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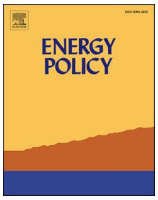

The impact of environmental accountability on air pollution: A public attention perspective

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ABSTRACT

Public attention to environment is an important form of environmental accountability, and is conducive to assisting the government in strengthening the control of air pollution. By using 7 types of daily air pollution data from 321 cities in China from December 1, 2013 to December 31, 2018, and merging with Baidu Index data, we studied the causal relationship between public attention and air pollution. The results show that public attention could reduce air pollution. Heterogeneity analysis shows that the suppression effect of public attention on air pollution is stronger in large, first-tier, and ministerial cites and cities with severe air pollution. Mechanism analysis shows that public attention could reduce air pollution through "complaint to the government" and "concern about health". Dynamic analysis shows that public attention is gradually increasing in restraining air pollution. This paper not only provide policy reference for the efficient control of air pollution in China and other developing countries, but also provide important insights for developed countries.

1. Introduction

China's long-term extensive development has severely overdrawn the environment in the past (Liu et al., 2020). As China's economy enters the transitional stage, the issue of air pollution has received more and more attention from both the government and residential departments, and the impact of the environmental accountability system is also expanding. Environmental accountability refers to the right of stakeholders to assess and decide actions that affect the natural environment (Grant and Keohane, 2005). Theoretically speaking, environmental accountability reflects the determination of the Chinese government and residents to control air pollution and achieve high-quality development, and could use the power of the public to help and urge government departments to improve the efficiency of environmental supervision and air quality. As the sole agent in traditional environmental regulation methods (Cole and Grossman, 1999; Bell and Russell, 2002; Shao et al., 2020; Shi et al., 2020), the government could only supervise large fixed pollution sources, while cannot supervise small and dispersed pollution sources because of the high cost (Tian et al., 2020; Yang et al., 2021). However, these small pollution sources might emit more air pollutants, thereby offsetting the government's efforts in air pollution control (Kolstad, 2011). Environmental accountability enables residents to fully participate in air pollution control, and to a certain extent makes up for the deficiencies of government departments in the process of air pollution control. It is not only conducive to supervising the prudential exercise of pollution rights by enterprises, but also urging the government to perform pollution control obligations in a timely manner. Therefore, building the environmental accountability system is not only an important manifestation of China's high-quality development, but also an important way for residents to participate in air pollution control.

Existing literature studies environmental accountability from the perspective of different market players (Lund-Thomsen, 2005; Jepson, 2005; Burritt, 2012). Young (2019) believes that the lack of an environmental accountability mechanism is an important cause of environmental degradation, and verified the role of environmental accountability in requiring the government and enterprises to assume environmental responsibility by examining the protest movements of grassroots communities and non-governmental organizations. Noah et al. (2021) used capture theory to study the causes of poor environmental accountability and found that lack of political will, fraud by regulatory agencies, and elite corruption are not conducive to corporate environmental accountability. Birkin et al. (2021) used a model of cognitive change and system theory to study the impact of ancient Chinese belief systems on corporate environmental responsibility. They

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found that Chinese accountants have a strong environmental ethics derived from their beliefs, which facilitates the accountability of corporate environmental behaviors. With increasing emphasis on environmental accountability, more and more serious contradictions have emerged between environmental degradation and environmental accountability. On the one hand, polluters are not responsible for the government's environmental protection department. On the other hand, organizations related to environmental protection are more concerned about whether environmental accountability has occurred, while not concerned about whether air pollution has improved after environmental accountability (Kramarz and Park, 2016).

Public attention is the foundation of environmental accountability. A low degree of social information interconnection would limit public participation in air pollution control and prevent the public from exerting social influence. On the one hand, the information asymmetry between the government and the public has greatly weakened the public's participation in air pollution control (Li et al., 2008). On the other hand, questionnaires and hotline-based channels cannot guarantee the quality of public participation in air pollution control (Johnson, 2010), and this process also prevents the public from knowing whether their opinions are understood or adopted by the government (Chen et al., 2015). With the development of the Internet, the social information between the government and the public is highly interconnected. The public's attention to the environment has become more and more important in the process of government departments and air pollution control, and has gradually become the basic form of environmental accountability. The public's attention to air pollution is not limited by time and space on the one hand, and it can be known to the government and pollution departments at any time, so as to help government departments deal with air pollution more effectively. On the other hand, it may also lead to a more advanced and formal environmental accountability mechanism, thereby promoting an increase in the efficiency of solving air pollution problems. In a word, as the Chinese economy enters a high-quality development stage, public attention will play an increasingly important role in the government's process of air pollution control. Public attention has also become an important breakthrough in quantitative research on environmental accountability due to its universality and basic nature. However, the current literature pays more attention to the government's treatment of air pollution, while does not conduct in-depth empirical research from the perspective of public attention.

In order to explore the causal relationship between public attention and air pollution, we use daily data from 321 cities in China from December 1, 2013 to December 31, 2018, and study the impact of public attention on air pollution. The results show that public attention could reduce air pollution. We analyze the heterogeneity of the air pollution reduction effect of public attention and find that the most significant reduction effect of public attention is in the large, first-tier, and ministerial city and cities with severe air pollution. Our mechanism analysis shows that public attention could reduce air pollution through "complaint to the government" and "concern about health". We have also discovered through dynamic effects research that the suppression effect of public attention on air pollution has shown an increasing trend year by year.

This paper makes several contributions. First, to the best of our knowledge, this paper is among the first to study the impact of environmental accountability on air pollution from the perspective of public attention. Most of the literature studies the impact on air pollution from the perspective of government environmental regulations (Li et al., 2021; Jia et al., 2021). Environmental accountability is an important trend in environmental protection and democratic construction. From the perspective of public's environmental attention, examining the inhibitory effect of environmental accountability on air pollution is an important advancement in the quantitative study of environmental accountability.

Second, this paper uses more detailed data to describe and characterize air pollution and public attention. Early studies mostly used annual data of a single pollutant at the provincial level to characterize China's air pollution (He, 2015). Research on this scale ignores the more detailed temporal and spatial differences in air pollution, and fails to make a more comprehensive assessment of air pollution itself. The advantage of our data is that, in the identification of air pollution, the real-time monitoring data of air pollutant concentration released by the meteorological department is aggregated to the daily and prefecture level. Compared with the provincial annual remote sensing data used in the previous literature, the recognition has been improved in terms of space, time, pollution measurement methods, and pollution evaluation dimensions. On the other hand, the Baidu Index of *Air Pollution* is used in the investigation of public attention. Compared with the single evaluation index used in the previous literature, this paper solves the problem that the popularity and quantity of entries cannot be balanced, and improves the identifiability of public attention.

Third, this paper explained the mechanism and other effects of public attention on air pollution. Existing literature on public attention and air pollution focused on the public's perception of air pollution (Peng et al., 2019), as well as their defensive behaviors (Xu et al., 2021), while not studied the mechanism of public attention that affects air pollution. We not only analyzed and verified in detail the mechanisms by which public attention reduce air pollution in two ways, including "complaint to the government" and "concern about health", but also found through heterogeneity analysis that the suppression effect of public attention on air pollution is stronger in large, first-tier, and ministerial cites and cities with severe air pollution. In addition, we explored the dynamic characteristics of public attention on air pollution at the annual level, and found that the effect of public attention on air pollution is gradually increasing.

The paper proceeds as follows. Section 2 outlines the theoretical mechanisms and hypotheses of public attention on air pollution. Section 3 explains our estimation strategy, data and variables. Section 4 presents the empirical results. Section 5 carries out extensive research. Section 6 concludes.

2. Theoretical mechanisms and hypothesis development

Paying attention to pollution and health issues could enhance the public's participation in environmental management (Chen et al., 2015), and it is also conducive to building a good environmental governance system (Martens, 2006) and solving actual environmental problems (Renn, 2006). Public participation in environmental management could enhance the awareness of the environment, promote effective communication between all parties, discover and resolve social conflicts, and establish mutual trust with other environmental subjects (Al-Kodmany, 1999). Environmental policies that include public values could gain more public recognition and support in the implementation process, making it easier to achieve set goals. The public attention to the environment may become a social force to improve the environment, and lack of attention to environmental issues may limit or delay the introduction of effective environmental protection measures (Liu and Mu, 2016). Therefore, public attention and social participation in environmental issues are beneficial to improve the quality of environmental decision-making and sustainable development (Reed, 2008; Koehler and Koontz, 2008; Iyer-Raniga and Treloar, 2000). Its impact is specifically manifested in the following aspects.

First, residents could put pressure on polluters by disclosing illegal emission activities. On the one hand, residents' attention to the environment could deter enterprises from illegal discharge, which is conducive to reducing non-compliant pollution emissions. On the other hand, residents' attention is conducive to timely handling of pollution incidents (Martens, 2006; Chen et al., 2015), thereby minimizing pollution losses. Second, residents' attention to the environment and health may lead to further green actions. The promotion of environmental protection and health awareness has promoted the public's

attention to environmental issues, and the attention could support further environmental protection actions. Specially, in areas with higher environmental democracy, it is more convenient for informal organizations or individuals to initiate environmental protection actions, and the public's support for green actions is more effective (Blake and Urmetzer, 1997). Third, residents' attention for the environment is conducive to mitigating collusion between government and enterprises at the pollution level. Regardless of the intention of a "political competition" or the corrupt intentions of officials themselves, the early excess emissions of enterprises were conspired by government and enterprises more or less. Residents' attention to the environment could slow down the illegal emissions of enterprises under the collusion of government and enterprises. And even when environmental protection became an important indicator for the promotion of government officials, it was undeniable that there was public attention boosting (Zheng et al., 2014). Therefore, this paper proposes the first hypothesis.

Hypothesis 1. Public attention to the environment could reduce environmental pollution.

Public attention to environmental pollution is an important catalyst for accelerating the introduction of environmental policies (Anderson et al., 2017). At any given time in society, residents and policy makers are faced with many public issues, and these issues always vie for attention. Due to the limited scope of attention and processing capabilities, issues with a low degree of attention often have a lower state of discussion. So, they are unlikely to be seriously considered and dealt with in the decision-making process (Loveridge et al., 1973; Jones, 1994). The same is true for environmental issues. Before environmental protection has become a key indicator for performance evaluation, environmental degradation will not naturally cause pressure on the government. Only when the public's dissatisfaction with the environment reaches a certain level that may cause social problems can it cause pressure on the government (Rohrschneider, 1998). After environmental protection has become a key indicator of political performance, public dissatisfaction with the environment will also put pressure on the local government by threatening the promotion of officials.

Specifically, since residents' environmental behavior is largely determined by their perception and understanding of pollution information (Liu et al., 2010), direct exposure to severe air pollution can easily trigger public attention and collective complaints by residents (Dong et al., 2011). And public attention and complaints and other dissatisfaction with the environment can create pressure on the government to manage the environment, so that the government needs to take measures to meet public environmental demands to a certain extent (Anderson et al., 2017). And because the public is usually familiar with nearby polluting companies (Dasgupta et al., 1996; Huang and Miller, 2006), their complaints can provide supervisors with valuable information and allocate inspection resources more effectively (Dong et al., 2011). Therefore, this paper proposes the second hypothesis.

Hypothesis 2. The public puts pressure on the government by expressing their dissatisfaction with the environment, thereby helping to improve air quality.

Concerns about health issues will increase public attention to environmental issues, and attention to environmental issues can also promote public awareness of health risks. When the relationship between environmental pollution and residents' health becomes stronger, residents can also put pressure on the government's environmental governance by expressing concerns about health problems. A typical fact that the disclosure of health risks puts public opinion pressure on the government is the development of the betel nut industry in Hunan, China. The betel nut industry has always been a key industry in Hunan and is also regarded by the government as an important industry to help farmers get rid of poverty. However, after the carcinogenic risk of betel nut was revealed, the government faced huge social ethical pressure and had to impose certain restrictions on the development of the betel nut industry. The local government has not only made many restrictions on the advertising of betel nuts, but in the future, it may also introduce the health risks based on the way of cigarette sales.

In the same way, the exposure of health risks to environmental issues may have similar effects. With the continuous advancement of research in the field of environmental science, a series of studies exposing the health hazards of air pollution have sprung up in an endless stream. The latest literature pointed out that air pollution not only increases the risk of lung cancer (Raaschou-Nielsen et al., 2016), but also invades the placenta (Bové et al., 2019), increases the probability of pregnancy loss (Zhang et al., 2019) and affects all organs' development of the newborn. The improvement of air quality can quickly and significantly reduce the risk of a series of diseases such as asthma, myocardial infarction and stroke, and even lead to longer life expectancy (Schraufnagel et al., 2019). The occurrence of these health risks and their gradual recognition by the public will cause a "ripple effect" in society (Everard et al., 2016), which will cause a certain amount of public attention and put pressure on the government. Moreover, the higher the education level, the clearer the awareness of pollution hazards, and the greater the pressure on the local government (Weersink and Raymond, 2007). The higher the degree of accountability, the more protest methods the public can take, and the greater the pressure on the government (Baettig and Bernauer, 2009; Neumayer, 2002; Schaffer and Bernauer, 2014). Therefore, residents' concern about health risks and the occurrence of health risks will catalyze the introduction of new policies by exerting pressure on the government (Anderson et al., 2017), thereby contributing to the reduction of environmental pollution. Based on this, this paper proposes the third hypothesis.

Hypothesis 3. Public attention to the environment may put pressure on the government through concerns about health risks, thereby reducing air pollution.

3. Empirical strategy

3.1. Model

In identifying the causal relationship between public attention and air pollution, and even though we do not need to worry about omitted variables bias as we controlled variables that have a key impact on air pollution at different levels, the reverse causality problem still presents a significant challenge. Clearly, the increase in air pollution would also increase public attention (Beamon, 1999). In order to avoid the bias caused by the reverse causality problem, we combined with the actual situation in China to lag the public attention. Since the formation speed of public attention, the efficiency of the government's handling of air pollution incidents, and the time required for the rectification of enterprises of different sizes are different in different regions (Zhang et al., 2020), we set the average lag period to 60 periods:

$$Pollution_{it} = \alpha_0 + \alpha_1 Attention_{it-60} + \alpha_2 X_{it} + \varphi_1 \delta_i + \gamma_1 \delta_t + \varepsilon_{it}. \quad (1)$$

where subscript i represents the city, and subscript t represents the date, t-60 represents 60 periods lag. *Pollution* represents the degree of air pollution. *Attention* represents public attention. X represents a series of city economic, weather and climate control variables. δ_i represents the city fixed effect, while δ_t represents a series of time fixed effect (including holiday, season, date, and weekend fixed effects). ϵ_{it} represents the random error term. α_1 is the coefficient of interest in this paper, which indicates the impact of public attention on air pollution. This paper clusters standard errors to the city level.

In order to explore the mechanisms of public attention on air pollution, this paper, according to Baron and Kenny (1986), constructed the following intermediary effect model:

$$Mec_{it} = \beta_0 + \beta_1 Attention_{it-60} + \beta_2 X_{it} + \varphi_2 \delta_i + \gamma_2 \delta_t + \varphi_{it}. \quad (2)$$

$$Pollution_{it} = \theta_0 + \theta_1 Attention_{it-60} + \theta_2 Mec_{it-60} + \theta_3 X_{it} + \varphi_3 \delta_i + \gamma_3 \delta_t + \tau_{it}. \quad (3)$$

where *Mec* is mechanism variable, and other variables are the same. Models (1), (2) and (3) together constitute the intermediary effect model. If the coefficients α_1, β_1, and θ_2 are significant, and θ_1 is smaller than α_1 or become insignificant, then it indicates that the mechanism variables in this paper have intermediary effect.

3.2. Data and variables

(1) Air pollution. The dependent variable of this paper is city-by-daily level air pollution data, including the air quality index (*AQI*) and six individual air pollutants (fine particulate matter ($PM_{2.5}$), inhalable particulate matter (PM_{10}), carbon monoxide (*CO*), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3)). Air pollution data comes from the collection of air quality monitoring stations on the Air Quality Online Detection and Analysis Platform.[1]

(2) Public attention. The independent variable of this paper is public attention (*Attention*), which is an index constructed based on the search volume of keywords on Baidu by netizens. According to Zhang et al. (2018), we use the Baidu index webpage[2] for statistics, and the keywords mainly include the following categories: pollution phrases that are most familiar to the public (e.g., air quality, air pollution, AQI, air pollution, environmental pollution, etc.), individual pollutants that cause air pollution ($PM_{2.5}$, PM_{10}, CO, NO_2, SO_2, O_3), and pollution phrases that are most easily observed by the public (e.g., smog, acid rain, photochemical smog, red smog, etc.). We build public attention indicators by adding up the search volume of keywords.

(3) Mechanism variables. The mechanisms verified in this paper are "health concerns" and "environmental dissatisfaction", which are characterized by the search volume of the phrase "health" (*Health*) and the phrase "complaint" (*Complain*), respectively. The phrase "health" includes public searches for "asthma", "cough", "shortness of breath", "chest pain", and "chest tightness" mainly caused by air pollution for respiratory diseases. The phrase "complaint" includes "pollution complaints", "Environmental Protection Agency", "Ministry of Environmental Protection", "Environmental Protection Law", "12369" and other keywords for online complaints made by the public. We also build these mechanism variables by adding up the search volume of keywords.

(4) Control variables. The control variables in this paper mainly include city economic variables, climate variables and weather variables. City economic variables include the total population at the end of the year (POP), the proportion of employees in the secondary industry (IND), the land area of the administrative area (ARE), the gross regional product (GDP), the number of industrial enterprises above designated size (ENT), the total output value of industries above designated size (OUT), and population density (DEN). Climatic variables include average temperature (TEM), average humidity (HUM), average precipitation (RAI), and sunshine (SUN). Weather variables include maximum temperature (HTEM), minimum temperature (LTEM), wind power (WIND), and whether it is raining or snowing (PREC). The city economic variables come from the China City Statistical Yearbook, the climate variables come from the China Meteorological Yearbook, and the daily weather variables come from Air Quality Online Detection and Analysis Platform.

[1] https://www.aqistudy.cn/historydata/.
[2] https://index.baidu.com/v2/index.html#/.

Table 1 shows the descriptive statistics of the main variables in this paper. We found that the average value of AQI is 85.67, which indicates that the air quality is generally good. However, the standard error is 50.33, indicating there is a huge difference in air quality between different regions. The standard errors of the 6 individual pollutants are also large, and this provides a good heterogeneous sample for the study of this paper. The average value of the public attention variable is 197.9, shows that the public generally pays more attention to air quality, but the standard error is 631.9, which means that the regional difference of public attention is also large. This provides us with rich information on the impact of public attention on air pollution.

4. Results

4.1. The effects of public attention on air pollution

We used formula (1) to examine the effect of public attention on air pollution, and the baseline results are presented in Table 2. In column (1), we only control the city fixed effect and time fixed effect (including holiday, season, date, and weekend fixed effects) for regression. We found that increased public attention could reduce air pollution. On average, every 1% increase in public attention could reduce air pollution by 0.8% at a significant level of 1%.

In order to reduce the bias of the model setting and obtain more accurate estimation results, we, on the basis of column (1), added the control variables of city economic (column (2)), the climate variables at the annual level (column (3)) and weather variables at the daily level (column (4)) in turn. Especially, we found from column (4) that the coefficient on public attention is significantly negative at the 1% level, indicating that in a statistical sense, public attentions significantly inhibit air pollution, and these findings are in line with previous theoretical analysis. Specifically, on average, for each additional public attention (0.51%), the probability of air pollution decreases by 0.86% (9.66%). This corresponds to an elasticity between public attention and air pollution of 17.04%. Also, we can convert the magnitude using standard deviations. The estimates indicate that a one standard deviation increase in public attention decreases air pollution by 0.093 standard deviations. Furthermore, in comparison with previous studies that explored the factors influencing air pollution among public attention (Liu et al., 2021; Sun et al., 2016; Zhang et al., 2018), we considered that our estimates had economic significance. These results provide supportive evidence for Hypothesis 1.

Table 1
Descriptive statistics.

	Variable	N	Mean	S.D.	Min	Max
Dependent variables	AQI	265,409	85.67	50.33	0.00	500.00
	$PM_{2.5}$	265,409	53.91	43.49	0.00	1031.0
	PM_{10}	265,409	90.89	64.33	0.00	2366.0
	CO	265,409	1.183	16.77	0.00	7668.0
	NO_2	265,409	33.01	18.47	0.00	234.00
	SO_2	265,409	27.86	29.39	0.00	737.00
	O_3	265,409	85.43	42.80	0.00	385.00
Independent variable	Attention	265,409	197.9	631.9	0.00	102748
Control variables	POP	265,409	46.94	13.79	9.85	83.430
	IND	265,409	15732	19365	1201	252777
	ARE	265,409	28.12	35.33	2.01	281.80
	GDP	265,409	1428	1578	23.0	10776
	ENT	265,409	43.75	52.20	0.43	322.40
	OUT	265,409	465.7	349.2	5.73	2648.0
	DEN	265,409	15.38	4.944	−0.88	25.300
	TEM	265,409	69.35	10.28	34.0	91.000
	HUM	265,409	2477	37067	41.8	2938.2
	RAI	265,409	1927	519.4	247	3277.0
	PREC	265,409	0.335	0.472	0.00	1.0000
	WIND	265,409	2.592	0.849	0.00	11.500
	HTEM	265,409	20.02	10.73	−42.0	41.000
	LTEM	265,409	11.31	11.12	−34.0	37.000

Table 2
Baseline results: the effects of public attention on AQI.

	AQI			
Variable	(1)	(2)	(3)	(4)
Attention	−0.0080***	−0.0086***	−0.0089***	−0.0086***
	(0.0024)	(0.0019)	(0.0019)	(0.0017)
POP		−0.0435	−0.0454	−0.0429
		(0.0316)	(0.0333)	(0.0315)
IND		0.0256	0.0005	0.0277
		(0.1821)	(0.1905)	(0.1860)
ARE		0.0027*	0.0028**	0.0027*
		(0.0014)	(0.0014)	(0.0014)
GDP		−0.0001	−0.0001	−0.0001
		(0.0001)	(0.0001)	(0.0001)
ENT		0.0039	0.0041	0.0043*
		(0.0026)	(0.0025)	(0.0025)
OUT		0.0001	−0.0001	−0.0001
		(0.0001)	(0.0001)	(0.0001)
DEN		−0.0043	−0.0032	−0.0033
		(0.0114)	(0.0114)	(0.0114)
TEM			1.3526	0.7557
			(1.0658)	(1.0597)
HUM			−0.2770*	−0.2560
			(0.1623)	(0.1621)
RAI			−0.0001*	−0.0001
			(0.0000)	(0.0000)
SUN			0.0005	0.0003
			(0.0034)	(0.0034)
HTEM				1.1102***
				(0.0983)
LTEM				−0.6387***
				(0.1323)
WIND				−1.8181***
				(0.3064)
PREC				−7.0720***
				(0.3866)
City fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Constant	233.7381***	205.0055***	200.2463***	199.9680***
	(11.6935)	(22.0393)	(27.3407)	(27.1024)
Observations	502,557	253,258	248,016	248,016
Adjusted R^2	0.2282	0.2648	0.2681	0.2843
Cities	321	283	278	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

Since AQI is composed of six types of air pollutants, the sources of different pollutants are not the same, and the public pays different attention to different pollutants. Therefore, the impact of public attention on air pollution might only be significant for some pollutants. From the perspective of pollutant sources, $PM_{2.5}$, PM_{10} and CO are mainly derived from environmental by-products produced in the production process of industrial enterprises (Cheng et al., 2020). NO_2 is produced in industrial production and automobile exhaust (Maddix and Adams, 2020). In addition to the above two sources, SO_2 also comes from scattered coal burned in residents' daily lives (Zhao et al., 2018). O_3 is mainly derived from secondary pollution formed by chemical reactions with other pollutants in the air (Lou, 2014). Its generation and concentration changes depend on the proportion of other pollutants in the air.[3] From the perspective of the public's sensitivity to different pollution, $PM_{2.5}$ and PM_{10} are the main components of haze, which could be easily perceived by the public, so they are also the pollutants that attract the most public attention. SO_2 and NO_2 could be perceived by the public through pungent odors only at a certain concentration, so they could only receive public attention in severe pollution. Although CO and O_3 are one of the main components of air pollution, they are relatively low in concentration and difficult to be perceived, so they rarely receive public attention. In order to verify this inference, this paper further analyzes the impact of public attention on the six air pollutants based on the baseline model.

The regression results of public attention on different air pollutants are shown in Table 3. We found that the increase in public attention has a significant inhibitory effect on the concentration of all air pollutants. Public attention has a stronger suppression effect on the two pollutants that constitute smog, $PM_{2.5}$ and PM_{10}. Public attention also has inhibitory effect on NO_2 and CO at the 5% significance level, which is in line with our expectations. However, the public attention does not significantly inhibit SO_2 and O_3 at the 10% significance level, which is inconsistent with the expected results. The possible reason is that public attention could only interfere with the production of industrial enterprises to a large extent, but not to the household energy consumption. Although the pollution emissions of industrial enterprises have been converged, the increase in household energy consumption may offset the reduction of SO_2 emissions by enterprises to a certain extent (Almond et al., 2009). As for O_3, the possible explanation is that the decrease in $PM_{2.5}$ concentration provides a good environment for the chemical generation of O_3, which ultimately leads to an increase in the O_3 concentration in the air (Lou et al., 2014; Li et al., 2019). This result is also consistent with the description of the reverse relationship between $PM_{2.5}$ and O_3 concentration changes in the series of reports "China's Air Pollution Prevention and Control Process". Due to the special nature of SO_2 and O_3, we focused on $PM_{2.5}$, PM_{10}, CO and NO_2 in the following part.

4.2. Endogenous issues

This paper avoids the endogenous problem of reverse causality through lagging public attention by 60 days. In order to get a more accurate estimation result, we employ the instrumental variable (IV) method to estimate.

We choose the public attention of all other cities in the province as IV (Zheng and Ward, 2011), and the specific reasons are as follows. From the perspective of relevance, due to the relatively fast transmission of information on the Internet, changes in public attention in a city will inevitably affect changes in public attention in other cities in the same province, such as the outbreak of environmental pollution incidents and government regulations on environmental pollution. Therefore, the IV we selected satisfies the relevance requirements. From the perspective of exclusivity, public attention will only affect the local government's strengthening of air pollution control, and will not affect the environmental control decisions of other local government departments. Therefore, the IV we selected satisfies the requirement of exclusivity. Table 4 reports the estimated results using the IV method. It could be found that after excluding the endogenous problem of the model, public attention could still suppress air pollution at a significant level of 1%.

4.3. Robustness test

4.3.1. Adjusting lag period

The impact of public attention on air pollution has a lagging effect. Based on traditional literature and the actual situation in China, this paper selects a 60-day lag for research. However, due to the large differences in the formation speed of online public opinion, the time required for the rectification of polluting departments of different scales, and the efficiency of local government environmental regulations in different regions (Li and Ramanathan, 2018), we choose to lag 40, 50, 70 and 80 days for robustness testing. The estimation results in Table 5 show that the inhibitory effect of public attention on air pollution is not significant when the lag is 40 or 80 days, while significant at 50 or 70 days, indicating that the public attention has a lagging effect (about 60 days) on air pollution. The baseline regression results are convincing.

[3] It has a variety of complex chemical reaction processes such as photochemical reaction and heterogeneous reaction with $PM_{2.5}$, NO_2, etc. Readers can refer to the related papers of Lou (2014) and Li (2019).

Table 3
Baseline results: the effects of public attention on six types of air pollutants.

Variable	$PM_{2.5}$	PM_{10}	CO	NO_2	SO_2	O_3
	(1)	(2)	(3)	(4)	(5)	(6)
Attention	−0.0059***	−0.0055***	−0.0005***	−0.0030**	−0.0022	−0.0035
	(0.0014)	(0.0020)	(0.0001)	(0.0015)	(0.0019)	(0.0023)
Control variables	YES	YES	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
Constant	164.9515***	199.4553***	22.3404***	32.2335*	66.1632***	71.0774
	(24.5104)	(39.0310)	(5.7700)	(16.4746)	(21.3040)	(43.3829)
Observations	248,016	248,016	248,016	248,016	248,016	248,016
Adjusted R^2	0.3429	0.3241	0.2807	0.4235	0.3032	0.4976
Cities	278	278	278	278	278	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

Table 4
IV estimation.

Variable	AQI	$PM_{2.5}$	PM_{10}	CO	NO_2
	(1)	(2)	(3)	(4)	(5)
Attention_IV	−0.0283***	−0.0268***	−0.0605***	−0.0042***	−0.0129***
	(0.0045)	(0.0040)	(0.0070)	(0.0006)	(0.0016)
Control variables	YES	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES
F value of the first stage	153.2735	153.2735	153.2735	153.2735	153.2735
Kleibergen-Paap rk LM statistic	116.2826	116.2826	116.2826	116.2826	116.2826
Cragg-Donald Wald F statistic	129.4301	129.4301	129.4301	129.4301	129.4301
Anderson-Rubin Wald test	50.2511	64.2649	173.8128	84.1637	123.9898
P-value	0.0000	0.0000	0.0000	0.0000	0.0000

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

Table 5
Robustness test: adjust the lag period.

Variable	40-period lag	50-period lag	70-period lag	80-period lag
	(1)	(2)	(3)	(4)
Attention	0.0004	−0.0071***	−0.0092***	−0.0093*
	(0.0053)	(0.0023)	(0.0018)	(0.0048)
Control variables	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Constant	129.9304***	45.5293	100.3636***	82.8660***
	(28.7198)	(28.9815)	(25.1217)	(24.9016)
Adjusted R^2	0.2926	0.2856	0.2801	0.2803
Observations	253,562	250,789	245,240	242,479
Cities	278	278	278	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

Table 6
Robustness test: eliminate interference from other factors.

Variable	Drop low Internet access rates	Drop data fraud intervals	Drop 2 + 26 cities	Drop carbon market pilots
	(1)	(2)	(3)	(4)
Attention	−0.0074***	−0.0069***	−0.0132***	−0.0098***
	(0.0018)	(0.0017)	(0.0051)	(0.0018)
Control variables	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Constant	235.7699***	210.7124***	199.8875***	192.3123***
	(31.4330)	(33.0552)	(30.1497)	(29.1211)
Adjusted R^2	0.3071	0.2956	0.2724	0.3002
Observations	214,958	153,864	219,742	221,667
Cities	237	278	251	253

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

4.3.2. Eliminate interference from other factors

Firstly, we eliminate provinces with low Internet access rates. Since the public attention index in this paper is mainly expressed by the public's online search volume for related terms, the network access rate would affect the local online search volume. The amount of Internet searches in provinces with low Internet access rates cannot represent all public attention, thus biasing the estimation results. In order to eliminate the error caused by insufficient network access rate, we classified provinces based on the fixed broadband access rate in the "Report on China's Broadband Popularization Status", and excludes provinces with fixed broadband access rates below 70%. The results in column (1) of Table 6 show that after excluding provinces with a network access rate of less than 70%,[4] the inhibitory effect of public attention on air pollution is still significant at the 1% level, indicating that the results of the baseline regression are robust.

Secondly, we excluded potential data fraud intervals. The air pollution data of a few cities may be adjusted under the strict environmental protection policy of the central government (Ghanem and Zhang, 2014).

[4] Including Inner Mongolia, Yunnan, Guizhou, Heilongjiang, Qinghai, and Jilin provinces.

For example, in order not to affect the process of economic development or to improve the air quality rating, some cities would take the initiative to carry out small-scale air quality improvement activities near the air quality monitoring points, so that the degree of air pollution measured at the monitoring points is lower than other places in the city (Chen et al., 2013). Therefore, this paper draws on the practice of Shi et al. (2020) and eliminate the daily data of cities whose AQI values are in the intervals of [50, 55], [100, 105], [150, 155], [200, 205], [300, 305] and 500. So as to reduce the deviation of the model estimation caused by the possibly artificial modification of the air pollution data. The results in column (2) of Table 6 show that after excluding possible false data intervals, public attention could still suppress air pollution at the significant level of 1%.

Thirdly, we have excluded the influence of government air pollution control policies. In order to improve environmental quality and achieve sustainable development, the central government has promulgated many air pollution prevention and control policies (Peng et al., 2020). The air pollution control policies promulgated by the central government could greatly reduce the level of air pollution, thereby overestimating the impact of public attention on air pollution. In order to more accurately estimate the impact of public attention on air pollution, we excluded the "2 + 26" cities[5] with the highest intensity of environmental regulations in the "Air Pollution Prevention and Control Action Plan" policy (Cai et al., 2017; Feng et al., 2019; Maji et al., 2020). The results in column (3) of Table 6 show that after excluding the impact of other environmental governance policies on air pollution, public attention still has an inhibitory effect on air pollution.

Finally, we excluded the carbon market pilot cities. Given the homology and synchronization of CO_2 and air pollutants (Burtraw et al., 2003), carbon market pilots policy could also have an impact on air pollution (Li et al., 2021), thus overestimating the impact of public attention on air pollution. We have excluded the impact of carbon market pilots policy on air pollution in column (4) of Table 6, and found that public attention could still significantly curb air pollution.

4.3.3. Replace model and variables

Firstly, replace the model. There may be a self-selection effect in the process of identifying the causal relationship between public attention and air pollution. In other words, the level of public attention in areas with severe chronic air pollution has always been high. In order to eliminate this self-selection effect and more accurately identify the causal effects of public attention and air pollution, we use the PSM method to estimate. On the other hand, we have added the interaction terms between the city fixed effect and the time fixed effect to further control the impact of changes in the characteristics of each city at different times on air pollution. The results in columns (1) and (2) of Table 7 show that after replacing the model, public attention has a significant inhibitory effect on air pollution, and the results of the baseline regression are robust.

Secondly, replace the variables. With the convening of the Paris Conference and the formulation of China's "dual carbon" target,[6] carbon emissions have gradually become an indicator of concern to residents. In addition, since carbon emissions have the same roots as air pollution (Burtraw et al., 2003; Li et al., 2021), carbon emissions are also proportional to air pollution to a certain extent. We replaced the dependent variables with carbon emissions and per capita AQI in the columns (3) and (4) of Table 7, respectively, and found that the results are still significant, proving that public attention has a significant inhibitory effect on air pollution.

[5] Incluling Beijing, Tianjin, Shijiazhuang, Tangshan, Langfang, Baoding, Cangzhou, Hengshui, Xingtai, Handan, Taiyuan, Yangquan, Changzhi, Jincheng, Jinan, Zibo, Jining, Dezhou, Liaocheng, Binzhou, Heze, Zhengzhou, Kaifeng, Anyang, Hebi, Xinxiang, Jiaozuo, and Puyang.

[6] Achieve carbon peak by 2030, and carbon neutrality by 2060.

Table 7
Robustness test: replace model and variables.

Variable	PSM	Interactive item	CO_2	AQI per capita
	(1)	(2)	(3)	(4)
Attention	−0.0070***	−0.0086***	−0.0001**	−0.0028***
	(0.0014)	(0.0017)	(0.0001)	(0.0010)
Control variables	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
City-by-time FE	–	YES	–	–
Constant	72.7645*	200.9623***	199.8875***	91.0311***
	(40.2692)	(27.1465)	(30.1497)	(31.9475)
Adjusted R^2	0.3071	0.2956	0.1170	0.1610
Observations	59,947	248,016	246,950	248,016
Cities	244	278	277	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

4.4. Heterogeneity analysis

4.4.1. Heterogeneity of city types

We examine the differential impact of public attention on air pollution from the three types of heterogeneity in city's population size, economic development degree, and administrative level.

First, the heterogeneity of population size. The more residents exposed to the pollution, the higher the degree of public attention arouses, and the greater the pressure on the government to deal with air pollution. Therefore, a city with a larger population might have a stronger suppression effect of public attention on air pollution. In accordance with the State Council's classification standards for cities, we divide cities into large cities and small cities according to the number of people for comparative analysis. Columns (1) and (2) of Table 8 show the regression results of the relationship between public attention and air pollution in samples of different population sizes. It could be found that the impact of public attention on air pollution in cities with larger populations is significantly negative at the 1% significance level, while the impact of public attention on air pollution in small cities is not significant.

Second, the heterogeneity of economic development. Residents in economically developed areas have higher requirements for the quality of the living environment (Kireenko and Nevzorova, 2015). At the same time, due to better infrastructure construction in economically developed areas, the government could deal with air pollution more efficiently, so that the public attention in economically developed areas has a stronger inhibitory effect on air pollution. Based on the classification of first-tier, second-tier and third-tier cities by the Chinese Academy of Social Sciences, this paper combines second-tier cities and third-tier cities into non-first-tier cities and compares them with first-tier cities. Columns (3) and (4) of Table 8 respectively give the regression results of the impact of public attention on air pollution in each tier city. The results show that the impact of public attention on air pollution in first-tier cities is significant at a significance level of 1%, while the impact of public attention on air pollution in s non-first-tier cities is not significant.

Third, the heterogeneity of city administrative levels. Ministerial cities (sub-provincial cities and municipalities) need to play a pioneering role in building a beautiful China and implementing the conviction that lucid waters and lush mountains are invaluable assets. Due to the accumulation of a large number of political resources, ministerial-level cities have stronger motivation and capabilities for green development (Li et al., 2021). Therefore, the degree of public attention in

Table 8
Heterogeneity analysis: different city type.

Variable	AQI					
	Large city	Small city	first-tier city	Non-first-tier city	Ministerial city	Non-ministerial city
	(1)	(2)	(3)	(4)	(5)	(6)
Attention	−0.0067***	0.0076	−0.0063**	0.0058	−0.0057**	0.0063
	(0.0017)	(0.0249)	(0.0026)	(0.0165)	(0.0023)	(0.0145)
Control variables	YES	YES	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
Constant	152.7909***	288.1364***	−8.5496	223.8554***	−103.9546	222.0154***
	(46.6873)	(51.3827)	(107.3177)	(25.9221)	(107.9568)	(26.7303)
Adjusted R^2	0.3189	0.2792	0.3327	0.2835	0.3298	0.2852
Observations	79,874	168,142	20,074	227,942	20,096	227,920
Cities	80	198	19	259	19	259

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

ministerial-level cities may have a stronger inhibitory effect on air pollution than non-ministerial cities. Columns (5) and (6) of Table 8 show the results of the impact of public attention on air pollution in ministerial and non-ministerial cities. It could be found that in ministerial-level cities, the impact of public attention on air pollution is significant at the 1% significance level. In non-ministerial cities, the impact of public attention on air pollution is not significant.

4.4.2. Heterogeneity of air pollution

In addition to city characteristics, differences in air pollution levels may also cause differences in the relationship between public attention and air pollution. According to the air quality evaluation standards issued by the Ministry of Ecology and Environment in 2012, we divide the sample into $PM_{2.5}<35$, $35\leq PM_{2.5}\leq 150$ and $PM_{2.5}>150$ (Table 9). The results show that public attention has an inhibitory effect on air pollution in each pollution interval, and the more serious the air pollution, the stronger the restraining effect of public attention. Specifically, when the air quality is excellent, the effect of public attention on air pollution is −0.0029. When the air quality is good or lightly polluted, the effect of public attention on air pollution is −0.0078. When the air quality is moderately polluted or more serious, the effect of public attention on air pollution is −0.0537.

5. Further discussion

5.1. Mechanism analysis

Combined with theoretical analysis, we mainly explored two important mechanisms that public attention affects air pollution, including complaints to government departments about air pollution incidents, and concerns about health issues caused by air pollution.

Table 9
Heterogeneity analysis: different $PM_{2.5}$ concentration.

Variable	$PM_{2.5}$		
	<35	35–150	>150
	(1)	(2)	(3)
Attention	−0.0029**	−0.0078*	−0.0537**
	(0.0014)	(0.0043)	(0.0233)
Control variables	YES	YES	YES
City fixed effect	YES	YES	YES
Time fixed effect	YES	YES	YES
Constant	33.2344*	117.1328***	−150.8818
	(19.1038)	(42.0763)	(428.3067)
Adjusted R^2	0.2386	0.2330	0.4584
Observations	19,426	147,135	871
Cities	264	278	97

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

As government departments pay more attention to the environment, public complaint channels have become more and more important means for government departments to monitor air pollution. With the increasing popularity of the Internet, the Environmental Protection Bureau, the Environmental Protection Agency and other government departments related to environmental pollution have opened corresponding complaint channels. Compared with offline complaints, complaints to relevant government departments through online channels are more convenient, efficient and transparent. We analyze the mechanism of public complaints in Table 10. The results in column (1) of Table 10 show that the increase of public attention could promote the increase of public complaints. According to the significance of the coefficients of the "complaint" variables in columns (2) to (6), we could comprehensively judge that an increase in complaints would reduce air pollution. Combining the above results, it could be determined that public attention could put pressure on the government by increasing environmental complaints, thereby prompting government departments to intervene in corporate pollution behavior and reducing air pollution. Therefore, Hypothesis 2 is verified.

In addition, the public's concern for their own health is also an important mechanism. Severe air pollution could cause a variety of diseases related to the respiratory system (e.g., cough, asthma) and even death. As air pollution intensifies, residents' concerns about their own health issues and the resulting public opinion would also prompt government departments to speed up the control of air pollution, thereby reducing air pollution. The results reported in Table 11 show that the public's concern for their own health and the resulting public opinion is a mechanism for public attention to suppress air pollution. Hypothesis 3 is proved.

What needs to be pointed out is that the "environmental dissatisfaction" mechanism reflects the story of the public using reports, complaints, and public opinion to force the government to take measures due to serious environmental pollution. The effectiveness of this mechanism is largely determined by residents' determination to improve the environment. The "health concern" mechanism describes the public's social rendering of health concerns caused by environmental pollution, which enables the government to intervene in environmental pollution under the ethics of governance and humanistic sentiments. The effectiveness of this mechanism is mainly determined by the implementation of the government's people-oriented philosophy. The effectiveness of the above two mechanisms proves that the Chinese government has a strong degree of heteronomy and self-discipline in environmental management.

Table 10
Mechanism analysis: complaint to the government.

Variable	Complain	AQI	$PM_{2.5}$	PM_{10}	CO	NO_2
	(1)	(2)	(3)	(4)	(5)	(6)
Attention	0.0966*	0.0007	−0.0017	−0.0020	0.0006	−0.0020
	(0.0518)	(0.0027)	(0.0021)	(0.0034)	(0.0004)	(0.0013)
Complain		−0.0069***	−0.0044***	−0.0052**	−0.0007**	−0.0024*
		(0.0018)	(0.0014)	(0.0021)	(0.0003)	(0.0012)
Control variables	YES	YES	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
Constant	−846.6339***	200.3969***	163.8305***	198.0288***	22.7005***	30.9338*
	(286.4241)	(27.1772)	(24.4778)	(39.2597)	(5.7504)	(16.6359)
Adjusted R^2	0.1803	0.2843	0.3428	0.3241	0.2808	0.4235
Observations	265,409	248,016	248,016	248,016	248,016	248,016
Cities	278	278	278	278	278	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

Table 11
Mechanism analysis: concern about health.

Variable	Health	AQI	$PM_{2.5}$	PM_{10}	CO	NO_2
	(1)	(2)	(3)	(4)	(5)	(6)
Attention	0.3506***	0.0012	−0.0003	0.0019	−0.0000	−0.0004
	(0.1080)	(0.0019)	(0.0017)	(0.0027)	(0.0003)	(0.0008)
Health		−0.0072***	−0.0045***	−0.0060***	−0.0006**	−0.0025**
		(0.0018)	(0.0015)	(0.0022)	(0.0003)	(0.0012)
Control variables	YES	YES	YES	YES	YES	YES
City fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
Constant	−94.9211	199.8960***	164.9722***	199.2414***	22.3152***	32.2303*
	(548.8526)	(27.0830)	(24.5238)	(38.9125)	(5.7664)	(16.4423)
Adjusted R^2	0.2853	0.2843	0.3428	0.3241	0.2807	0.4234
Observations	265,409	248,016	248,016	248,016	248,016	248,016
Cities	278	278	278	278	278	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

5.2. Dynamic effect analysis

The goals of public attention are generally short-term, or even a stress response. When the focus of attention shifts or disappears, the local environmental pollution level might rebound, and is similar to the "political blue sky". (Fu et al., 2021; Shi et al., 2020). In order to study the dynamic effects of public attention on air pollution, we merged daily data into an annual level and studied the long-term impact of public attention on air pollution. Table 12 reports the dynamic impact of public attention on air pollution. On the whole, at the annual level, public attention has not had a significant impact on air pollution before 2016, while both the significance of the impact and the marginal effect of the impact have increased significantly after 2016. This is not only benefited from the government's strengthening of air pollution control measures and the improvement of relevant laws and regulations, but also benefited from the gradual deepening of the belief in green development. In addition, with the increasing popularity of the Internet, more and more people could participate in the ranks of city pollution supervision.

Table 12
The dynamic effect of public attention on AQI.

Variable	AQI			
	(1)	(2)	(3)	(4)
2014	0.0132**	−0.0046	0.0081	−0.0041
	(0.0061)	(0.0056)	(0.0058)	(0.0056)
2015	−0.0102	−0.0241	−0.0268	−0.0240
	(0.0185)	(0.0164)	(0.0174)	(0.0166)
2016	−0.0430*	−0.0149	−0.0316	−0.0148
	(0.0250)	(0.0222)	(0.0234)	(0.0222)
2017	−0.0532**	−0.0364*	−0.0262	−0.0385*
	(0.0214)	(0.0201)	(0.0207)	(0.0202)
2018	−0.1080***	−0.0498***	−0.0662***	−0.0500***
	(0.0176)	(0.0163)	(0.0170)	(0.0163)
Control variables	NO	NO	YES	YES
City fixed effect	YES	YES	YES	YES
Time fixed effect	NO	YES	NO	YES
Constant	81.0137***	86.2459***	50.7943***	69.7421***
	(0.3696)	(5.4786)	(6.9755)	(8.8357)
Adjusted R^2	0.0999	0.2973	0.2119	0.3019
Observations	1234	1234	1234	1234
Cities	278	278	278	278

Note: Standard errors clustered at the city level are reported in parentheses; *, ** and *** indicate significant at the levels of 10%, 5%, and 1%, respectively. The time fixed effect includes the holiday, season, date, and weekend fixed effects.

6. Conclusion and policy implications

Public attention to environment is an important form of environmental accountability, and the construction of environmental accountability is conducive to accelerating the process of democratization in China. Studying the impact of environmental accountability on air pollution is not only conducive to China's exploration of low-cost and high-efficiency air pollution control methods, but also promotes the exchange of information between environmental subjects and reduces social conflicts. By using 7 types of daily air pollution data from 321 cities in China from December 1, 2013 to December 31, 2018, and matching the data with Baidu Index, we studied the causal relationship between public attention and air pollution for. The results, supported by

multiple robustness tests, show that public attention could reduce air pollution. This paper analyzes the heterogeneity of the air pollution reduction effect of public attention and finds that the most significant reduction effect of public attention is in the large, first-tier, and ministerial city and cities with severe air pollution. Our mechanism analysis shows that public attention could reduce air pollution through "complaint to the government" and "concern about health". We have also discovered through dynamic effects research that the suppression effect of public attention on air pollution has shown an increasing trend year by year. Thus, our policy recommendations are as follows:

First, further open and unblock public information feedback channels. Although China's air pollution control has achieved certain results, many regions still have not completely got rid of the haze and other typical air pollution problems. Since the public attention to air quality is conducive to the control of air pollution, improving the efficiency of public feedback on air pollution and increasing the public's feedback channels on environmental issues could make the culprits of pollution problems nowhere to hide. At this stage, the public attention to environmental issues is more through the fermentation of public opinion that causes social pressure on relevant departments, which has an impact on environmental governance. However, the public attention to most environmental issues may not be able to form high-influential public opinion, which makes it difficult to have a substantial impact on the governance of environmental pollution. But if the public's feedback on pollution information could always be efficiently transmitted to the environmental management department, no matter what response the environmental management department makes, it will be beneficial to the control of air pollution. Because even if the local environmental protection department does not handle the pollution incident in time, the public feedback on pollution will also make the polluter and the local environmental protection department a hot spot for public opinion, and ultimately put pressure on the government to deal with environmental pollution. Therefore, a more open and transparent environmental information feedback channel is of great significance to the role of public attention in pollution control. Specifically, by further increasing the public's transparency and interactive construction of environmental information feedback channels, the convenience, simplicity and efficiency of environmental feedback will be realized. Finally, the suppression effect of public attention on air pollution will be more widely and effectively brought into play.

Second, strengthen public awareness of environmental protection and popularization of health knowledge. A large population base has advantages and disadvantages for China's development, but it has more advantages than disadvantages for environmental supervision. The huge population makes every piece of open land in China exposed to the public's sight. Of course, environmental pollution is not difficult to be noticed by the public. As long as the government issues standards for determining environmental pollution, the public could find the source of most of the pollution. However, in many cases, the public chose to turn a blind eye to pollution because of the fear of stakeholders and the underestimation of pollution to their own rights. Only by letting the public understand more clearly the hazards of pollution and the country's determination in pollution control could the public's role in monitoring pollution be further effectively brought into play. Therefore, the government should strengthen the public's awareness of environmental protection, increase the spread of knowledge about the health damage caused by pollution, and make environmental protection a major issue for everyone, so as to form a low-cost and highly effective environmental supervision method. Specifically, on the one hand, knowledge of the relationship between environmental pollution and health risks could be added to the textbooks of elementary education; on the other hand, the conviction of environmental protection could be promoted in the form of community propaganda columns and TV public service advertisements.

Third, improve laws and regulations on public feedback on the environment. The improvement of laws and regulations could not only make public reports and complaints on environmental issues more realistic basis, but also enhance the efficiency of the public's attention to improving environmental quality. A sound law stipulates the rights and obligations of relevant actors. The public has the right to report illegal pollutant discharge, and the relevant departments have the obligation to investigate and verify the content of complaints and reports. If the relevant departments do not deal with the well-documented illegal discharge, it is easier to form a hot issue of public opinion. Therefore, under a sound legal and regulatory framework, public attention to environmental issues could play a more effective role in suppressing pollution. Moreover, the improvement of laws and regulations could better protect the rights of the public and compliant emitters. On the one hand, laws and regulations stipulate the rights of the public, which helps to reduce the public's fear of reporting illegal emissions, thereby further mobilizing the public's enthusiasm for participation in supervision. On the other hand, sound laws and regulations could also limit false accusations and unprovoked rumors, thereby ensuring the normal production activities of compliant companies. Specifically, local governments could issue specific laws and regulations based on actual conditions, penalize illegal emissions in different situations, and reward effective complaints and reports. In general, reports that do not provide evidence need not be accepted, and reports or complaints that provide evidence must be accepted and further investigated and verified. While under normal circumstances, a report or complaint must provide corresponding images, videos, texts or other forms of evidence. When it is difficult to collect evidence, the complainant could also insist on reporting, but for false accusations that cause major consequences, they must also bear certain legal liabilities.

This study contributes to the discussion on public attention and air pollution by generating better causal identification. Our conclusions not only provide policy reference for the efficient control of air pollution in China, but also provide important insights for other countries.

However, there are some limitations in this paper. Due to lack of data, we use Baidu Index to construct public attention indicators. Furthermore, there may be other mechanisms whereby public attention could reduce air pollution which we were unable to investigate. Future studies would more accurately describe the degree of public attention and conduct a more comprehensive analysis of the mechanism by which public attention affects air pollution.

CRediT authorship contribution statement

Xing Li: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Funding acquisition. **Zhigao Hu:** Data curation, Software, Methodology, Validation, Writing – review & editing. **Jianhua Cao:** Funding acquisition, Supervision, Writing – review & editing. **Xing Xu:** Data curation, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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