported that

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4 230 37% of non-smokers had SHS exposure from smoking teachers.²⁰ More disappointing
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6 231 was that SHS exposure in indoor public places was remarkably high in 49.5% in this
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8 232 study, which is similar to results from the latest study on Guangzhou adults (50.3%)
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10 233 and the Global Youth Tobacco Survey (47.8%).^{22,23} After the implementation of a
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12 234 smoke-free legislation, very few respondents (1-2%) reported smoking in public
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14 235 places in England,²⁴ but smoking behaviors still remained high in public places in
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16 236 Guangzhou because of unwillingness of the policymakers to implement tougher
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18 237 smoke-free policies and poor compliance with the smoke-free law among smokers.²³
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20 238 These findings reveal that a partial smoke-free legislation has a weak impact on
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22 239 smoking cessation, but a comprehensive smoke-free legislation can substantially
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24 240 attenuate smoking behaviors, which point out the urgent need for a comprehensive
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26 241 smoke-free legislation covering all public places in Guangzhou to protect the public
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28 242 from SHS hazards.

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35 243 A few published studies have indicated that SHS exposure may be a risk factor of
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37 244 respiratory symptoms, but the potential relationship for setting-specific exposure was
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39 245 still unclear.^{15,16,25,26} Recent studies of Chinese adolescents indicated that there were
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41 246 positive associations between household SHS exposure and respiratory symptoms, but
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43 247 the association for SHS exposure in public places or in schools was unknown.^{15,16} In
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45 248 addition, the surveys of London casino workers and Shanghai workers revealed that
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47 249 there was an significant association between SHS exposure at work and respiratory
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49 250 symptoms, but the association for SHS exposure in homes or in public places was
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51 251 unknown.^{25,26} It is noteworthy that the influence of SHS exposure from indoor
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4 252 campuses on respiratory symptoms is still unclear, and the potential dose-response
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6 253 relationship between frequency of SHS exposure and respiratory symptoms is also
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8 254 uncertain. We found that there were positive and frequency-risk relationships between
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10 255 setting-specific SHS exposure and respiratory symptoms. When examining the
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12 256 associations by source of exposure, there was still evidence of similar dose-response
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14 257 relationships for SHS exposure in indoor campuses from smoking teachers and
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16 258 smoking classmates. These findings provide new evidence of dose-response
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18 259 relationships between SHS exposure and respiratory symptoms among adolescents.
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23 260 Further research is needed to establish the causal relationship, and confirm that
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25 261 elimination of SHS exposure (or stricter smoke-free legislation in Guangzhou) will
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27 262 lead to a reduction in respiratory symptoms among adolescents. Although the 2010
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29 263 report of the Surgeon General explained beyond a shadow of a doubt how tobacco
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31 264 smoke causes disease,²⁷ additional research should establish the potential biological
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33 265 mechanisms for the impact of SHS.
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38 266 Globally, outdoor smoking restrictions are uncommon, though the
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40 267 outdoor-campus smoking bans implemented in Guangzhou City on 1 September 2010.
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42 268 A few published studies have indicated that smoking increases PM_{2.5} concentrations in
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44 269 outdoor areas to levels that are potentially hazardous to health,^{28,29} but research
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46 270 linking SHS exposures from outdoor environments to health effects is still rare.
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48 271 Notably, the potential relationship between outdoor SHS exposure and respiratory
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50 272 symptoms is still unclear. To our knowledge, this is the first study to reveal the
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52 273 relationship between SHS exposure in outdoor campuses and respiratory symptoms
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4 274 among adolescents, and found that outdoor SHS exposure was positively associated
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6 275 with respiratory symptoms in a monotonically increasing trend. When examining the
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8 276 associations by source of exposure, there were still similar frequency-risk
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10 277 relationships for SHS exposure in outdoor campuses from smoking teachers and
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12 278 smoking classmates. Although outdoor SHS is more transient than indoor SHS,
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14 279 evidence from review of the research literature on SHS levels in outdoor hospitality
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16 280 venues suggested that tobacco-generated PM_{2.5} in outdoor setting may occasionally be
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18 281 equivalent to or higher than levels observed in indoor setting when smoking is
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20 282 permitted at close proximity.²⁸ These findings provide more evidence for the adverse
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22 283 effects of outdoor SHS exposure on human respiratory symptoms, and also support
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24 284 growing concern about SHS exposure in outdoor campuses. Future studies on school
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26 285 SHS exposure in adolescents and protective measures against SHS should take
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28 286 outdoor campuses SHS into consideration.

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35 287 This study adds to the literature by focusing on Chinese tobacco control and
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37 288 Chinese youth along with its global context. Additionally, we contribute additionally
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39 289 to the literature by exploring the potential frequency-risk relationships and
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41 290 differentiating SHS exposure in specific settings and specific sources to make
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43 291 exposure and potential relationships clearer. There are also some potential limitations
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45 292 in this study. First, all data was self-reported, including SHS exposure and respiratory
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47 293 symptoms. For SHS exposure, biochemical measures can give objective
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49 294 measurements, but cannot distinguish the sources of exposure, the key factors in this
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51 295 study. A previous survey has found that school children are capable of reporting their
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4 296 health conditions reliably,³⁰ and the presence of frequent cough and phlegm was quite
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6 297 obvious to avoid measurement error. Second, causal association between SHS
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8 298 exposure and respiratory symptoms could not be ascertained due to the cross-sectional
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11 299 design. However, the notion of reverse causation that students with respiratory
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13 300 symptoms deliberately increased their exposure to noxious SHS seems improbable.
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15 301 The strong associations observed in other studies also supported our data validity and
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17 302 provided support for the deduction of causation.^{15,31,32} Finally, few people would be
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19 303 completely unexposed to SHS in densely populated Guangzhou even now, when
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21 304 smoking was still allowed in public places (e.g., cafes, bars, night clubs, amusement
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23 305 parks, restaurants, and workplaces). Therefore, the control groups who reported no
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25 306 SHS exposure have probably underestimated their exposure, and the risk for
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27 307 respiratory symptoms in these groups would also be underestimated.

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33 308 In conclusion, SHS exposure in indoor and outdoor campuses is still at a high
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35 309 level, which suggests poor compliance with the full smoke-free ban in schools and
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37 310 supports growing concern about SHS exposure in campuses. Additionally, this study
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39 311 contributes to the literature by finding monotonically increasing frequency-risk
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41 312 relationships between SHS exposure and respiratory symptoms among adolescents in
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43 313 addition to differentiating SHS exposure in specific settings and specific sources to
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45 314 make these relationships clearer. Future longitudinal studies are needed to establish
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47 315 the causal relationship and the biological mechanisms for the impact of SHS.
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55 317 **Contributors**

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4 318 CZ, LG, LS, JT, XB, CJ and YX were involved in the design of the study, data
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6 319 analysis and writing of the draft of the manuscript. All the authors read and approved
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8 320 the final version of the manuscript.
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11 321

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14
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16
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22 23 326 **Competing interests None.**

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26 27 328 **Ethics approval**

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29 329 The Ethics Committee of Guangdong Pharmaceutical University.
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34 35 331 **Data sharing statement**

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37 332 No additional data are available.
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4 413 **Figure Legends**

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6 414 **Figure 1.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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8 415 exposure (A: exposure in indoor public places; B: exposure in homes).
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13 417 **Figure 2.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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15 418 exposure in campuses (A: exposure in indoor campuses; B: exposure in outdoor
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17 419 campuses).
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23 421 **Figure 3.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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25 422 exposure from smoking teachers (A: exposure in indoor campuses; B: exposure in
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27 423 outdoor campuses).
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33 425 **Figure 4.** Predicted prevalence of respiratory symptoms based on second-hand smoke
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35 426 exposure from smoking classmates (A: exposure in indoor campuses; B: exposure in
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37 427 outdoor campuses).
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429 **Table 1.** Demographic characteristics of the study participants

Characteristics	<i>n</i>	%	Characteristics	<i>n</i>	%
Respiratory symptoms			Grade		
No	3098	86.7	1-2	2329	65.2
Yes	477	13.3	4-5	1246	34.8
SHS exposure in general			Only-child		
No	1101	30.8	No	1353	37.8
Yes	2474	69.2	Yes	2222	62.2
SHS exposure in indoor public places			Gender		
No	1806	50.5	Male	1818	50.9
Yes	1769	49.5	Female	1757	49.1
SHS exposure in homes			Pocket money monthly(¥)		
No	2342	65.5	<100	2039	57.0
Yes	1233	34.5	100-399	1125	31.5
SHS exposure in indoor campuses			≥400	411	11.5
No	2763	77.3	Father's education		
Yes	812	22.7	Primary school	838	23.4
SHS exposure in outdoor campuses			Middle school	1215	34.0
No	2532	70.8	University and above	1522	42.6
Yes	1043	29.2	Mother's education		
Asthma history			Primary school	978	27.4
No	3514	98.3	Middle school	1165	32.6
Yes	61	1.7	University and above	1432	40.0

430 *n*, number of participants; %, the proportion of participants.

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433 **Table 2.** Relationship between binary SHS exposure and respiratory symptoms

SHS exposure	<i>n</i>	Respiratory symptoms (%)	Unadjusted OR(95%CI)	Adjusted OR(95%CI) ^a
SHS exposure in general				
No	1101	106(9.6)	1.00	1.00
Yes	2474	371(15.0)	1.66(1.32-2.08)	1.72(1.35-2.17)
SHS exposure in indoor public places				
No	1806	200(11.1)	1.00	1.00
Yes	1769	277(15.7)	1.49(1.23-1.81)	1.60(1.30-1.95)
SHS exposure in homes				
No	2342	275(11.7)	1.00	1.00
Yes	1233	202(16.4)	1.47(1.21-1.79)	1.53(1.25-1.87)
SHS exposure in indoor campuses				
No	2763	338(12.2)	1.00	1.00
Yes	812	139(17.1)	1.48(1.19-1.84)	1.43(1.14-1.79)
SHS exposure in indoor campuses from smoking teachers				
No	2940	369(12.6)	1.00	1.00
Yes	635	108(17.0)	1.43(1.13-1.80)	1.34(1.05-1.71)
SHS exposure in indoor campuses from smoking classmates				
No	3149	399(12.7)	1.00	1.00
Yes	426	78(18.3)	1.54(1.18-2.02)	1.54(1.15-2.06)
SHS exposure in outdoor campuses				
No	2532	309(12.2)	1.00	1.00
Yes	1043	168(16.1)	1.38(1.13-1.69)	1.37(1.10-1.69)
SHS exposure in outdoor campuses from smoking teachers				
No	2917	362(12.4)	1.00	1.00
Yes	658	115(17.5)	1.49(1.19-1.88)	1.38(1.09-1.75)
SHS exposure in outdoor campuses from smoking classmates				
No	2873	366(12.7)	1.00	1.00
Yes	702	111(15.8)	1.29(1.02-1.62)	1.33(1.03-1.71)

434 *n*, number of participants; SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.435 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
436 history (yes vs no).

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438 **Table 3.** Relationship between frequency of SHS exposure and respiratory symptoms

Frequency of SHS exposure	<i>n</i>	Respiratory symptoms (%)	Unadjusted OR(95%CI)	Adjusted OR(95%CI) ^a
SHS exposure in indoor public places				
No exposure	1806	200(11.1)	1.00	1.00
1-4 days/week	1242	184(14.8)	1.40(1.13-1.73)	1.50(1.20-1.86)
5-7 days/week	527	93(17.7)	1.72(1.32-2.25)	1.87(1.41-2.46)
Continuous SHS in indoor public places ^b			2.06(1.52-2.80)	2.30(1.67-3.16)
SHS exposure in homes				
No exposure	2342	275(11.7)	1.00	1.00
1-4 days/week	570	97(17.0)	1.54(1.20-1.98)	1.62(1.25-2.09)
5-7 days/week	663	105(15.8)	1.41(1.11-1.80)	1.45(1.13-1.87)
Continuous SHS in homes ^b			1.56(1.18-2.07)	1.64(1.23-2.20)
SHS exposure in indoor campuses				
No exposure	2763	338(12.2)	1.00	1.00
1-4 days/week	539	81(15.0)	1.27(0.98-1.65)	1.24(0.95-1.63)
5-7 days/week	273	58(21.3)	1.94(1.42-2.64)	1.84(1.32-2.56)
Continuous SHS in indoor campuses ^b			2.19(1.53-3.12)	2.09(1.42-3.07)
SHS exposure in indoor campuses from smoking teachers				
No exposure	2940	369(12.6)	1.00	1.00
1-4 days/week	412	59(14.3)	1.16(0.87-1.57)	1.13(0.84-1.53)
5-7 days/week	223	49(22.0)	1.96(1.40-2.74)	1.78(1.25-2.53)
Continuous SHS in indoor campuses from smoking teachers ^b			2.27(1.54-3.33)	2.06(1.37-3.09)
SHS exposure in indoor campuses from smoking classmates				
No exposure	3149	399(12.7)	1.00	1.00
1-4 days/week	271	45(16.6)	1.37(0.98-1.92)	1.38(0.97-1.97)
5-7 days/week	155	33(21.3)	1.86(1.25-2.78)	1.84(1.20-2.82)
Continuous SHS in indoor campuses from smoking classmates ^b			2.04(1.30-3.20)	2.00(1.22-3.26)
SHS exposure in outdoor campuses				
No exposure	2532	309(12.2)	1.00	1.00
1-4 days/week	704	105(14.9)	1.26(0.99-1.60)	1.28(1.01-1.64)
5-7 days/week	339	63(18.6)	1.64(1.22-2.21)	1.56(1.13-2.15)
Continuous SHS exposure in outdoor campuses ^b			1.79(1.27-2.51)	1.70(1.18-2.47)
SHS exposure in outdoor campuses from smoking teachers				
No exposure	2917	362(12.4)	1.00	1.00
1-4 days/week	456	71(15.6)	1.30(0.99-1.72)	1.24(0.94-1.64)
5-7 days/week	202	44(21.8)	1.97(1.38-2.79)	1.74(1.20-2.50)
Continuous SHS in outdoor campuses from smoking teachers ^b			2.53(1.71-3.74)	2.20(1.45-3.33)
SHS exposure in outdoor campuses from smoking classmates				
No exposure	2873	366(12.7)	1.00	1.00
1-4 days/week	451	62(13.8)	1.09(0.82-1.46)	1.16(0.86-1.57)
5-7 days/week	251	49(19.5)	1.66(1.19-2.31)	1.66(1.16-2.39)
Continuous SHS in outdoor campuses from smoking classmates ^b			1.55(1.05-2.30)	1.58(1.03-2.42)

439 *n*, number of participants; SHS, second-hand smoke; OR, odds ratio; CI, confidence interval.440 ^a: adjusted for gender (male vs female), grade (4-5 vs 1-2), only-child (yes vs no) and asthma
441 history (yes vs no).442 ^b: Use logarithmic exposure (days/week) in the model.

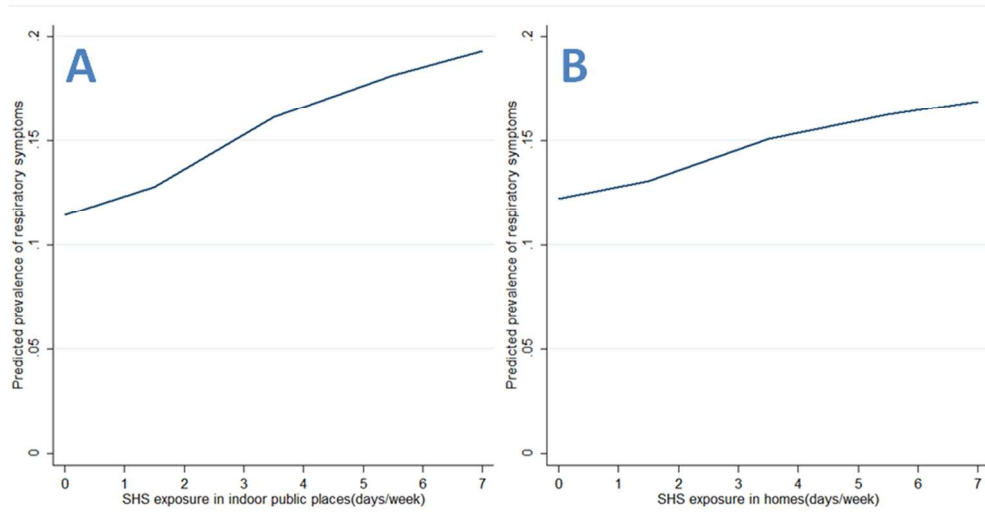


Figure 1. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure (A: exposure in indoor public places; B: exposure in homes).

124x63mm (300 x 300 DPI)

review only

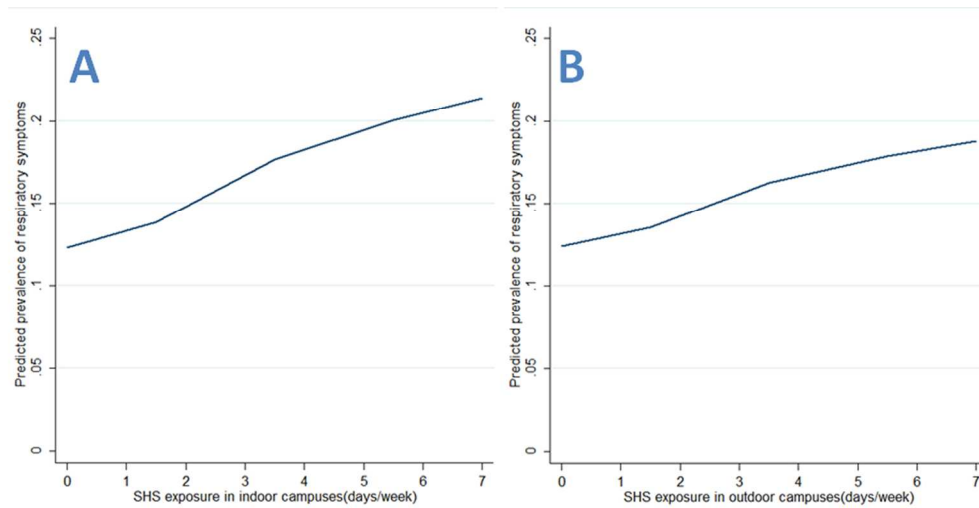


Figure 2. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure in campuses (A: exposure in indoor campuses; B: exposure in outdoor campuses).

125x64mm (300 x 300 DPI)

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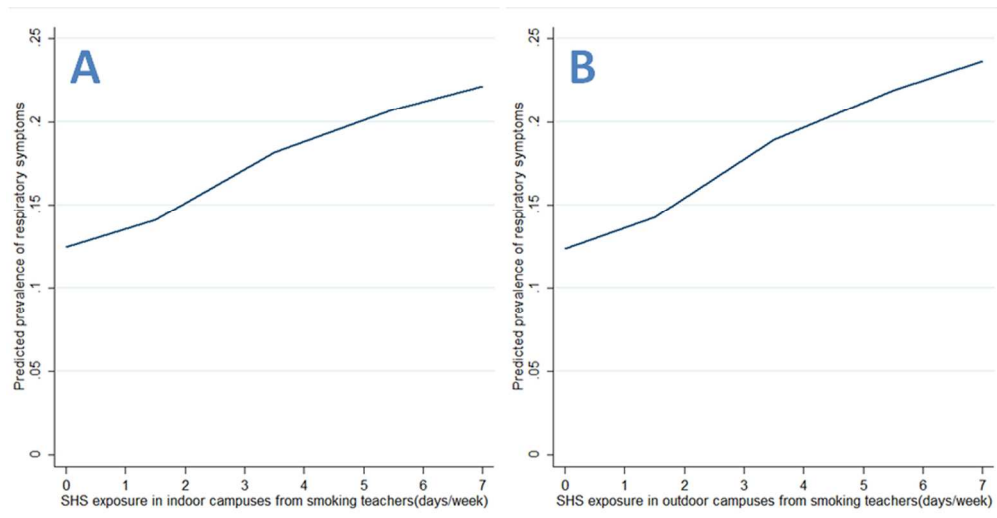


Figure 3. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure from smoking teachers (A: exposure in indoor campuses; B: exposure in outdoor campuses).

124x63mm (300 x 300 DPI)

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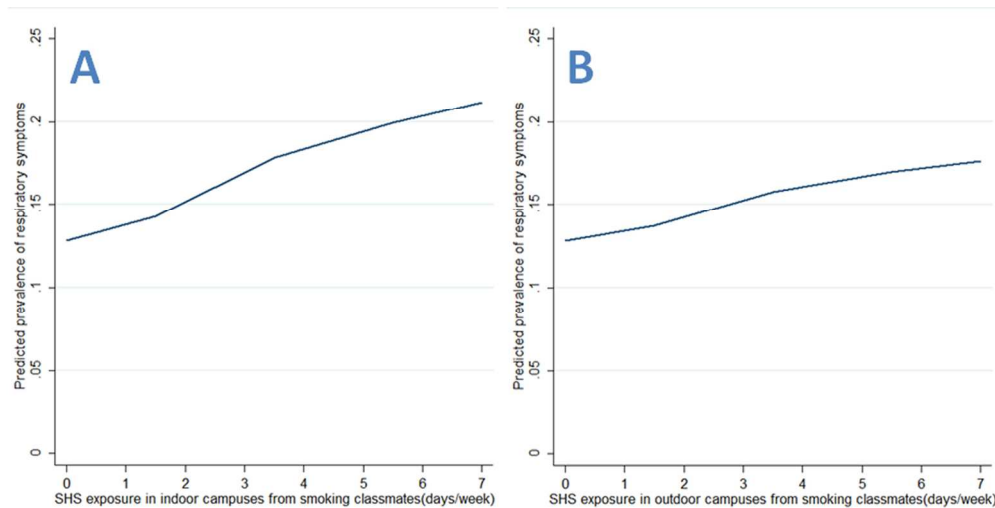


Figure 4. Predicted prevalence of respiratory symptoms based on second-hand smoke exposure from smoking classmates (A: exposure in indoor campuses; B: exposure in outdoor campuses).

124x63mm (300 x 300 DPI)

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	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
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
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	6-7
Study size	10	Explain how the study size was arrived at	5-6
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	No missing data
		(d) If applicable, describe analytical methods taking account of sampling strategy	No applicable
		(e) Describe any sensitivity analyses	7
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	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	No applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	8
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	8-10
		(b) Report category boundaries when continuous variables were categorized	8-10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	No applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
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	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
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	No funding

*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.