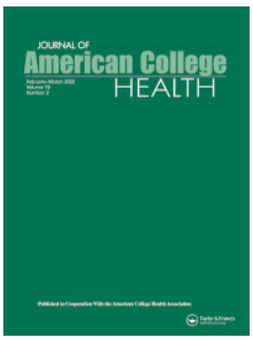

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The effect of secondhand smoke exposure on self-satisfaction and perceived freedom of life choice

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ABSTRACT

Objective: The present study aims to examine whether secondhand smoke exposure (SHSE) in university students can affect three indices of self-satisfaction related to depression as indiced by appearance, weight, and freedom of life choice. **Participants:** We collected data from 740 nonsmoking students in the summer of 2018, of which 57.84% were exposed to secondhand smoke. **Methods:** Depressive symptoms, SHSE, smoking status, weight satisfaction, appearance satisfaction, and freedom of life choice were self-reported via a questionnaire. **Results:** The generalized linear analyses revealed that SHSE was linked to lower scores of perceived freedom of life choice but not significantly associated with weight nor appearance satisfaction. The mediation analyses indicated that perceived freedom of life choice fully mediated the association between SHSE and depressive symptoms. **Conclusions:** These findings shed light on the importance of SHSE and its effects on mental health in university students. Preventive strategies should therefore locally target university campuses.

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Appearance satisfaction; depressive symptoms; freedom of life choice; secondhand smoke; weight satisfaction

Introduction

Depression, one of the main causes of disability in young people[1,2] remains a major public health issue.[3,4] A meta-analysis including 43 countries stated that the overall pooled crude prevalence of depression was 27.2%.[5] In Chinese medical students specifically, the prevalence of depression was 66.8%.[6]

Among all the factors that can increase the risk of depression in the university students, secondhand smoke exposure (SHSE) is inavoidable and passive for the majority people.[7–9] A previous study investigated 12 provinces in China and found that 65% of nonsmokers were annoyed by SHSE.[10] In fact, much evidence has even shown that SHSE increases the risk of depression.[11–13] However, no studies have thus far explored the latent mediators in the pathway from SHSE to depression.

As for university students, various indictors may be related to depression, e.g., lower self-esteem,[14] lower life satisfaction,[15] lower freedom of choice and life control,[16] lower body image satisfaction,[17] and etc. Moverover, in order to exclude the effect of the substantive conditions like weight, Richard and colleagues[17] found that the significant association between depression and body weight satisfaction was independent of body mass index (BMI), age, and sex. In the same vein, "loss of self-confidence or feeling self-abased," denoting the decrease of self-satisfaction, is one of symptoms indicated in the diagnostic criteria for major depressive disorder.[18] In fact, passive smoking can impact life satisfaction and self-reported health (well-being) in adolescents.[19] Occupational SHSE does not only have negative consequences on physical health, but it can also impact life satisfaction of nonsmokers.[20] However, directly supporting evidence to illustrate the association between SHSE and body image satisfaction and freedom of life cholice is lacking.

In the present study, we therefore focused on body image satisfaction including weight [17] and appearance,[21] combined with perceived freedom of life choice [16] to examine whether these factors could be affected by SHSE, as well as their

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mediation effects on the association between SHSE and depressive symptoms.

Methods

Participants

Data of the study were collected via an online system at the authors' universitiy, which was approved by the medical research ethics committee of the affiliated institute. Participants submitted their answers to our online system during two time periods: July to August 2018 (predominantly undergraduates) and first week of November 2018 (postgraduates). Informed consents were signed online. Data can be accessed via github (https://github.com/wanb-psych/SecondhandSmoke_FreedomLife).

Before conducting the survey, we have known that the general secondhand smoking exposure (SHSE) rate is around 65%,[10] the rate of having depressive symptoms in medical students is 42.8%,[5] and SHSE contributes to depressive symptoms (OR = 1.32).[11] In a power analysis, we set the $\alpha = 0.5$ and power = 0.8. It resulted in a minimal simple size of 757 individuals.

Finally, a total of 798 young adults completed our online questionnaire system, of which 740 (92.73%) were qualified. Following procedure was employed to screen the participants. Firstly, we assured that the participants were a current university student. Secondly, to exclude that a person submitted more than one questionnaire, we checked the username and IP address. Finally, to ensure that the participants were all nonsmokers, the smoking condition was screened according to the question "Are you continuously or cumulatively a smoker for 6 months or more?."

Measurements

Depressive symptoms

Depressive symptoms were self-reported using the Chinese edition of the Center for Epidemiologic Studies Depression (CES-D) Scale.[22] The CES-D is a well-validated screening tool for depressive disorder and has been used in many population-based epidemiologic studies worldwide.[23] The CES-D contains 20 items about symptoms describing the frequency in a past week on a 4-point Likert scale (higher marks indicate severer symptoms). The Chinese version of the CES-D scale has showed acceptable reliability and validity among all age groups both in urban and rural populations.[22] Scores greater than 15 scores are the recognized cutoff value of depression.[23,24]

SHSE. Frequency of SHSE was self-reported and consistently assessed in these surveys using a module developed and field-tested in China.[13,25] To ascertain the SHSE status, participants were asked the following question: "During the past 30 days, how many days a week have you breathed in smoke (including tobacco or e-cigarettes) exhaled from smokers in any places?."[13,25] Five options were available, i.e., almost no exposure, 1 day per week (1 day means "exposed to secondhand smoke to 15 minutes or longer per day"), 1–3 days per week, 3–5 days per week, and almost every day. At least 1 day per week was defined as SHSE, and the participants were categorized into two groups (no or yes).

Body satisfaction and freedom of life choice

Weight and appearance satisfaction: "Answer if you are satisfied with your body weight/appearance." 0 = not at all and 10 = a great deal.[17] Self-reported freedom of choice and control over life[16] was used to measure perceived freedom of life choice. The instructing statement was as follows. "Someone thinks there is no problem for them to choose his/her own life, but some others think they are incapable to control life. To what extent can you freely choose your life? 0 = you cannot control or determine your life and 10 = you can freely choose your life."

Statistical analysis

Mean value with SD and/or proportion were used to describe the variables. Chi-square test was performed to examine the difference between individual with and without SHSE in gender, living conditions, and socio-economic status. T-tests and non-parametric (Mann-Whiteney U) tests were performed in the univariate analyses to compare the differences in the scores of depressive symptoms, weight satisfaction, appearance satisfaction, and perceived freedom of life choice between SHSE and non-SHSE.

The associations between body satisfactions, perceived freedom of life choice, and depressive symptoms were examined via Pearson correlation. Partial correlation analyses were performed to control for the confounders such as gender, age, living condition, and socio-economic status.

Generalized linear model (GLM) was applied on continuous and non-normally distributed dependent variables (Kolmogorov–Smirnov tests with all p values < 0.001), including depressive symptoms scores, scores of perceived freedom of life choice, and scores of body satisfaction. Demographic variables were put into a starting model (confounders) to predict the continuous dependent variables. SHSE was then added to the models.

These analyses were carried out in the Statistical Product and Service Solutions (SPSS 22.0, IBM Corp., Armonk). Mediating analysis was employed to test the pathway of body satisfactions and freedom of life choice from SHSE to depressive symptoms in Process version 3.0[26] while controlling for the demographic variables. The indirect path is marked by a′b′ and the direct path is marked by c′. No mediating effect is observed when no path is significant or only the path c′ is significant. Full mediating effect is observed when only a′b′ path is significant and part mediating effect is observed when both a′b′ and c′ are significant.[27] The bootstrap was run with 10,000 samples to establish the effect size and 95% confidence interval (CI). All statistical tests were two-tailed and the significance level was set at 0.05.

Results

Population characteristics

In the final sample of 740 nonsmoking individuals aged 16 to 31 years [mean: 21.3, standard deviation (SD): 2.1], 29.19% were males. The living condition was categorized into alone (i.e., living in a house alone), sharing a room (i.e., 2–5 peers sharing a living room), sharing public areas (i.e., living in a room in a house), and home. The socio-economic status was categorized into low (below CNY 600 per month), middle-low (CNY 600–2,000 per month), middle-high (CNY 2,000–4,000 per month), and high (above CNY 4,000 per month). The majority of the participants (86.22%) shared a dormitory with other 2–5 peers and 72.84% had a relatively low socio-economic status. More than half of the individuals (57.84%) were exposed to secondhand smoke regardless of living condition, gender, and socio-economic status. Self-reported depression level in the present sample was relatively high (mean value score: 17.9, SD: 12.0, range: 0–55) and the weight satisfaction scores ranged from 0 to 10 [mean (SD) = 5.6 (3.0), freedom of life choice: mean (SD) = 6.5 (2.2); appearance satisfaction: mean (SD) = 5.8 (2.2)]. Individuals with SHSE were characterized as being younger and stayed more at home in the sample, and a lower proportion of sharing public areas (Table 1). There was no significant difference of distribution in gender or socio-economic status between SHSE and non-SHSE.

SHSE and body satisfaction/freedom of life choice

In the sample, 57.84% of individuals were exposed to secondhand smoke. T-tests showed that the differences in appearance satisfaction ($t = 1.18$, $df = 738$, $p = .237$), weight satisfaction ($t = .40$, $df = 738$, $p = .690$), and perceived freedom of life choice ($t = 1.80$, $df = 738$, $p = .073$) between SHSE and non-SHSE were not significant (Figure 1A). Non-parametric tests also showed the similar significance ($p = .242$, $p = .707$, and $p = .063$, respectively).

Multiple GLMs suggested that models using SHSE and demographic variables to predict self-satisfaction and freedom of life choice were significant (Table 2). Overall, the socio-economic status was a significant factor in the three models. Respectively, socio-economic status was a positive predictor for perceived freedom of life choice ($B = .36$, $\chi^2 = 5.61$, $p = .018$) and appearance satisfaction ($B = .39$, $\chi^2 = 6.71$, $p = .010$), and a negative predictor for weight satisfaction ($B = -.41$, $\chi^2 = 4.22$, $p = .040$). SHSE might predicte perceived freedom of life choice although predictive power did not reach significance ($B = .32$, $\chi^2 = 3.60$, $p = .058$) but did not significantly predict weight ($B = .11$, $\chi^2 = 0.24$, $p = .627$) and appearance ($B = .19$, $\chi^2 = 1.23$, $p = .268$) satisfaction. Other varibles including gender, age, and living condition were not significantly predictive of the satisfaction of appearance, weight, or freedom of life choice.

SHSE and depressive symptoms

T-test suggested that individuals with SHSE had higher depressive symptoms scores compared with individuals without SHSE [mean (SD): 18.6 (12.0) V.S. 16.8 (11.9), $t = 2.00$, $df = 738$, $p = .046$] (Figure 1A). When regarding SHSE as a five-category variable, we also observed SHSE was significantly associated with depressive symptoms ($F = 2.494$, $df = 735$, $p = .042$) but not significantly associated with the three self-satisfaction items. GLM was also significant ($B = 2.27$, $\chi^2 = 6.18$, $p = .013$) while adjusting for demographic variables (Table 4).

Self-satisfaction and depressive symptoms

As expected, decreased body satisfactions' scores and scores of perceived freedom of life choice were significantly correlated with increased depressive symptoms scores (Table 3). Depressive symptoms and perceived freedom of life choice showed the strongest correlation (Pearson $r = -.46$, $df = 738$, $p < .001$), followed by the correlation between depressive symptoms and self-evaluation of appearance (Pearson $r = -.34$, $df = 738$, $p < .001$). There was a week correlation between depressive symptoms and weight satisfaction (Pearson $r = -.17$, $df = 738$, $p < .001$).

In addition, body satisfaction and perceived freedom of life choice correlated with each other. Particularly, weight satisfaction was strongly correlated with appearance

Table 1. Demographic characteristics.

	SHSE (N = 428)	Non-SHSE (N = 312)		
Variable	N (%)/Mean (SD)	N (%)/Mean (SD)	t/χ^2	p
Age (years)	20.93 (1.86)	21.92 (2.35)	6.16	< .001
Gender			1.75	.186
Female	295 (68.9%)	229 (73.4%)		
Male	133 (31.1%)	83 (26.6%)		
Living condition			15.23	.002
Alone	13 (3.0%)	6 (1.9%)		
Sharing a room	363 (84.8%)	275 (88.1%)		
Sharing public areas	5 (1.2%)	14 (4.5%)		
Home	47 (11.0%)	17 (5.4%)		
Socio-economics status			2.67	.445
Low	13 (3.0%)	4 (1.3%)		
Middle-low	307 (71.7%)	232 (74.4%)		
Middle-high	96 (22.4%)	67 (21.5%)		
High	12 (2.8%)	9 (2.9%)		

SD: standard deviation. SHSE: secondhand smoke exposure.

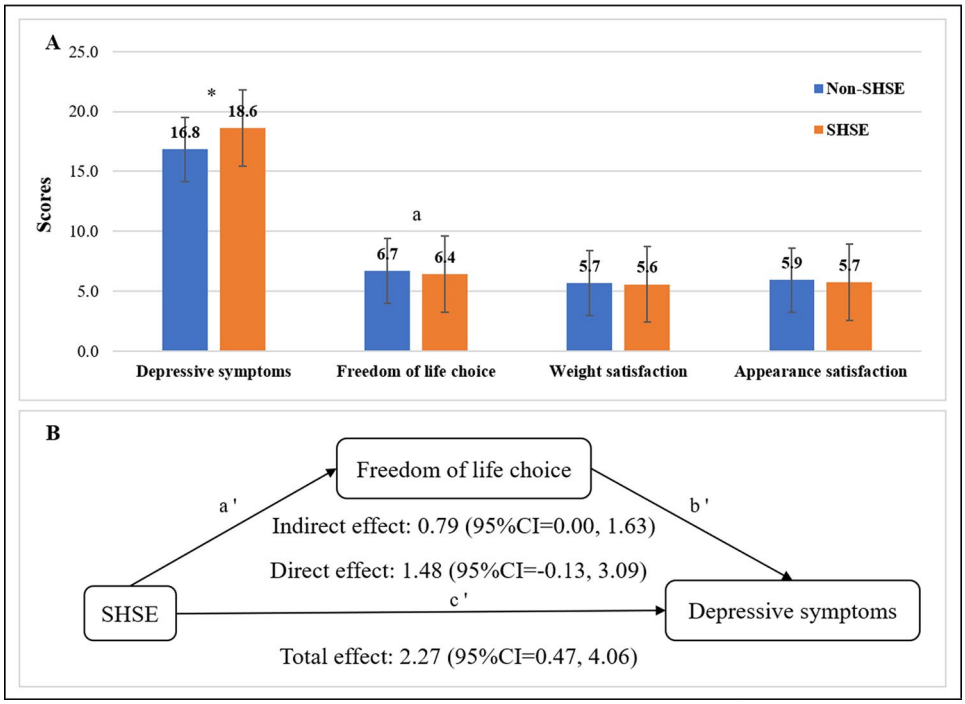

Figure 1. Association of SHSE with self-satidfaction and depressive symptoms. (A) Comparison of scores of depressive symptoms, perceived freedom of life choice, weight satisfaction, and appearance satisfaction between SHSE and non-SHSE. (B) The mediation model of the effect of SHSE on depressive symptoms through perceived freedom of life choice with adjustment for demograpgic varibles. [a]$p < .01$, *< .05. a'b' = indirect effect, c' = direct effect, a'b'+c' = total effect (mediation model). Appearance, body appearance satisfaction; Choice, perceived freedom of life choice; CI, confidence interval; SHSE, secondhand smoke exposure; Weight, body weight satisfaction.

Table 2. Multiple generalized linear model to predict freedom of life choice and body satisfaction.

	Freedom of life choice (Likelihood ratio χ^2 = 10.00, p = 0.075)				Weight satisfaction (Likelihood ratio χ^2 = 5.11, p = 0.403)				Appearance satisfaction (Likelihood ratio χ^2 = 9.28, p = 0.098)			
Predictor	*B*	*SE*	Wald χ^2	*p*	*B*	*SE*	Wald χ^2	*p*	*B*	*SE*	Wald χ^2	*p*
Gender	.09	.18	.23	.631	.12	.24	.27	.605	−.16	.18	.82	.365
Age	−.04	.04	.84	.359	−.03	.05	.29	.590	.02	.04	.17	.681
Living condition	−.06	.14	.22	.638	−.07	.18	.16	.692	.06	.14	.20	.651
Socio-economic status	.36	.15	5.61	**.018**	−.41	.20	4.22	**.040**	.39	.15	6.71	**.010**
SHSE	.32	.17	3.60	**.058**	.11	.23	.24	.627	.19	.17	1.23	.268

SHSE, secondhand smoke exposure; SE, standard error.
Bold values means (close to) significance level 0.05.

satisfaction (Pearson $r = .50$, $df = 738$, $p < .001$) and weakly correlated with perceived freedom of life choice (Pearson $r = .17$, $df = 738$, $p < .001$). Furthermore, partial correlation indicated that the associations between depressive symptoms and body satisfaction/perceived freedom of life choice were still robust after adjusting for demographic variables (Table 3).

Mediation analyses

Since SHSE, depressive symptoms, and perceived freedom of life choice were interlinked, perceived freedom of life choice was added to model 3 (Table 4). We found that perceived freedom of life choice was still significantly associated with depressive symptoms ($B = -2.43$, $\chi^2 = 192.71$, $p < .001$) but SHSE reached no significance ($B = 1.48$, $\chi^2 = 3.31$, $p = .069$). Besides, a positive significant association between age and depressive symptoms was observed in these models (model 2: $B = .49$, $\chi^2 = 5.42$, $p = .020$; model 3: $B = .40$, $\chi^2 = 4.60$, $p = .032$).

Furthermore, a mediation analysis was performed while controlling for gender, age, living condition, and socio-economic status (Figure 1B). The analysis showed that the mediating model was significant (total effect size = 2.27, 95%CI = 0.47, 4.06) and perceived freedom of life choice had a fully mediating role in the association between SHSE and depressive symptoms (direct effect size = 1.48, 95%CI = −.13, 3.09; indirect effect size = .79, 95%CI = 0.00, 1.63).

Discussion

Depression is arguably one of the most well-known medical illnesses and challenges the everyday-life of those affected. Multiple factors can contribute the condition—some more obvious than others—but some may be less evident and therefore have not received their rightful empirical attention. In the present study, we collected information about SHSE, depressive symptoms, body satisfaction, perceived freedom

Table 3. Correlations between depressive symptoms and satisfaction.

Variable	1	2	3	4
1. Depressive symptoms (scores)	–	−.46***	−.17***	−.34***
2. Perceived freedom of life choice (scores)	−.46***	–	.17***	.38***
3. Weight satisfaction (scores)	−.18***	.17***	–	.50***
4. Appearance satisfaction (scores)	−.34***	.37***	.52***	–

*** $p < .001$.
The gray cells are partial correlation coefficients after controlling for gender, age, living conditions, and socio-economic status.

Table 4. The generalized linear model to predict depressive symptoms scores.

	Predictor	*B*	*SE*	Wald χ^2	*p*
Model 1	Gender	.20	.97	.04	.835
(Likelihood ratio χ^2 = 4.14,	Age	.37	.21	3.25	.071
$p = 0.387$)	Living condition	.15	.73	.04	.836
	Economics	−.78	.81	.92	.338
Model 2	Gender	.33	.96	.12	.729
(Likelihood ratio χ^2 = 10.30,	Age	.49	.21	5.42	**.020**
$p = 0.067$)	Living condition	.08	.73	.01	.913
	Economics	−.77	.81	.89	.345
	SHSE	2.27	.91	6.18	**.013**
Model 3	Gender	.54	.86	.40	.526
(Likelihood ratio χ^2 = 181.57,	Age	.40	.19	4.60	**.032**
$p < 0.001$)	Living condition	−.08	.65	.01	.906
	Economics	.11	.72	.02	.883
	SHSE	1.48	.81	3.31	.069
	Freedom of life choice	−2.43	.18	192.71	**<.001**

Model 1 used primary variables (gender, age, living condition, and econo\mics) to predict depression scores and model 2 added SHSE based on model 1, and model 3 added perceived freedom of life choice based on model 2.
SHSE, secondhand smoke exposure; SE, standard error.
Bold values means (close to) significance level 0.05.]

of life choice, and demographic characteristics among 740 current university students. When adjusting for demographic variables including age, gender, living conditions, and socio-economic status, we found that SHSE could affect individuals' perceived freedom of life choice, but that it was not significantly associated with self-satisfaction of appearance or weight. SHSE was significantly associated with the increased depressive symptoms scores and with the decreased scores of freedom of life choice. Finally, freedom of life choice played a full mediation effect on the association between SHSE and depressive symptoms.

At first, the present study provided direct and novel evidence of the association between SHSE and self-satisfaction. Rajani and colleagues elucidated the negative association between SHSE and life satisfaction regardless of the smoking status.[20] We found that SHSE decreased perceived freedom of life choice but did not affect body weight or appearance satisfaction. In addition, Ngamaba and colleagues[16] suggested that freedom of choice contributed to life satisfaction and happiness. Combined with our finding that freedom of life choice was related to depressive symptoms, one may argue that SHSE have a profound influence on the individuals' mental health including life satisfaction, happiness, and depression. Freedom of life choice may therefore be the latent node in this linkage between SHSE and mental health. However, an alternative and plaussible explanation for this relationship is that people with low freedom of life choice are simply more vulnerable to or do not have the resources to avoid SHSE. Consequently, low freedom of life choice may not only increase SHSE, but in addition induce depressive symptoms. Nevertheless, "perceived freedom of choice and perception of controlling over life"[16] has the possiblity to be intervened by some behavioral therapy such as mindfulness meditation.

In light of preventive strategies, mindfulness has the potential to decouple the traingle associations among SHSE, depressive symptoms, and freedom of life choice. A review[28] suggested that mindfulness-based therapies function in part by decoupling the normative relationships between internal experiences (e.g., depression) and other internal/overt behavior (e.g., smoke). Gao and colleagues[7] also stated that a higher level of mindfulness was associated with an increase in the odds ratio (OR) of conscious secondhand smoke avoidance. Therefore, mindfulness could potentially be implemented in strategies to alleviate the negative effects of SHSE.

As we also found that individuals' socio-economic status contributed to freedom of life choice and age contributed to depressive symptoms, mindfulness interventions in these groups (i.e., students with lower socio-economic status and/or higher age such as postgraduates), would be beneficial. In fact, a recent survey[29] suggested that approximately one-third of postgraduates sought help for anxiety or depression.

Although individuals with SHSE showed higher scores of depressive symptoms than those without SHSE, it dose not necessarily imply that SHSE are at risk of major depression. Unlike previous literature[11–13] that supported association between SHSE and depression, a national study in Germany did not find any significant association between SHSE and depression in the overall population.[30] This may be related to population characteristics such as gender. Erdsiek and Brzoska[30] stated that male never-smokers with SHSE were counterintuitively at a significantly lower likelihood of depression than unexposed men but not significant in females. The sample of the present study, however, only included current

university students, most of whom were females. Hence, when we set a cutoff value as having depression (usually CES-D > 15), there was not a significant difference between SHSE and non-SHSE in the proportion of having depression.

Our study is the first to explore the mediators in the association between SHSE and depressive symptoms. Although body weight and appearance satisfactions were not significant mediators, this null-finding suggests that not all the early predictors related to depression can be associated with the environmental risk factors. In addition to the weak correlation between depressive symptoms and weight satisfaction, we found appearance satisfaction was moderately associated with depressive symptoms. This indicates that appearance satisfaction may be more sensitive in the development of depression. For example, prosocial behavior increases with improvement of appearance satisfaction,[31] and depression is characterized by the reduction of prosocial behavior.[32]

Nevertheless, the current study still involves some limitations. Firstly, we did not compute a variable that could discriminate postgraduates from undergraduates. Instead, they were categorized based the age in the explanation. Besides, the convenience sampling method was applied in the study and questionnaires were collected via the Internet, causing possible selection bias (e.g., more females in the present study). The majority of participants were medical students, and extrapolation to other groups can be suboptimal. Last but not least, the cross-sectional study cannot de facto explain a causal association. Optimally a follow-up investigation should be conducted to identify the possible causality.

Conclusion

Our findings suggest that SHSE may increase depressive symptoms and decrease perceived freedom of life choice, but is not significantly associated with body weight and appearance satisfaction. Besides, perceived freedom of life choice can mediate the association between SHSE and depressive symptoms. Our work enhances the knowledge of mental health effects of environmental risk factors (particully the SHSE and depression) and advocates that it is essential to avoid harmful effects of secondhand smoke. Psychological prevention methods (e.g., mindfulness meditation) and political incentives are potential strategies to impede the consequences of SHSE.

Conflict of interest disclosure

The authors have no conflicts of interest to report. The authors confirm that the research presented in this article met the ethical guidelines, including adherence to the legal requirements, of China and received approval from the South China Normal University.

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