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Air pollution as a catalyst for supporting tobacco control policies? Evidence from a nationwide study on Chinese medical students

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ABSTRACT

Purpose Few studies have discussed how the increasing ambient air pollution may affect policy-related attitudes. Medical professionals constitute an important interest group who analyse and solve public issues within a medicalised framework. The current study investigates whether ambient air pollution is associated with a greater likelihood of supporting tobacco control measures among medical students.

Methods We conducted multistage sampling among the medical students from 42 cities in China. We employed propensity-score matching to eliminate the selection bias and used multilevel logistic regressions for the main analysis (n1=9458, n2=42).

Results we found that city-level air particulate matter is consistently associated with the support for tobacco control among medical students, net of other individual-level and city-level covariates. For one standard increase in air particulate matter, people are 1.21 times more likely to fully support tobacco control measures ($p<0.05$). This association is significantly stronger among medical students who are financially worse-off and are ethnic majority.

Conclusions Environmental pollution has a significant correlation with people's attitudes towards health policies, even when such policies are not directly concerned with the natural environment. Policy makers may use this opportunity to implement tobacco control measures against the backdrop of China's pollution crisis.

INTRODUCTION

Ambient air pollution and tobacco control

The implementation of a variety of tobacco control policies is indispensable for achieving the long-term goal of reducing population-level tobacco use. Currently, most studies on support for tobacco control policies have primarily focused on individual-level social psychological antecedents, while few have explored the association between extraneous environmental factors and support for tobacco control policies. Among the little investigated environmental factors, a prominent and very urgent one in contemporary industrial societies is ambient air pollution. Use China for example, more than half of all Chinese cities have been under an environmental 'red alert' since 2012. In the winter of 2016, the smog was so severe that the invisibility led to flight cancellations in 23 cities stranding thousands of travellers[i]. It is estimated that the air pollution in China causes a drop in life expectancy by 5.5 years.[1]

As of the time of this study, some scholars have discussed how people may react and how communities are mobilised to protect their perceived welfare and public good from environmental risks.[2–5] When exogenous environmental threat appears, the public would adopt different reactionary strategies politically and socially available to them and mobilise resources embedded in their social networks. However, there is a lack of understanding of how ambient air pollution may specifically motivate people to support tobacco control measures. This gap is surprising because the mechanisms and harms caused by air pollution and tobacco smoking are largely comparable.[6–8] The pathophysiological pathways linking ambient air pollution to cardiorespiratory diseases are strikingly similar to that caused by tobacco smoke: oxidative stress and inflammation, vascular dysfunction and atherosclerosis, cardiac autonomic malfunction and translocation of particle constituents.[9] One study even quantifies that each day spent in China's average air pollution season amounts to smoking 2.4 cigarettes.[10]

Given tobacco smoking and air pollution's similar physiological pathways of affecting health, people may be more concerned about restricting tobacco use in the public sphere when they realise that atmospheric pollution has intensified. Risk is an inherent feature of modern society; the presence of systematic risks leads to the quest for social control via political, religious or economic measures.[11 12] Therefore, as social control, restricting tobacco smoking can be regarded by many as a more viable measure in addition to fighting against ambient air pollution whose source is more ambiguous and harder to eradicate. For example, proponents of smoke-free legislation often cite the damaged air quality as a threat to public good and evidence for their cause.[13] In fact, a study showed that air quality in Boston area improved after a public smoking ban.[14] A 32-country study showed that the concentration of atmospheric particulate matters is lower where smoking is prohibited in public space.[15]

[i] http://www.scmp.com/news/china/society/article/2056009/continued-heavy-smog-sparks-massive-flight-delays-and-around

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Support for tobacco control among medical students

The agenda settings of public policies rely on the cooperation of agents at various levels. Depending on their different social backgrounds and access to institutional resources, some groups may strive for voice in the public policy arena, whereas others may adopt a more rebellious strategy in response to environmental crisis.[16] Broadly speaking, insider agents (eg, medical professionals, interest groups, governmental agents) have much greater influence on the legislation and promulgation of health policies compared with outsider agents such as the general public.[17] Currently, empirical studies on support for tobacco control policies have overwhelmingly focused on popular opinion, but it would be more important to understand how extraneous environmental factors such as ambient air pollution affect tobacco control support among insider agents who have the potential capacity to guide the course of health policy legislations.

One important type of insider agents in the arena of health policies is medical students. Medical students as the in-the-making medical authority are actively involved in medicalisation—a phenomenon that our social problems are increasingly explained, intervened and solved within a medical framework—which allows them to conceptualise air pollution as a public emergency threatening public health.[18–20] Such a medicalised view of air pollution may further fuel medical students' strong interest in public health policies that are related to air quality, such as the tobacco control policies. Therefore, stronger air pollution may constitute a trigger for medical students to support more tobacco control measures, and what medical professionals have to say and act about air pollution carries significant weight to the implementation of tobacco control policies. This study thus tests the hypothesis: *higher levels of ambient air pollution at city-level is positively associated with individual-level support for comprehensive tobacco control among medical students, net of the effects of other individual- and city-level covariates.*

However, this hypothesis may face some unique challenges in China where over 20% of all physicians and over 30% of medical students are smokers themselves.[21–24] Also, scholars have elaborated a self-exempting mechanism that people develop in response to uncertain risks.[25–27] For example, smokers often cite the 'ubiquity belief' (the argument that risk is too omnipresent to avoid) in defence of smoking.[28] Both conditions make this study an interesting and important contribution to our understanding of how extraneous environmental factors, an understudied area, may influence attitudes towards tobacco control in unique demographic and social contexts.

Furthermore, support for health policies, including tobacco control, is not always a direct transformation of medical knowledge acquired through formal education.[29] Instead, it is heavily influenced by background factors such as gender and economic well-being. Medical students come from diverse demographic backgrounds, with some being more enthusiastic about tobacco control than others, even when they have received similar health knowledge through formal education.[30–32] The current literature on risk perception showed that liberals, women and whites are more in favour of environmental laws, although the evidence is inconsistent.[33–36] In the face of the disagreement on how demographic background affects medical students' response to pollution, we further test the tentative hypothesis that: *the association between city-level air pollution and individual support for comprehensive tobacco control is stronger among female, ethnic majority, and economically better-off medical students.*

METHODOLOGY

Sample

The data set used for the purpose of this study is a part of the Global Health Professions Student Survey (GHPSS). Specifically, the Tobacco Control in China extension of the GHPSS.[23 37]

The study employed a multistage sampling design and collected the sample in 2013. In Stage 1, 60 potential universities with medical programme were identified across regions. While this project primarily focused on smoking and tobacco control, it was also concerned with other aspects of health promotion, including obesity and mental health. From the 60 universities in the programme, students were recruited at 42 participating universities from all regions of China (Northeast, Northwest, North, Southeast, Southwest and South) to complete the survey. Stage 2 of the sampling strategy involved the selection of classes within each university. All students attending the randomly selected medical/health classes from these 42 participating universities received a questionnaire to answer anonymously. Because the survey questionnaires were administered during regular class sessions by faculty or school officials at each university, we achieved a high response rate of 97.5%. A total of 10 507 medical students were finally sampled from 42 cities with varying degrees of air particulate matter (see Figure 1). About 1500 non-medical students were also sampled by the project, but were not used for the purpose of this study.

Measurement

The dependent variable, support for tobacco control policies, is a binary variable. Value 1 was assigned to people who answered positively to all five questions: 'cigarettes should not be sold to adolescents', 'there should be a prohibition against advertising tobacco products', 'tobacco smoking should be prohibited in restaurants', 'tobacco smoking should be prohibited in bars, internet café, dance clubs', 'tobacco smoking should be banned from enclosed public places'. The first two questions concern the attitude towards some existing tobacco control measures in China, the other three questions concern the most popular measures of tobacco control currently being discussed or implemented.[23 38] Similar survey items have been used in other GHPSS surveys.[37]

The focal independent variables at the city level, sulfur dioxide emission and atmospheric fine particulate matter (more famously known as PM2.5), were obtained from a 2013 Greenpeace report on the air quality of 74 Chinese cities as well as from China City Statistical Yearbook of the National Bureau of Statistics.[39 40] All the city-level control variables also came from the latter source in 2013, which included Gross Domestic Product per capita in Yuan, population density per square kilometre, the proportion of the tertiary sector in economy and average disposable income in Yuan. These variables were found by previous studies to be associated with environmental pollution[35 41 42] and may also simultaneously contribute to local tobacco policies.[42 43] Control variables at individual level include: age, personal spending per month in Yuan (five categories: 0–500, 501–1000, 1001–1500, 1501–2000, 2000+), gender, ethnicity (Han, others), chronic health issue ('Do you have chronic health problems such as high blood pressure, migraine, gastritis?'), academic performance (top thirds, middle, low thirds), research university (doctor-granting institutions), smoking status (abstinent, smoking) and a broadly defined paternal occupation (working class, bureaucrats/public

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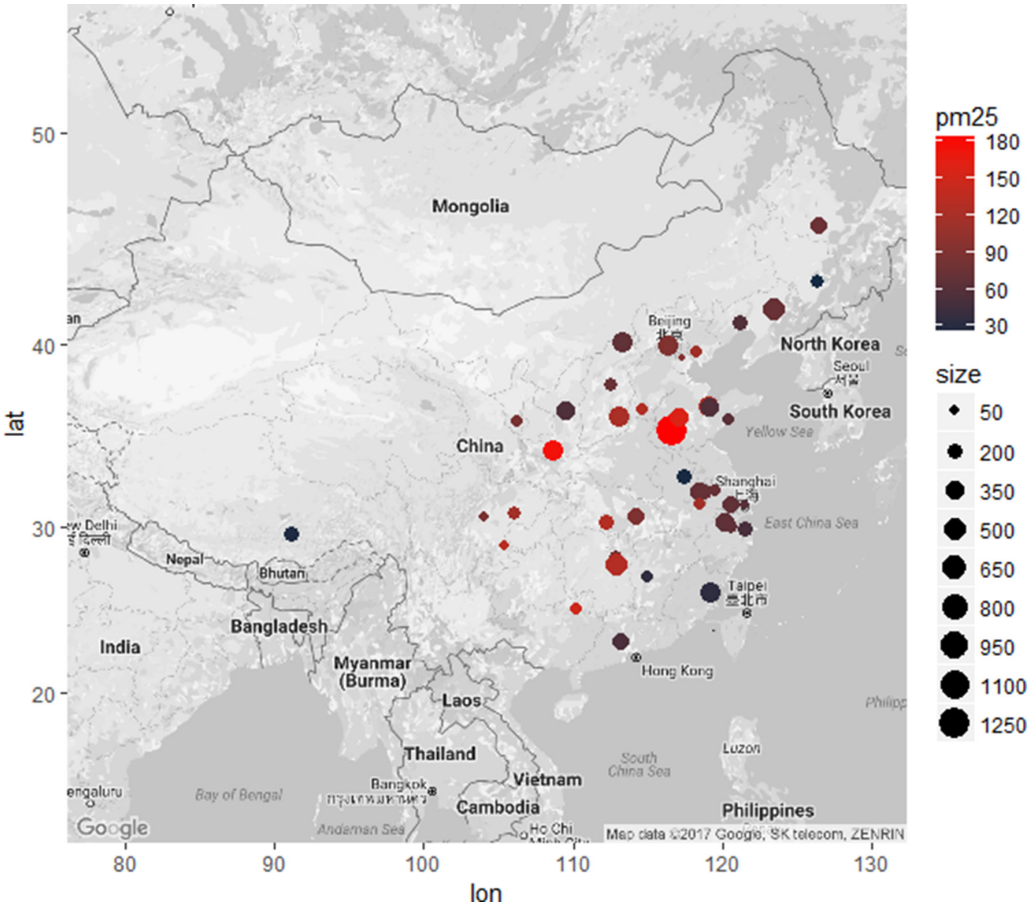

Figure 1 Size and level of air particle matter (pm2.5) in sampled cities on a map.

servants, intelligentsia)[ii]. For descriptive statistics, the original scales of the variables were retained. For other models, the city-level variables were standardised by dividing their centred values by SDs: $beta = \frac{x_i - \bar{x}}{sd}$. For these standardised variables, OR is induced by unit increase in SD.

Analytical strategy

When a sample involves clustering by bigger geographical loci, the advantages of multilevel (or mixed-effect) modelling over linear regression are apparent and fully elaborated elsewhere.[44] In this study, we adopted multilevel logistic regression to test hypothesis 1, with individuals as the first-level units and cities as the second-level units: $y_{ij} = \alpha_{ij} + \beta X_{ij} + \gamma Z_j + \lambda P_j + u_j + e_{ij}$, where y_{ij} is a binary value of supporting tobacco control policies for ith individual in jth city, P_j is the air pollution in jth city, X_{ij} is a vector of individual-level controls, Z_j is a vector of city-level controls, u_j is the city-level variance and e_{ij} is the error term for individuals. For hypothesis 2 that expects the impact of ambient air pollution to be moderated by gender, ethnicity and financial well-being, we included cross-level interaction terms and tested their significance. For these interaction terms, beyond the conventional significance test, we also calculated the region of significance to inform readers of the threshold at which the air pollution effect starts to differ between demographic backgrounds.[45]

A key issue in the studies of the effects of a higher ecological level (eg, neighbourhood effect, environmental effect, group-mean effect) is one that concerns causal identification, particularly that undermined by endogeneity and selection bias.[46 47] In this study, we resorted to propensity-score matching to rule out the possible endogenous selection bias. We employed the popular two-step method[48] to match those who go to school in a heavily polluted city (Air Quality Index (AQI) ≥90) with those in a cleaner city (AQI <90). The covariates used for the matching are gender, age, chronic health problem, studying in a different province than hometown, ethnic minority, father's occupation, smokers in family and academic performance. With these characteristics balanced between the subsamples from the polluted and unpolluted cities, we will be confident that our respondents are not self-selected into polluted cities. Only matched cases were retained for subsequent analyses (n=9458). Statistical analyses were facilitated by software R version 3.3.

RESULTS

Table 1 presents the basic descriptive statistics of all the variables later used in the analyses. At individual level, the percentage of supporting all five tobacco control measures asked in the questionnaire is 49.3%; 33.9% of the respondents are men, most of them are Han ethnic majority, the average age is 21 years and 22.8% of them reported having a chronic

[ii]The close collinearity between paternal and maternal occupation under this broad classification requires us to use only one of them.

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Table 1 Descriptive statistics for original sample, city-level variables unscaled

	Scale	Mean (SD)	Proportion (%)
Individual-level variables (n=10 507)			
Male	0, 1		33.9
Ethnic Han	0, 1		93.6
Age	15, 39	21.2 (1.7)	
Had chronic health problem	0, 1		22.8
Father occupation	0, 1		
Working class			79.4
Bureaucrats			14.3
Intelligentsia			6.3
Monthly spending level	1, 5	2.36 (0.77)	
Smoking status	0, 1		
Smoker			8
Never smoked			92.0
Academic performance	1, 3	1.87 (0.69)	
Research university	0, 1		41.9
Support comprehensive tobacco control	0, 1		49.3
City-level variables (n=42)			
Sulfur dioxide (thousand tons)	1.08, 313.1	94.41 (54.01)	
Air particulate matter (PM2.5)	21.7, 185.0	98.44 (47.76)	
High pollution (AQI>90)			55.0
Population density (per km^2)	103, 3826	1235 (595.5)	
GDP per capita (thousand Yuan)	12.87, 118.3	58.03 (26.4)	
Tertiary economy percentage	12.2, 76.9	44.33 (16.29)	
Average disposable income (thousand Yuan)	16.85, 40.19	26.89 (5.83)	

AQI, Air Quality Index.

health issue; even as a medical student population, 8% are smokers.

Across 42 cities, the average emission of sulfur dioxide is 94.4 thousand tons (SD=54.0) and the average index for atmospheric particulate matter is 98.44 with a substantial variation across cities (SD=47.76). According to the overall AQI, 55% of the cities would be considered 'heavily polluted'.

Before the main analysis, we tested the crude bivariate associations between support for tobacco control and city-level indicators, as displayed in table 2. Distinctly, among the 'supporting' people, sulfur dioxide is significantly higher in their cities (94.38>91.10, p<0.001); among the 'supporting' people, PM2.5 is also significantly higher in their cities (100.47>97.14, p<0.001). The city-level average disposable income is higher among the 'supporting' populace (27.19>26.91, p<0.05), while tertiary economy is negatively associated with supporting tobacco control (43.97<44.68, p<0.05).

Before the main analysis, we also used propensity-score matching for our sample based on a range of background characteristics. The matching results shown in the appendix A indicated that the matching was successful and that living in a highly polluted city is unlikely a selection effect based on personal background.

We present the multilevel models in table 3 that controlled for blocks of covariates step by step. Model 1 is the intercept-only model, serving as a baseline comparison. Model 2 includes all city-level variables and the propensity weight. We found that air particular matter is significantly associated with support for tobacco control (1.23, p<0.05), after controlling for all other city-level factors. For every SD increase in the level of air particulate matter, medical students living in that city are 1.23 times more likely to support comprehensive tobacco control. If a city's air particulate matter increases by two SDs, medial students therein will be 1.5 times more likely to support comprehensive tobacco control. The random effect of the intercept in model 2 changes from 0.064 to 0.042, indicating that 34.4% of the variation at the city level is explained by our city-level variables.

Model 3 of table 3 further included all the individual-level covariates. The significant effect of air particulate matter is not affected by the addition of individual-level variables. After accounting for individual differences, a standard unit increase in air particulate matter is associated with 1.21 times higher likelihood of supporting tobacco control, confirming our first hypothesis that ambient air pollution is positively associated with support for tobacco control among medical students. Higher average disposable income is also associated with tobacco control support. At individual level, we found that being male (0.73, p<0.001), having worse academic grades (0.86, p<0.001) and higher monthly spending (0.90, p<0.001) are associated with a lower likelihood of supporting tobacco control. On the other hand, older students (1.07, p<0.001) and non-smokers (2.55, p<0.001) are more likely to support tobacco control.

Taking account of cross-level interactions, table 4 shows that the effect of city-level air particulate matter is significantly stronger among ethnic Hans compared with ethnic minorities. The negative interaction between spending and air particulate matter also implies that richer students' tobacco control support is less affected by air pollution. Region of significance for ethnicity indicates that the divergent ethnic effect becomes significant when the standardised value of air particulate matter reaches above −0.19 (translates to pm2.5=80 on the raw scale) or falls below −4.17 (pm2.5=-105, which is unrealistic). Region of significance for monthly spending means that the divergent effect of economic well-being emerges when standardised air

Table 2 Bivariate associations between city-level variables and supporting tobacco control, based on Welch two-sample t-test

	Support tobacco control		t Value	95% CI of mean difference
	No	Yes		
Sulfur dioxide	91.10	94.38	−3.29***	−5.23 to −1.33
PM2.5	97.14	100.47	−3.48***	−5.21 to −1.45
Population density	1225.7	1245.2	−1.68	−42.31 to 3.22
GDP per capita	57.88	57.31	1.12	−0.43 to 1.59
Tertiary economy percentage	44.68	43.97	2.25*	0.09 to 1.34
High pollution	0.44	0.46	−1.08	−0.03 to 0. 01
Disposable income	26.91	27.19	−2.44*	−0.50 to −0.05

Note: *p<0.05, ***p<0.001, all two-tailed significance

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Table 3 Multilevel regression of support for tobacco control. City-level variables are scaled by dividing their centred values by SDs

	Model 1		Model 2		Model 3	
Fixed effects	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Individual level (n=9458)						
Male					0.73***	0.66 to 0. 80
Age					1.07***	1.03 to 1.10
Han ethnicity					1.16	0.95 to 1.43
Chronic health problem					0.95	0.86 to 1.05
Academics					0.86***	0.81 to 0. 91
Monthly spending					0.90***	0.85 to 0. 96
Father occupation						
Bureaucrats					0.96	0.84 to 1.09
Intelligentsia					0.94	0.79 to 1.12
Non-smoker					2.55***	2.12 to 3.06
Research university					1.08	0.91 to 1.33
Propensity weight			0.84**	0.73 to 0. 96	0.99	0.85 to 1.14
City level (n=42)						
Sulfur dioxide			1.04	0.95 to 1.14	0.99	0.91 to 1.09
Air particular matter			1.23*	1.02 to 1.50	1.21*	1.00 to 1.46
Population density			1.03	0.94 to 1.13	1.01	0.92 to 1.12
GDP per capita			0.84*	0.72 to 0. 98	0.90	0.77 to 1.06
High pollution			0.76	0.55 to 1.07	0.76	0.54 to 1.06
Tertiary economy			1.09	0.94 to1.26	1.05	0.91 to 1.21
Disposable income			1.16*	1.01 to 1.33	1.15*	1.00 to 1.31
Random effect						
Intercept	0.064		0.042		0.039	
Fitness index						
Akaike Information Criterion, Bayesian Information Criterion	13 038, 13 053		13 031, 13 103		12 758, 12 902	
Deviance, df	13 034, 9456		13 011, 9448		12 718, 9438	

Note: *p<0.05, **p<0.01, ***p<0.001, based on two-tailed t-value

particulate matter reaches above −0.45 (pm2.5=76 on the raw scale). Figure 2 visualises the contrasting effects of air particulate matter on the support for tobacco control between ethnic Hans and minorities, between people with low and high levels of spending. Taken together, our findings suggest that the policy reaction among richer students and ethnic minorities is more elastic in relation to ambient air pollution.

DISCUSSION

Ambient air pollution is a severe public health threat to the respiratory and cardiovascular health. While the health consequences of ambient air pollution have been forcefully demonstrated,[6 7 9 49] little do we know about the policy implications of air pollution. When the public have perceived a sufficient level of environmental threat, they often resort to political outlets and strategically support policy measures that may benefit their cause.[2 3 50] Air pollution and tobacco smoking both harm respiratory and cardiovascular health through similar mechanism, both of them directly pose a tangible feeling of deteriorated air quality and both elicit a sentiment of avoidance in the public space. Rooted in a literature tradition of environmental sociology and psychology, we hypothesise that medical students would favour stronger tobacco control policies when air pollution menaces.

With multilevel logistic regressions, this study shows that atmospheric particulate matter is positively associated with support for comprehensive tobacco control among medical students from 42 universities across China, after controlling for individual-level and city-level covariates. However, overall AQI and the emission of sulfur dioxide are not significantly associated with individual-level tobacco control support. We suspect this is because air particulate matter causes a greater sensation of discomfort than overall air quality and emitted sulfur dioxide. Sulfur dioxide emission is simply a measurement of industrial waste, which may or may not have been processed and purified before it reaches the general population. In contrast, people can hardly avoid inhaling and feeling the air particulate matter that floats in the atmosphere. As a result, air particulate matter may create a much more vivid psychological impact than other indicators of air quality and motivate the affected people to support related measures aiming at the air

Table 4 Interaction terms and random coefficients, all other fixed effects remain similar to model 3 of table 3

	OR	95% CI	Region of significance
Fixed effects			
Air particulate matter X Male	0.98	0.89 to 1.07	−2.04, 4.96
Air particulate matter X Ethnic Han	1.36*	1.07 to 1.74	−4.17, −0.19
Air particulate matter X Spending	0.92**	0.87 to 0. 98	−5.74, −0.45
Random effect			
Intercept	0.00		
Sex	0.003		
Ethnicity	0.004		
Spending	0.004		

Note: *p<0.05, **p<0.01, based on two-tailed t-value

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Figure 2 Cross-level interaction effects on the predicted probability of supporting tobacco control

quality in the public spaces, one of which is comprehensive tobacco control.

We have also found two moderating factors for the association: air pollution is associated with tobacco control support at a significant greater magnitude among the ethnic majority and less well-off respondents, while the ethnic minorities and respondents with higher monthly spending are comparatively less likely to support tobacco control in cities with worse air pollution. This finding indicates that tobacco control policies have a greater potential of gaining support from a somewhat populist demography: the worse-off ethnic majority.

Overall, this study found that extraneous environmental factors such as ambient air pollution constitute an important layer in the motivation of supporting tobacco control among

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medical students. Considering this finding and the fact that medical professionals often actively design and promote health policies as a means of expanding their influence in the public discourse,[18 51 52] the severe air pollution issue in China may serve as a complicated blessing. Policy makers may want to use this opportunity to push forth policies that can ultimately benefit the respiratory and cardiovascular well-being of the population. On the other hand, we also caution readers against the generalisability of such findings among medical professionals to the general population. It is well documented in the literature that people of different backgrounds may resort to very different strategies to deal with environmental threats, with the professionals and middle class being more likely to express their dissatisfaction through formalised policy channels.[4 16] How the general population, without as much knowledge on the harms of both tobacco smoke and ambient air pollution, would respond to the rising environmental issue remains another intriguing question.

LIMITATIONS

We have recognised a few limitations in this study. First, even though we have employed propensity-score matching to eliminate potential selection biases, without a longitudinal study design, the findings of this study cannot be taken as the evidence for a causal relationship between ambient air pollution and the support for tobacco control policy. Second, although we have shown a clear correlation between city-level air pollution and individual support for tobacco control, we have not formally tested the pathway between these two factors. A person must have actually perceived a severity of air pollution before s/he initiates counterstrategies. Lacking the exact measurement on individual perception of the air pollution in this survey, we defer this mediation test to future studies. As for a third limitation, despite matching respondents with the same demographic background and controlling for several city-level variables, it is worth the speculation whether certain unobserved endogenous variables would have caused a spurious association between air pollution and support for tobacco control. Could some cities have a more authoritarian orientation that promotes stronger attitude on both air pollution and tobacco use? Could some people be more likely to support tobacco control and have heightened environmental awareness due to their liberal ideologies? Future studies may further explore this area of knowledge.

What this paper adds

- We know ambient air pollution affects human health, and people may resort to public policies when the pollution threat menaces.
- No study has explored whether air pollution is associated with greater support for tobacco control.
- We found that support for tobacco control is positively associated with city-level air particulate matter (pm2.5) among medical students.

Contributors XYY designed the study and analysed the data provided by TY. FN revised the manuscript.

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