When Perception Shapes Reality: A Large-Scale Study of Mental Health Outcomes in Polluted and Non-Polluted Environments in China

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Abstract

This study investigates the relationship between perceived and actual pollution and mental health, emphasizing how exposure illusion and exposure neglect may contribute to mental health. The research draws on a representative sample of 16,607 Chinese residents, examining the associations between perceived and actual pollution and mental health outcomes, including depression, anxiety, and stress. The study utilizes a generalized linear mixed model, incorporating various pollution conditions, gender, age, education, and urbanization as fixed effects, while the provinces are treated as random effects. The results indicate that even in the absence of high levels of actual pollution, the mere perception of pollution is associated with increased levels of depression ($\beta=0.51$, OR = 1.66, $p<.001$), anxiety ($\beta=0.43$, OR = 1.54, $p<.001$), and stress ($\beta=0.30$, OR = 1.35, $p<.001$) among residents. When residents' perception of pollution aligns with actual pollution levels, the negative effects on mental health appear to be more pronounced (depression: $\beta=0.90$, OR = 2.46, $p<.001$; anxiety: $\beta=0.96$, OR = 2.60, $p<.001$; stress: $\beta=0.56$, OR = 1.76, $p<.001$). These findings demonstrate that perceived pollution may play a primary role in its association with mental health compared to actual pollution. It is important to emphasize that this study is cross-sectional, and thus it cannot establish causal conclusions regarding perceived pollution leading to mental health issues. Furthermore, only air pollution was used as an indicator of actual pollution, which may limit the generalizability of our findings.

Keywords: Mental Health; Pollution; Anxiety; Depression; Stress; Risk Perception

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Industrialization has led to significant environmental pollution(Opoku & Aluko, 2021), which is increasingly attracting public attention due to its negative impact on the physical and mental health of citizens. Residents living in environmental pollution areas often face challenges such as poor air quality, contaminated water sources, and soil pollution (Koop & van Leeuwen, 2017; Solomon et al., 2016). Early environmental health studies primarily focused on the direct impacts of chemical and physical pollutants, such as air and water quality pollution on human health (Cohen et al., 2017; Lelieveld et al., 2015). Recent research has increasingly indicated that environmental pollution, in addition to physical factors, can have potential long-term effects on the mental health of residents (Braithwaite et al., 2019; Burrows et al., 2024; T. Yang et al., 2023).

Mental health issues have been steadily increasing in recent years, with conditions like depression, anxiety, and stress becoming more widespread across diverse populations (Goodwin et al., 2020; Keyes et al., 2019; Q. Liu et al., 2020; Ramón-Arbués et al., 2020). Against this backdrop, environmental pollution may pose an even greater threat to the physical and mental health of residents (Farooqi et al., 2020; Hahad et al., 2024; W. Liu et al., 2021). The associations between environmental pollution and both physical and mental health have been well-documented in pathology (Reuben et al., 2022; Q. Wang & Yang, 2016; W. Wu et al., 2018). Regarding mental health, pollution may impact public well-being not only through physiological pathways but also through subjective risk perceptions. This study investigates how environmental pollution relates to residents' mental health and introduces a new perspective: even at low actual pollution levels, residents' subjective perceptions of pollution can trigger mental health issues. Perceived pollution may affect mental health independently of actual pollution, providing insights into the mechanisms by which pollution influences mental well-being.

Literature Review

Environmental Pollution and Mental Health

Existing research has extensively explored associations between exposure to pollutants and impacts on both physical and mental health (Burrows et al., 2024; Jiang et al., 2023; Peprah et al., 2024; Simoes et al., 2022). This section briefly summarizes evidence on how environmental pollution correlates with public mental health issues, focusing on the perspectives of depression, anxiety, and stress. These are currently the most pressing mental health issues, closely intertwined with environmental pollution (Nochaiwong et al., 2021).

In polluted environments, anxiety often appears related to uncertainty about future health and perceived threats (Powell et al., 2007; Soutar & Wand, 2022). Residents may frequently monitor air quality, water safety, and soil conditions, experiencing potential anxiety over health risks (Reames & Bravo, 2019; S. Wang et al., 2022). This sustained concern over largely uncontrollable factors is associated with anxiety responses (Stapinski et al., 2010). Media coverage of pollution events and health issues within communities can further intensify anxiety, especially where there is limited understanding of pollutant effects and mitigation measures (Auyero & Swistun, 2008; Kim & Kim, 2021; Pearson, 2024). The uncertainty and anticipation model of anxiety offers a neuroscientific lens on this phenomenon (Grupe & Nitschke, 2013).

Physiological research suggests that pollution is linked to neuroinflammation and oxidative stress, potentially heightening anxiety symptoms (Zundel et al., 2022).

Environmental pollution and its potential links to depression have been widely studied (Borroni et al., 2022; Fan et al., 2020). Depression in polluted environments may relate to chronic health concerns and reduced quality of life (Selinheimo et al., 2019). When living environments are associated with physical discomfort or affect daily quality of life, residents may experience feelings of powerlessness and pessimism (Gerhardstein et al., 2019; Rautio et al., 2018). Natural degradation and reduced community activities will limit residents' outdoor engagement and social interactions (Yan et al., 2019; Yu et al., 2021), which has been linked to feelings of isolation and depressive symptoms (Erzen & Çikrikci, 2018; Santini et al., 2020). Neurological studies suggest that pollution may affect the hippocampus, central nervous system, and neurotransmitter functions, potentially associated with neuroinflammation and depressive symptoms (Bosch & Meyer-Lindenberg, 2019; Fonken et al., 2011).

Environmental pollution is also associated with daily life stress and chronic stress (Mehta et al., 2015; Miller et al., 2019; Petrowski et al., 2019). In polluted areas, residents often encounter higher health costs and require additional measures to address pollution effects, such as missed workdays and increased medical expenses (Ain et al., 2021; Chen & Chen, 2021). Living in polluted environments is also linked to lower self-esteem and heightened psychological pressure (Petrowski et al., 2019; Schraml et al., 2011). Neurological analyses found that exposure to environmental pollution can induce activation of the hypothalamicpituitary-adrenal axis, which is closely associated with stress (de Rooij et al., 2012; Thomson, 2019; Thomson et al., 2013).

Perceived Pollution and Mental Health

Apart from actual exposure, subjective perceptions of exposure also have significant effects on health (Mendoza & González, 2024). Studies have found that perceived pollution may also be related to mental health outcomes. In a case-control study, Li et al. (2021) found a negative association between PM2.5 exposure and stress in pregnant women, with perceived air pollution exacerbating this association. Zhu & Lu (2023), using survey data from China, found that satisfaction with residence was a better predictor of self-reported mental health problems than objective measures of air pollution. People may perceive higher levels of pollution due to a lack of understanding of pollution-related knowledge. Luís et al. (2022) found that older people's increased perception of environmental risks related to pharmaceuticals was mainly due to inadequate knowledge of diseases and prescription drugs. Omanga et al. (2014) highlighted that the perception of industrial pollution risk is associated with the awareness of environmental pollution. This misunderstanding may also stem from inaccurate media reports or misconceptions within communities (Y. Wang et al., 2019).

People's mental health can be influenced by their expectations (Kube & Herzog, 2023). This phenomenon is known in clinical contexts as the nocebo effect, which is often observed in placebo groups of drug trials where participants report side effects (Colloca, 2024). The concept has now been extended to adverse reactions reported after exposure to benign new technologies, environmental agents, or stimuli when individuals believe that these substances may cause symptoms or other negative health effects (Petrie & Rief, 2019). Consider a scenario in which a person perceives that he or she is in a highly polluted environment, despite effective pollution controls in the area. Recognizing the impact of pollution on health, this individual may begin to obsessively monitor his or her health, potentially experiencing negative psychological consequences. The nocebo effect has already been validated in the context of environmental pollution, such as the association between water pollution and special education enrollment rates (Roy et al., 2023) and industrial pollution and health problems (Chapman, 2015). When residents perceive health risks in their environment, psychological distress may increase. Lima (2004) surveyed residents living near an incinerator and found that risk perception was associated with increased symptoms of anxiety, depression, and stress. Fleury-Bahi et al. (2015) conducted a survey in a French city and found that risk evaluation triggered by air pollution can predict the perceived global quality of life in industrial cities. Similarly, Peek et al. (2009) surveyed residents living near a large petrochemical complex in the United States and found that subjective exposure (concerns about petrochemical health risks) was positively associated with perceived health assessment. Zhu & Zhao (2021) surveyed Chinese adults during peak air pollution periods and found a positive association between lower pollution coping strategies (such as trauma-focused reactions) and distress, as well as perceived changes in health.

The Present Study

The above evidence suggests that both perceived and actual pollution may be related to mental health outcomes, however, there has not been a thorough integration of subjective and actual considerations. People's perceived risks do not always correspond to actual risks (Dettori et al., 2020). Perceiving exposure to pollution, even in the absence of actual pollution, creates a sense of exposure illusion, which may contribute to mental health problems. Furthermore, the failure to recognize actual pollution when exposed to it, known as exposure neglect, may reduce the perceived impact of pollution on physical and mental health. This study, based on a representative sample in China, explores the differences in mental health outcomes (depression, anxiety, and stress) under different combinations of perceived (perceived or not perceived) and actual pollution (polluted or not polluted), with particular attention to the conditions of exposure illusion and exposure neglect.

This study addresses a gap in existing literature regarding exposure to pollution without perceiving it, as well as exposure in non-polluted areas were perceived pollution. By delving deeper into this field, we aim to offer a more comprehensive perspective on the complex relationship between environmental pollution and mental health, thereby advocating for more effective public health strategies. Furthermore, this study utilized resident-specific geographic information data, which offers a higher level of granularity compared to typical evaluation studies conducted at the parcel or county scale (F. Li & Zhou, 2020).

Method

Data Source

The data for this study is sourced from the Psychology and Behavior Investigation of Chinese Residents (PBICR), a national cross-sectional study led by the School of Public Health at Peking University, conducted from June 20 to August 31, 2022 (Y. Wu et al., 2024; Y. Yang et al., 2024). This study employed stratified and quota sampling methods across 148 cities and

780 communities in China. The targeted participants were permanent residents of mainland China aged 12 years and above who could complete the questionnaire independently or with investigator assistance. Investigators distributed the electronic questionnaires at community health service centers or relevant stations. In areas where face-to-face distribution was not feasible, investigators shared the questionnaire individually via instant messaging tools such as WeChat. The duration of each survey was approximately 30 to 40 minutes. To ensure data representativeness, sample sizes in each province were determined based on population proportions from the Seventh National Census of China. After excluding respondents who were deemed ineligible due to extremely short completion times, inconsistent answer patterns, or a lack of awareness regarding nearby environmental pollution, a total of 16,607 responses were included in our research.

Predictor Variables

Perceived pollution: We utilized a question from the PBICR survey to assess respondents' perception of pollution in their residential environment: 'Is there currently a highly polluting industry within 5 kilometers of your home?' Response options included Yes, No, and Uncertain. Responses marked as 'Uncertain' were excluded from the analysis.

Actual Pollution: For assessing actual pollution, we focused on PM2.5 and NO2, two widely recognized indicators of environmental pollution (Ji et al., 2022; Mebrahtu et al., 2023; Ministry of Ecology and Environment, 2020; Olaniyan et al., 2020). PBICR respondents provided their recent residential address along with high-precision latitude and longitude coordinates. We utilized the 2022 data from the China High Air Pollutant (CHAP) dataset (https://weijing-rs.github.io/product.html), which provides annual averages of these pollutants on a 1KM grid (Wei et al., 2021, 2022). We identified the nearest grid points based on the latitude and longitude coordinates of the residential area and matched their exposure values.

For evaluating pollution exposure, in line with recommendations from the Chinese Ambient Air Quality Standard (Environmental Development Center, 2016), we defined PM2.5 levels less than or equal to 35 μg/m3 as indicating no risk of PM2.5 exposure and NO2 levels less than or equal to 40 μg/m3 as representing low NO2 exposure. To mitigate the influence of individual pollution indicators, we defined situations where any of the indicators exceeded the exposure thresholds as constituting actual pollution exposure, and otherwise as non-actual pollution exposure.

Outcome Variables

Participants' depression severity was measured using the Patient Health Questionnaire-9 (PHQ-9), a standardized self-report tool that assesses the presence and severity of depressive symptoms. The PHQ-9 includes nine items, each reflecting a core symptom of depression based on DSM-IV criteria and is scored on a 4-point Likert scale (0 = not at all, to 3 = nearly every day), yielding a total score range of 0 to 27. Higher scores indicate greater symptom severity. According to Kroenke et al. (2001), a score of 5 or more suggests mild depression, often used to indicate the presence of depression in clinical and research contexts. For this study, we defined scores of 5 or above as indicative of depression and performed sensitivity analyses using alternative thresholds of 10 and as continuous scores to validate robustness. The Cronbach's α for PHQ-9 in this study is 0.923.

Anxiety severity among participants was measured using the Generalized Anxiety Disorder-7 (GAD-7), a brief self-report scale developed to identify probable cases of generalized anxiety disorder (GAD). The GAD-7 includes seven items that reflect key DSM-IV criteria for GAD symptoms, such as feeling nervous, excessive worry, and restlessness. Each item is rated on a 4-point Likert scale, ranging from 0 (never) to 3 (nearly every day), with total scores ranging from 0 to 21, where higher scores indicate greater anxiety severity. A commonly used cut-off score of 10 or higher suggests the presence of anxiety, while a score of 15 or above often indicates higher severity (Spitzer et al., 2006). In our study, scores of 10 and above were categorized as indicative of anxiety, and in sensitivity analyses, we also examined a threshold of 15 and continuous outcomes. The Cronbach's α for PHQ-9 in this study is 0.942.

Perceived stress among participants was measured using the Perceived Stress Scale-4 (PSS-4). Four items across two dimensions were rated on a 5-point Likert-type scale (Vallejo et al., 2018). The total score ranged between 4 and 20, with higher scores indicating greater perceived stress. Stress was categorized as present by classifying respondents with PSS-4 scores at and above the 75th percentile (scores above 12) (Avila-Palencia et al., 2017). In sensitivity analyses, we assessed an alternative cut-off value (1 standard deviation above the sample mean, scores above 13) as well as continuous outcomes (Liang et al., 2019). The Cronbach's α for perceived stress in this study is 0.671.

Statistical Analysis

The probability of mental health under various pollution conditions was assessed using a generalized linear mixed model implemented through the *glmer* function of the *lme4* package in the R software (Bates et al., 2015). The pollution condition was treated as a fixed effect with four conditions: not perceived pollution with no actual pollution (clear of pollution), perceived pollution with no actual pollution (exposure illusion), not perceived pollution with actual pollution (exposure neglect), and perceived pollution with actual pollution (confirmed pollution). Province was included as a random effect to accommodate variations across provinces. Additionally, we considered different confounding variables with categorical encoding: gender (female and male), age (12-17, 18-59, and ≥60), urbanization (urban and rural), and educational attainment (high school, university, and postgraduate). These variables were self-reported by participants in the questionnaire according to the current classification. To facilitate comparison of the results, we also report the odds ratios (OR), which provide a measure of the strength of association between variables. The OR quantifies the odds of an outcome occurring in one group relative to another. An OR of 1 indicates no association between the variables, while an OR greater than 1 suggests a higher likelihood of the outcome in the exposed group, and an OR less than 1 indicates a lower likelihood.

Sensitivity Analysis

To ensure the robustness of our results, we performed sensitivity analyses considering different strategies for assessing pollution and mental health.

For pollution conditions, first, we evaluated using the lower thresholds recommended by WHO (2021). We defined PM2.5 levels less than or equal to 25 μg/m³ as indicating no risk of PM2.5 exposure, and NO2 levels less than or equal to 30 μg/m³ as representing no risk of NO2 exposure. Secondly, we also reassessed the classification thresholds by using the average pollution values from the three years preceding the survey (2020-2022). Since our study remains cross-sectional, the three-year average provides slightly stronger longitudinal evidence before the mental health assessment. Finally, we attempted to distinguish between groups that perceived pollution and those that did not and examined the impact of actual pollution on mental health separately within these two groups. In all these scenarios, the analysis model was the same as in the main analysis, using a generalized linear mixed model, with province as a random effect, and gender, age, urbanization, and education as confounding variables.

For mental health, as described in the Outcome variables, we first focused on stricter classification thresholds. In this scenario, the analysis model remained the same as in the main analysis, using a generalized linear mixed model, with province as a random effect, and gender, age, urbanization, and education as confounding variables. Additionally, we conducted an analysis using continuous outcomes for mental health, applying a linear mixed model (*lmer* function of the *lme4* package in the R software), with the province as a random effect, and gender, age, urbanization, and education as confounding variables.

Result

Table 1 presents the basic characteristics of the included responses. Specifically, 68.51% (n = 11,377) of the participants were rural residents, and 49.01% (n = 8,139) were female. Additionally, 55.39% (n = 9,199) of the residents exhibited depressive symptoms, while 13.58% (n = 2,256) exhibited anxiety symptoms. The average concentrations of PM2.5 and NO2 were 30.32 μg/m3 and 24.20 μg/m3, respectively. Moreover, 7.79% (n = 1,294) of the residents perceived pollution from nearby areas, whereas 27.30% (n = 4,534) of the residents were exposed to actual polluted environments. There was a substantial disparity between perceived and actual pollution levels, with a lower likelihood of pollution perception among the residents. Table 2 displays demographic information under different pollution conditions, indicating a higher prevalence of exposure illusion among females and lower-educated groups. No significant differences were found in demographic information across different pollution conditions.

Table 3 and Figure 1 illustrate the relationship between perceived and actual pollution combinations and symptoms of depression, anxiety, and stress. Compared to situations with no perceived pollution and no actual pollution, exposure illusion (β=0.51, OR = 1.66, $p<.001$), as well as confirmed pollution (β=0.90, OR = 2.46, $p<.001$), were associated with higher levels of depressive symptoms. Similarly, compared to situations with no perceived pollution and no actual pollution, exposure illusion (β=0.43, OR = 1.54, $p<.001$), exposure neglect (β=0.17, OR = 1.19, p=.027), and confirmed pollution (β=0.96, $p<.001$) were linked to higher levels of anxiety symptoms. Moreover, compared to situations with no perceived pollution and no actual pollution, exposure illusion (β=0.30, OR = 1.35, $p<.001$) and confirmed pollution (β=0.56, OR = 1.76, $p<.001$) were associated with higher levels of stress. However, there were no statistically significant differences in symptoms of depression and stress between situations with exposure neglect and situations with no perceived pollution and no actual pollution.

Table S1 presents the results of the analysis based on continuous data from depression, anxiety, and stress scales. Under the analysis of continuous variables, the relationship between pollution and symptoms of depression, anxiety, and stress remained consistent. However, in comparison to situations with no perceived pollution and no actual pollution, the relationship between not perceiving pollution but with actual pollution and anxiety symptoms did not reach statistical significance.

Table S2 presents the results of the analysis based on different cutoff values for depression (10), anxiety (15), and stress (one standard deviation increase in mean). Under different cutoff values, the relationship between pollution and symptoms of depression, anxiety, and stress remained consistent. Compared to situations with no perceived pollution and no actual pollution, exposure neglect condition was associated with higher levels of depression and anxiety symptoms.

Table S3 presents the results of the analysis based on three-year average pollution indicators. In the prediction of pollution based on multi-year indicators, the relationship between pollution and symptoms of depression, anxiety, and stress remained consistent.

Table S4 presents the results of the analysis based on lower pollution thresholds (PM2.5 > 25 μg/m³ and NO2 > 30 μg/m³). The relationship between pollution and symptoms of depression, anxiety, and stress remained consistent. Notably, the level of depression in the exposure neglect condition was significantly lower than in the clear of pollution condition.

Tables S5 and S6 present the impact of actual pollution on mental health among groups perceiving pollution and those perceiving no pollution. The results indicate that, in the group perceiving no pollution, the impact of actual pollution on depression, anxiety, and stress was not statistically significant. However, in the group perceiving pollution, actual pollution showed a significant positive correlation with depression, anxiety, and stress.

Discussion

This study expanded on the roles of exposure illusion and exposure neglect in the relationship between perceived and actual pollution and mental health. Through the analysis of a representative sample from China, we found a significant positive correlation between exposure illusion and anxiety, depression, and stress. Exposure neglect showed a weak positive correlation with anxiety.

Our analysis observed that when perceived pollution aligned with actual pollution, residents reported higher levels of depression, anxiety, and stress. This finding aligns with previous research indicating that residents in high-pollution environments tend to experience more significant mental health issues (Burrows et al., 2024; Fan et al., 2020). Additionally, we identified a significant positive correlation between exposure illusion and anxiety, depression, and stress. This suggests that both perceived and actual pollution are jointly related to residents' mental health, indicating a dual-pathway phenomenon of environmental pollution on public mental health. Perceived risk may independently relate to individuals' mental health issues and also serve as a potential catalyst that enhances the harmful effects of actual pollution.

Perceived pollution may impact mental health through various psychological mechanisms. Residents' concerns about environmental pollution can result in enduring psychological distress, arising from worries about current health conditions as well as uncertainty regarding future health (Auyero & Swistun, 2008; Powell et al., 2007; Stewart & Hursthouse, 2018). Residents who are constantly in this state of distress may experience exacerbated mental health issues over time. Furthermore, relative information on pollution issues and discussions of health problems within communities may exacerbate residents' mental health risks (Q. Huang, 2020; Ramondt & Ramírez, 2020; S. Wang et al., 2015). During the process of information dissemination, excessive publicity of environmental issues may deepen residents' climate anxiety (Clayton, 2020; Tam et al., 2023). Even if the actual pollution levels are not high, residents may still experience mental health problems due to excessive fear and worry.

Pollution levels are associated with different socioeconomic statuses (Hajat et al., 2021). This study also found that education and gender play a role in the impact of pollution on mental health. Groups with higher levels of education experience fewer exposure illusion, possibly due to their higher environmental literacy and knowledge, enabling them to assess their pollution exposure more objectively (Elo, 2009; Zou et al., 2014). On the other hand, women tend to exhibit a higher pollution exposure illusion, which may be due to their greater concern for environmental issues and a higher tendency to experience negative emotion about environmental risks (Butter, 2006; Westergaard et al., 2017; Xiao & McCright, 2015).

This study found that even in the absence of actual pollution exposure, perceived pollution may still have a negative impact on mental health. This finding emphasizes the importance of considering residents' subjective experiences in environmental protection and public health strategies. While perceived pollution can be quantified with relative ease, controlling and eliminating it is much harder and more complex than controlling and eliminating actual pollution. However, given the negative impact of perceived pollution on mental health, it is crucial to reduce misconceptions about environmental issues and promote a more objective and rational perception of local pollution. For example, governments can provide accurate and transparent information on environmental impacts and organize educational initiatives to improve the public's scientific literacy on environmental issues, thereby reducing unnecessary anxiety and stress (Y. Yang et al., 2022; P. Zhu & Lin, 2022). Secondly, educating the public on how to assess environmental health risks is also important. Environmental education and public campaigns can assist residents in rationalizing environmental issues, and avoiding unnecessary panic due to misunderstanding or lack of information (Riley et al., 2021). Finally, enhancing community support and access to resources is also an effective way to reduce the impact of perceived pollution. Community-level support can empower residents with the strength and resources to cope with environmental stressors, thereby reducing the risk of mental health problems (Sapienza et al., 2020).

Theoretical and Practical Implications in Environmental Psychology

In terms of theoretical implication, this study provides new evidence for understanding the interactive effects of individuals' perceived pollution and actual pollution on mental health. It aligns with the core premise of environmental stress theory, which posits that individuals' perception of environmental risks influences their emotions and coping mechanisms (Gatersleben & Griffin, 2017). Traditional environmental stress models often emphasize the impact of actual pollution or environmental stressors on individuals' mental health. However, the findings of this study indicate that even when actual pollution levels are relatively low, a heightened perception of pollution risks can still trigger negative psychological outcomes such as anxiety, depression, and stress. This means when exploring the environment-mental health association, focusing only on objective indicators and ignoring people's subjective perceptions of pollution may have underestimated the actual mechanisms by which the environment affects mental health.

From a practical implication, this study reveals that even at low levels of actual pollution, residents' perceptions of pollution can cause significant psychological distress, which carries important implications for environmental governance. First, traditional environmental governance strategies focus on reducing actual pollution emissions, but this study suggests that policymakers should also emphasize the correct guidance of residents' subjective risk perceptions. This can be achieved through transparent information dissemination and scientific risk communication, thereby reducing the psychological burden caused by unnecessary panic or misunderstanding. Additionally, for populations with lower education levels or heightened concern about environmental issues, more targeted environmental education and psychological support services should be provided to help them develop more objective risk perceptions and emotional regulation skills.

Limitation

We must acknowledge several key limitations of this study. First, regarding the representation of actual pollution, participants were asked whether there were highly polluting industries in their area, which could include air, water, and soil pollution. However, actual exposure was assessed solely through air pollution indicators (PM2.5 and NO2) due to data availability constraints. This limitation implies that even under conditions of low air pollution, participants could still be exposed to other types of pollution, such as water or soil, which may influence their health outcomes and thus complicate the interpretation of our results. On the other hand, focusing on air pollution has its advantages. In China, air pollution is widely recognized as a significant issue (R.-J. Huang et al., 2014; Zeng et al., 2019), frequently discussed on social media platforms, especially regarding its health implications (Ye et al., 2022). This widespread discussion increases the likelihood of exposure illusion among residents. Air pollution tends to be pervasive and unavoidable, affecting all individuals within impacted areas, whereas water and soil pollution are more localized, and individuals may have more opportunities to avoid them (Marques & Lima, 2011).

Second, the cross-sectional nature of our study, while yielding significant results, also introduces limitations in establishing causal conclusions. Our results could reflect pre-exposure conditions—particularly for perceived pollution, where more anxious or depressed individuals may report higher levels of perceived pollution. However, we also assessed early pollution exposure information from the years before the survey, which yielded similar results. This provides some confidence in the potential causal relationship between pollution and mental health outcomes.

Lastly, despite incorporating large-scale representative datasets, the limited samples of pollution exposure may partly stem from recent substantial investments in environmental governance in China (Liao & Shi, 2018; Muganyi et al., 2021). Future investigations should strive to validate the findings of this study across larger and more diverse samples, including cross-cultural contexts.

Conclusion

The study indicates that exposure illusion is associated with symptoms of anxiety, depression, and stress, while exposure neglect shows a weak association only with anxiety. Perceived pollution, even when actual pollution levels are low, may relate to poorer mental well-being. These results highlight the importance of considering both actual pollution conditions and public perceptions in designing environmental and public health strategies.

Data Availability

All analyses scripts used in this study are available in Open Science Framework: https://osf.io/6tx2e/?view_only=96e17587f1994c949132b025b0288c5b.

Reference

Ain, Q., Ullah, R., Kamran, M. A., & Zulfiqar, F. (2021). Air pollution and its economic impacts at household level: Willingness to pay for environmental services in Pakistan. *Environmental Science and Pollution Research*, *28*(6), 6611–6618. https://doi.org/10.1007/s11356-020-11023-4

Auyero, J., & Swistun, D. (2008). The Social Production of Toxic Uncertainty. *American Sociological Review*, *73*(3), 357–379. https://doi.org/10.1177/000312240807300301

Avila-Palencia, I., Nazelle, A. de, Cole-Hunter, T., Donaire-Gonzalez, D., Jerrett, M., Rodriguez, D. A., & Nieuwenhuijsen, M. J. (2017). The relationship between bicycle commuting and perceived stress: A cross-sectional study. *BMJ Open*, *7*(6), e013542. https://doi.org/10.1136/bmjopen-2016-013542

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., Dai, B., Grothendieck, G., Green, P., & Bolker, M. B. (2015). Package 'lme4.' *Convergence*, *12*(1), 2.

Borroni, E., Pesatori, A. C., Bollati, V., Buoli, M., & Carugno, M. (2022). Air pollution exposure and depression: A comprehensive updated systematic review and meta-analysis. *Environmental Pollution*, *292*, 118245. https://doi.org/10.1016/j.envpol.2021.118245

Bosch, M. van den, & Meyer-Lindenberg, A. (2019). Environmental Exposures and Depression: Biological Mechanisms and Epidemiological Evidence. *Annual Review of Public Health*, *40*(Volume 40, 2019), 239–259. https://doi.org/10.1146/annurev-publhealth-040218-044106

Braithwaite, I., Zhang, S., Kirkbride, J. B., Osborn, D. P. J., & Hayes, J. F. (2019). Air Pollution (Particulate Matter) Exposure and Associations with Depression, Anxiety, Bipolar, Psychosis and Suicide Risk: A Systematic Review and Meta-Analysis. *Environmental Health Perspectives*, *127*(12), 126002. https://doi.org/10.1289/EHP4595

Burrows, K., Denckla, C. A., Hahn, J., Schiff, J. E., Okuzono, S. S., Randriamady, H., Mita, C., Kubzansky, L. D., Koenen, K. C., & Lowe, S. R. (2024). A systematic review of the effects of chronic, slow-onset climate change on mental health. *Nature Mental Health*, *2*(2), 228–243. https://doi.org/10.1038/s44220-023-00170-5

Butter, M. E. (2006). Are women more vulnerable to environmental pollution? *Journal of Human Ecology*, *20*(3), 221–226.

Chapman, S. (2015). *Symptoms, diseases and aberrant behaviours attributed to wind turbine exposure*. https://ses.library.usyd.edu.au/bitstream/handle/2123/10501/Wind_Disease_List.pdf?sequence=5

Chen, F., & Chen, Z. (2021). Cost of economic growth: Air pollution and health expenditure. *Science of The Total Environment*, *755*, 142543. https://doi.org/10.1016/j.scitotenv.2020.142543

Clayton, S. (2020). Climate anxiety: Psychological responses to climate change. *Journal of Anxiety Disorders*, *74*, 102263. https://doi.org/10.1016/j.janxdis.2020.102263

Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., Balakrishnan, K., Brunekreef, B., Dandona, L., Dandona, R., Feigin, V., Freedman, G., Hubbell, B., Jobling, A., Kan, H., Knibbs, L., Liu, Y., Martin, R., Morawska, L., … Forouzanfar, M. H. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the Global Burden of Diseases Study 2015. *The Lancet*, *389*(10082), 1907–1918. https://doi.org/10.1016/S0140-6736(17)30505-6

Colloca, L. (2024). The Nocebo Effect. *Annual Review of Pharmacology and Toxicology*, *64*(Volume 64, 2024), 171–190. https://doi.org/10.1146/annurev-pharmtox-022723-112425

de Rooij, S. R., Costello, P. M., Veenendaal, M. V. E., Lillycrop, K. A., Gluckman, P. D., Hanson, M. A., Painter, R. C., & Roseboom, T. J. (2012). Associations between DNA methylation of a glucocorticoid receptor promoter and acute stress responses in a large healthy adult population are largely explained by lifestyle and educational differences. *Psychoneuroendocrinology*, *37*(6), 782–788. https://doi.org/10.1016/j.psyneuen.2011.09.010

Dettori, M., Pittaluga, P., Busonera, G., Gugliotta, C., Azara, A., Piana, A., Arghittu, A., & Castiglia, P. (2020). Environmental Risks Perception Among Citizens Living Near Industrial Plants: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*, *17*(13), Article 13. https://doi.org/10.3390/ijerph17134870

Elo, I. T. (2009). Social Class Differentials in Health and Mortality: Patterns and Explanations in Comparative Perspective. *Annual Review of Sociology*, *35*(Volume 35, 2009), 553–572. https://doi.org/10.1146/annurev-soc-070308-115929

Environmental Development Center. (2016). *Ambient air quality standards*. https://english.mee.gov.cn/Resources/standards/Air_Environment/quality_standard1/201605/t20160511_337502.shtml

Erzen, E., & Çikrikci, Ö. (2018). The effect of loneliness on depression: A meta-analysis. *International Journal of Social Psychiatry*, *64*(5), 427–435. https://doi.org/10.1177/0020764018776349

Fan, S.-J., Heinrich, J., Bloom, M. S., Zhao, T.-Y., Shi, T.-X., Feng, W.-R., Sun, Y., Shen, J.-C., Yang, Z.-C., Yang, B.-Y., & Dong, G.-H. (2020). Ambient air pollution and depression: A systematic review with meta-analysis up to 2019. *Science of The Total Environment*, *701*, 134721. https://doi.org/10.1016/j.scitotenv.2019.134721

Farooqi, Z. U. R., Sabir, M., Latif, J., Aslam, Z., Ahmad, H. R., Ahmad, I., Imran, M., & Ilić, P. (2020). Assessment of noise pollution and its effects on human health in industrial hub of Pakistan. *Environmental Science and Pollution Research*, *27*(3), 2819–2828. https://doi.org/10.1007/s11356-019-07105-7

Fleury-Bahi, G., Préau, M., Annabi-Attia, T., Marcouyeux, A., & Wittenberg, I. (2015). Perceived health and quality of life: The effect of exposure to atmospheric pollution. *Journal of Risk Research*, *18*(2), 127–138. https://doi.org/10.1080/13669877.2013.841728

Fonken, L. K., Xu, X., Weil, Z. M., Chen, G., Sun, Q., Rajagopalan, S., & Nelson, R. J. (2011). Air pollution impairs cognition, provokes depressive-like behaviors and alters hippocampal cytokine expression and morphology. *Molecular Psychiatry*, *16*(10), 987–995. https://doi.org/10.1038/mp.2011.76

Gatersleben, B., & Griffin, I. (2017). Environmental Stress. In G. Fleury-Bahi, E. Pol, & O. Navarro (Eds.), *Handbook of Environmental Psychology and Quality of Life Research* (pp. 469–485). Springer International Publishing. https://doi.org/10.1007/978-3-319-31416-7_25

Gerhardstein, B., Tucker, P. G., Rayman, J., & Reh, C. M. (2019). A Fresh Look at Stress and Resilience in Communities Affected by Environmental Contamination. *Journal of Environmental Health*, *82*(4), 36–38.

Goodwin, R. D., Weinberger, A. H., Kim, J. H., Wu, M., & Galea, S. (2020). Trends in anxiety among adults in the United States, 2008–2018: Rapid increases among young adults. *Journal of Psychiatric Research*, *130*, 441–446. https://doi.org/10.1016/j.jpsychires.2020.08.014

Grupe, D. W., & Nitschke, J. B. (2013). Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience*, *14*(7), 488–501. https://doi.org/10.1038/nrn3524

Hahad, O., Kuntic, M., Al-Kindi, S., Kuntic, I., Gilan, D., Petrowski, K., Daiber, A., & Münzel, T. (2024). Noise and mental health: Evidence, mechanisms, and consequences. *Journal of Exposure Science & Environmental Epidemiology*, 1–8. https://doi.org/10.1038/s41370-024-00642-5

Hajat, A., MacLehose, R. F., Rosofsky, A., Walker, K. D., & Clougherty, J. E. (2021). Confounding by Socioeconomic Status in Epidemiological Studies of Air Pollution and Health: Challenges and Opportunities. *Environmental Health Perspectives*, *129*(6), 065001. https://doi.org/10.1289/EHP7980

Huang, Q. (2020). How Does News Media Exposure Amplify Publics' Perceived Health Risks About Air Pollution in China? A Conditional Media Effect Approach. *International Journal of Communication*, *14*(0), Article 0.

Huang, R.-J., Zhang, Y., Bozzetti, C., Ho, K.-F., Cao, J.-J., Han, Y., Daellenbach, K. R., Slowik, J. G., Platt, S. M., Canonaco, F., Zotter, P., Wolf, R., Pieber, S. M., Bruns, E. A., Crippa, M., Ciarelli, G., Piazzalunga, A., Schwikowski, M., Abbaszade, G., … Prévôt, A. S. H. (2014). High secondary aerosol contribution to particulate pollution during haze events in China. *Nature*, *514*(7521), 218–222. https://doi.org/10.1038/nature13774

Ji, J. S., Liu, L., Zhang, J. (Jim), Kan, H., Zhao, B., Burkart, K. G., & Zeng, Y. (2022). NO2 and PM2.5 air pollution co-exposure and temperature effect modification on pre-mature mortality in advanced age: A longitudinal cohort study in China. *Environmental Health*, *21*(1), 97. https://doi.org/10.1186/s12940-022-00901-8

Jiang, Q., Luo, X., Zheng, R., Xiang, Z., Zhu, K., Feng, Y., Xiao, P., Zhang, Q., Wu, X., Fan, Y., & Song, R. (2023). Exposure to ambient air pollution with depressive symptoms and anxiety symptoms among adolescents: A national population-based study in China. *Journal of Psychiatric Research*, *164*, 1–7. https://doi.org/10.1016/j.jpsychires.2023.05.077

Keyes, K. M., Gary, D., O'Malley, P. M., Hamilton, A., & Schulenberg, J. (2019). Recent increases in depressive symptoms among US adolescents: Trends from 1991 to 2018. *Social Psychiatry and Psychiatric Epidemiology*, *54*, 987–996. https://doi.org/10.1007/s00127-019-01697-8

Kim, S., & Kim, Y.-C. (2021). Attention to News Media, Emotional Responses, and Policy Preferences about Public Health Crisis: The Case of Fine Dust Pollution in South Korea. *International Journal of Environmental Research and Public Health*, *18*(24), Article 24. https://doi.org/10.3390/ijerph182413325

Koop, S. H. A., & van Leeuwen, C. J. (2017). The challenges of water, waste and climate change in cities. *Environment, Development and Sustainability*, *19*(2), 385–418. https://doi.org/10.1007/s10668-016-9760-4

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9: Validity of a Brief Depression Severity Measure. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Kube, T., & Herzog, P. (2023). Differential associations of positive and negative expectations with depressive symptoms. *Journal of Clinical Psychology*, *79*(3), 762–772. https://doi.org/10.1002/jclp.23442

Lelieveld, J., Evans, J. S., Fnais, M., Giannadaki, D., & Pozzer, A. (2015). The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature*, *525*(7569), 367–371. https://doi.org/10.1038/nature15371

Li, F., & Zhou, T. (2020). Effects of objective and subjective environmental pollution on well-being in urban China: A structural equation model approach. *Social Science & Medicine*, *249*, 112859. https://doi.org/10.1016/j.socscimed.2020.112859

Li, J., Huang, L., Han, B., van der Kuijp, T. J., Xia, Y., & Chen, K. (2021). Exposure and perception of PM2.5 pollution on the mental stress of pregnant women. *Environment International*, *156*, 106686. https://doi.org/10.1016/j.envint.2021.106686

Liang, L. A., Berger, U., & Brand, C. (2019). Psychosocial factors associated with symptoms of depression, anxiety and stress among single mothers with young children: A population-based study. *Journal of Affective Disorders*, *242*, 255–264. https://doi.org/10.1016/j.jad.2018.08.013

Liao, X., & Shi, X. (Roc). (2018). Public appeal, environmental regulation and green investment: Evidence from China. *Energy Policy*, *119*, 554–562. https://doi.org/10.1016/j.enpol.2018.05.020

Lima, M. L. (2004). On the influence of risk perception on mental health: Living near an incinerator. *Journal of Environmental Psychology*, *24*(1), 71–84. https://doi.org/10.1016/S0272-4944(03)00026-4

Liu, Q., He, H., Yang, J., Feng, X., Zhao, F., & Lyu, J. (2020). Changes in the global burden of depression from 1990 to 2017: Findings from the Global Burden of Disease study. *Journal of Psychiatric Research*, *126*, 134–140. https://doi.org/10.1016/j.jpsychires.2019.08.002

Liu, W., Xu, Y., Fan, D., Li, Y., Shao, X.-F., & Zheng, J. (2021). Alleviating corporate environmental pollution threats toward public health and safety: The role of smart city and artificial intelligence. *Safety Science*, *143*, 105433. https://doi.org/10.1016/j.ssci.2021.105433

Luís, S., Moura, R., Lima, M. L., Poggio, L., Aragonés, J. I., & Camilo, C. (2022). Judging Pharmaceutical Environmental Risk by its Cover? The Effects of Prescription Medication and Disease Severity on Environmental Risk Perception. *Risk Analysis*, *42*(10), 2231–2242. https://doi.org/10.1111/risa.13856

Marques, S., & Lima, M. L. (2011). Living in grey areas: Industrial activity and psychological health. *Journal of Environmental Psychology*, *31*(4), 314–322. https://doi.org/10.1016/j.jenvp.2010.12.002

Mebrahtu, T. F., Santorelli, G., Yang, T. C., Wright, J., Tate, J., & McEachan, R. RC. (2023). The effects of exposure to NO2, PM2.5 and PM10 on health service attendances with respiratory illnesses: A time-series analysis. *Environmental Pollution*, *333*, 122123. https://doi.org/10.1016/j.envpol.2023.122123

Mehta, A. J., Kubzansky, L. D., Coull, B. A., Kloog, I., Koutrakis, P., Sparrow, D., Spiro, A., Vokonas, P., & Schwartz, J. (2015). Associations between air pollution and perceived stress: The Veterans Administration Normative Aging Study. *Environmental Health*, *14*(1), 10. https://doi.org/10.1186/1476-069X-14-10

Mendoza, Y., & González, R. E. (2024). Objective and subjective measures of air pollution and self-rated health: The evidence from Chile. *International Archives of Occupational and Environmental Health*, *97*(4), 413–433. https://doi.org/10.1007/s00420-024-02056-0

Miller, J. G., Gillette, J. S., Manczak, E. M., Kircanski, K., & Gotlib, I. H. (2019). Fine Particle Air Pollution and Physiological Reactivity to Social Stress in Adolescence: The Moderating Role of Anxiety and Depression. *Psychosomatic Medicine*, *81*(7), 641. https://doi.org/10.1097/PSY.0000000000000714

Ministry of Ecology and Environment. (2020). *National Ecological and Environmental Statistics Bulletin 2016-2019*. https://www.mee.gov.cn/hjzl/sthjzk/sthjtjnb/202012/P020201214580320276493.pdf

Muganyi, T., Yan, L., & Sun, H. (2021). Green finance, fintech and environmental protection: Evidence from China. *Environmental Science and Ecotechnology*, *7*, 100107. https://doi.org/10.1016/j.ese.2021.100107

Nochaiwong, S., Ruengorn, C., Thavorn, K., Hutton, B., Awiphan, R., Phosuya, C., Ruanta, Y., Wongpakaran, N., & Wongpakaran, T. (2021). Global prevalence of mental health issues among the general population during the coronavirus disease-2019 pandemic: A systematic review and meta-analysis. *Scientific Reports*, *11*(1), 10173. https://doi.org/10.1038/s41598-021-89700-8

Olaniyan, T., Jeebhay, M., Röösli, M., Naidoo, R. N., Künzli, N., de Hoogh, K., Saucy, A., Badpa, M., Baatjies, R., Parker, B., Leaner, J., & Dalvie, M. A. (2020). The association between ambient NO2 and PM2.5 with the respiratory health of school children residing in informal settlements: A prospective cohort study. *Environmental Research*, *186*, 109606. https://doi.org/10.1016/j.envres.2020.109606

Omanga, E., Ulmer, L., Berhane, Z., & Gatari, M. (2014). Industrial air pollution in rural Kenya: Community awareness, risk perception and associations between risk variables. *BMC Public Health*, *14*(1), 377. https://doi.org/10.1186/1471-2458-14-377

Opoku, E. E. O., & Aluko, O. A. (2021). Heterogeneous effects of industrialization on the environment: Evidence from panel quantile regression. *Structural Change and Economic Dynamics*, *59*, 174–184. https://doi.org/10.1016/j.strueco.2021.08.015

Pearson, H. (2024). The rise of eco-anxiety: Scientists wake up to the mental-health toll of climate change. *Nature*, *628*(8007), 256–258. https://doi.org/10.1038/d41586-024-00998-6

Peek, M. K., Cutchin, M. P., Freeman, D., Stowe, R. P., & Goodwin, J. S. (2009). Environmental hazards and stress: Evidence from the Texas City Stress and Health Study. *Journal of Epidemiology & Community Health*, *63*(10), 792–798. https://doi.org/10.1136/jech.2008.079806

Peprah, P., Agyemang-Duah, W., Morgan, A. K., Onyina, E., & Asare, E. S. (2024). Differences in physical and mental health symptoms among residents living near municipal solid waste sites: A cross sectional study in the Ashanti Region, Ghana. *Journal of Health, Population and Nutrition*, *43*(1), 34. https://doi.org/10.1186/s41043-024-00527-1

Petrie, K. J., & Rief, W. (2019). Psychobiological Mechanisms of Placebo and Nocebo Effects: Pathways to Improve Treatments and Reduce Side Effects. *Annual Review of Psychology*, *70*(Volume 70, 2019), 599–625. https://doi.org/10.1146/annurev-psych-010418-102907

Petrowski, K., Bastianon, C. D., Bührer, S., & Brähler, E. (2019). Air Quality and Chronic Stress: A Representative Study of Air Pollution (PM: 2.5: , PM: 10:) in Germany. *Journal of Occupational and Environmental Medicine*, *61*(2), 144. https://doi.org/10.1097/JOM.0000000000001502

Powell, M., Dunwoody, S., Griffin, R., & Neuwirth, K. (2007). Exploring lay uncertainty about an environmental health risk. *Public Understanding of Science*, *16*(3), 323–343. https://doi.org/10.1177/0963662507074491

Ramón-Arbués, E., Gea-Caballero, V., Granada-López, J. M., Juárez-Vela, R., Pellicer-García, B., & Antón-Solanas, I. (2020). The Prevalence of Depression, Anxiety and Stress and Their Associated Factors in College Students. *International Journal of Environmental Research and Public Health*, *17*(19), Article 19. https://doi.org/10.3390/ijerph17197001

Ramondt, S., & Ramírez, A. S. (2020). Media Reporting on Air Pollution: Health Risk and Precautionary Measures in National and Regional Newspapers. *International Journal of Environmental Research and Public Health*, *17*(18), Article 18. https://doi.org/10.3390/ijerph17186516

Rautio, N., Filatova, S., Lehtiniemi, H., & Miettunen, J. (2018). Living environment and its relationship to depressive mood: A systematic review. *International Journal of Social Psychiatry*, *64*(1), 92–103. https://doi.org/10.1177/0020764017744582

Reames, T. G., & Bravo, M. A. (2019). People, place and pollution: Investigating relationships between air quality perceptions, health concerns, exposure, and individual- and area-level characteristics. *Environment International*, *122*, 244–255. https://doi.org/10.1016/j.envint.2018.11.013

Reuben, A., Manczak, E. M., Cabrera, L. Y., Alegria, M., Bucher, M. L., Freeman, E. C., Miller, G. W., Solomon, G. M., & Perry, M. J. (2022). The Interplay of Environmental Exposures and Mental Health: Setting an Agenda. *Environmental Health Perspectives*, *130*(2), 025001. https://doi.org/10.1289/EHP9889

Riley, R., de Preux, L., Capella, P., Mejia, C., Kajikawa, Y., & de Nazelle, A. (2021). How do we effectively communicate air pollution to change public attitudes and behaviours? A review. *Sustainability Science, 16*(6), 2027–2047. https://doi.org/10.1007/s11625-021-01038-2

Roy, S., Petrie, K. J., Gamble, G., & Edwards, M. A. (2023). Did a Nocebo Effect Contribute to the Rise in Special Education Enrollment Following the Flint, Michigan Water Crisis? *Clinical Psychology in Europe*, *5*(1), Article 1. https://doi.org/10.32872/cpe.9577

Santini, Z. I., Jose, P. E., Cornwell, E. Y., Koyanagi, A., Nielsen, L., Hinrichsen, C., Meilstrup, C., Madsen, K. R., & Koushede, V. (2020). Social disconnectedness, perceived isolation, and symptoms of depression and anxiety among older Americans (NSHAP): A longitudinal mediation analysis. *The Lancet Public Health*, *5*(1), e62–e70. https://doi.org/10.1016/S2468-2667(19)30230-0

Sapienza, M., Riccardi, M. T., Nurchis, M. C., Pascucci, D., & Damiani, G. (2020). Community Engagement: Reducing inequalities acting on environmental health. A Systematic Review. *European Journal of Public Health*, *30*(Supplement_5), ckaa165.653. https://doi.org/10.1093/eurpub/ckaa165.653

Schraml, K., Perski, A., Grossi, G., & Simonsson-Sarnecki, M. (2011). Stress symptoms among adolescents: The role of subjective psychosocial conditions, lifestyle, and self-esteem. *Journal of Adolescence*, *34*(5), 987–996. https://doi.org/10.1016/j.adolescence.2010.11.010

Selinheimo, S., Vuokko, A., Hublin, C., Järnefelt, H., Karvala, K., Sainio, M., Suojalehto, H., Suvisaari, J., & Paunio, T. (2019). Health-related quality among life of employees with persistent nonspecific indoor-air-associated health complaints. *Journal of Psychosomatic Research*, *122*, 112–120. https://doi.org/10.1016/j.jpsychores.2019.03.181

Simoes, M., Huss, A., Janssen, N., & Vermeulen, R. (2022). Self-reported psychological distress and self-perceived health in residents living near pesticide-treated agricultural land: A cross-sectional study in The Netherlands. *Occupational and Environmental Medicine*, *79*(2), 127–133. https://doi.org/10.1136/oemed-2021-107544

Solomon, G. M., Morello-Frosch, R., Zeise, L., & Faust, J. B. (2016). Cumulative Environmental Impacts: Science and Policy to Protect Communities. *Annual Review of Public Health*, *37*(Volume 37, 2016), 83–96. https://doi.org/10.1146/annurev-publhealth-032315-021807

Soutar, C., & Wand, A. P. F. (2022). Understanding the Spectrum of Anxiety Responses to Climate Change: A Systematic Review of the Qualitative Literature. *International Journal of Environmental Research and Public Health*, *19*(2), Article 2. https://doi.org/10.3390/ijerph19020990

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A Brief Measure for Assessing Generalized Anxiety Disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092–1097. https://doi.org/10.1001/archinte.166.10.1092

Stapinski, L. A., Abbott, M. J., & Rapee, R. M. (2010). Fear and perceived uncontrollability of emotion: Evaluating the unique contribution of emotion appraisal variables to prediction of worry and generalised anxiety disorder. *Behaviour Research and Therapy*, *48*(11), 1097–1104. https://doi.org/10.1016/j.brat.2010.07.012

Stewart, A. G., & Hursthouse, A. S. (2018). Environment and Human Health: The Challenge of Uncertainty in Risk Assessment. *Geosciences*, *8*(1), Article 1. https://doi.org/10.3390/geosciences8010024

Tam, K.-P., Chan, H.-W., & Clayton, S. (2023). Climate change anxiety in China, India, Japan, and the United States. *Journal of Environmental Psychology*, *87*, 101991. https://doi.org/10.1016/j.jenvp.2023.101991

Thomson, E. M. (2019). Air Pollution, Stress, and Allostatic Load: Linking Systemic and Central Nervous System Impacts. *Journal of Alzheimer's Disease*, *69*(3), 597–614. https://doi.org/10.3233/JAD-190015

Thomson, E. M., Vladisavljevic, D., Mohottalage, S., Kumarathasan, P., & Vincent, R. (2013). Mapping Acute Systemic Effects of Inhaled Particulate Matter and Ozone: Multiorgan Gene Expression and Glucocorticoid Activity. *Toxicological Sciences*, *135*(1), 169–181. https://doi.org/10.1093/toxsci/kft137

Vallejo, M. A., Vallejo-Slocker, L., Fernández-Abascal, E. G., & Mañanes, G. (2018). Determining Factors for Stress Perception Assessed with the Perceived Stress Scale (PSS-4) in Spanish and Other European Samples. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.00037

Wang, Q., & Yang, Z. (2016). Industrial water pollution, water environment treatment, and health risks in China. *Environmental Pollution*, *218*, 358–365. https://doi.org/10.1016/j.envpol.2016.07.011

Wang, S., Paul, M. J., & Dredze, M. (2015). Social Media as a Sensor of Air Quality and Public Response in China. *Journal of Medical Internet Research*, *17*(3), e3875. https://doi.org/10.2196/jmir.3875

Wang, S., Pei, J., Zhang, K., Gong, D., Rokpelnis, K., Yang, W., & Yu, X. (2022). Does Individuals’ Perception of Wastewater Pollution Decrease Their Self-Rated Health? Evidence from China. *International Journal of Environmental Research and Public Health*, *19*(12), Article 12. https://doi.org/10.3390/ijerph19127291

Wang, Y., McKee, M., Torbica, A., & Stuckler, D. (2019). Systematic Literature Review on the Spread of Health-related Misinformation on Social Media. *Social Science & Medicine*, *240*, 112552. https://doi.org/10.1016/j.socscimed.2019.112552

Wei, J., Li, Z., Lyapustin, A., Sun, L., Peng, Y., Xue, W., Su, T., & Cribb, M. (2021). Reconstructing 1-km-resolution high-quality PM2.5 data records from 2000 to 2018 in China: Spatiotemporal variations and policy implications. *Remote Sensing of Environment*, *252*, 112136. https://doi.org/10.1016/j.rse.2020.112136

Wei, J., Liu, S., Li, Z., Liu, C., Qin, K., Liu, X., Pinker, R. T., Dickerson, R. R., Lin, J., Boersma, K. F., Sun, L., Li, R., Xue, W., Cui, Y., Zhang, C., & Wang, J. (2022). Ground-Level NO2 Surveillance from Space Across China for High Resolution Using Interpretable Spatiotemporally Weighted Artificial Intelligence. *Environmental Science & Technology*, *56*(14), 9988–9998. https://doi.org/10.1021/acs.est.2c03834

Westergaard, N., Gehring, U., Slama, R., & Pedersen, M. (2017). Ambient air pollution and low birth weight—Are some women more vulnerable than others? *Environment International*, *104*, 146–154. https://doi.org/10.1016/j.envint.2017.03.026

WHO. (2021). *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. https://www.who.int/publications/i/item/9789240034228

Wu, W., Wu, P., Yang, F., Sun, D., Zhang, D.-X., & Zhou, Y.-K. (2018). Assessment of heavy metal pollution and human health risks in urban soils around an electronics manufacturing facility. *Science of The Total Environment*, *630*, 53–61. https://doi.org/10.1016/j.scitotenv.2018.02.183

Wu, Y., Fan, S., Liu, D., & Sun, X. (2024). Psychological and behavior investigation of Chinese residents: Concepts, practices, and prospects. *Chinese General Practice Journal*, *1*(3), 149–156. https://doi.org/10.1016/j.cgpj.2024.07.006

Xiao, C., & McCright, A. M. (2015). Gender Differences in Environmental Concern: Revisiting the Institutional Trust Hypothesis in the USA. *Environment and Behavior*, *47*(1), 17–37. https://doi.org/10.1177/0013916513491571

Yan, L., Duarte, F., Wang, D., Zheng, S., & Ratti, C. (2019). Exploring the effect of air pollution on social activity in China using geotagged social media check-in data. *Cities*, *91*, 116–125. https://doi.org/10.1016/j.cities.2018.11.011

Yang, T., Wang, J., Huang, J., Kelly, F. J., & Li, G. (2023). Long-term Exposure to Multiple Ambient Air Pollutants and Association With Incident Depression and Anxiety. *JAMA Psychiatry*, *80*(4), 305–313. https://doi.org/10.1001/jamapsychiatry.2022.4812

Yang, Y., Fan, S., Chen, W., & Wu, Y. (2024). Broader Open Data Needed in Psychiatry: Practice from the Psychology and Behavior Investigation of Chinese Residents. *Alpha Psychiatry*, *25*(4), 564–565. https://doi.org/10.5152/alphapsychiatry.2024.241804

Yang, Y., Zhu, Y., Wang, X., & Li, Y. (2022). The Perception of Environmental Information Disclosure on Rural Residents' Pro-Environmental Behavior. *International Journal of Environmental Research and Public Health*, *19*(13), Article 13. https://doi.org/10.3390/ijerph19137851

Ye, B., Krishnan, P., & Jia, S. (2022). Public Concern about Air Pollution and Related Health Outcomes on Social Media in China: An Analysis of Data from Sina Weibo (Chinese

Twitter) and Air Monitoring Stations. *International Journal of Environmental Research and Public Health*, *19*(23), Article 23. https://doi.org/10.3390/ijerph192316115

Yu, S., Guo, N., Zheng, C., Song, Y., & Hao, J. (2021). Investigating the Association between Outdoor Environment and Outdoor Activities for Seniors Living in Old Residential Communities. *International Journal of Environmental Research and Public Health*, *18*(14), Article 14. https://doi.org/10.3390/ijerph18147500

Zeng, Y., Cao, Y., Qiao, X., Seyler, B. C., & Tang, Y. (2019). Air pollution reduction in China: Recent success but great challenge for the future. *Science of The Total Environment*, *663*, 329–337. https://doi.org/10.1016/j.scitotenv.2019.01.262

Zhu, J., & Lu, C. (2023). Air Quality, Pollution Perception, and Residents' Health: Evidence from China. *Toxics*, *11*(7), Article 7. https://doi.org/10.3390/toxics11070591

Zhu, P., & Lin, B. (2022). Vanishing Happiness: How Does Pollution Information Disclosure Affect Life Satisfaction? *International Journal of Environmental Research and Public Health*, *19*(15), Article 15. https://doi.org/10.3390/ijerph19159530

Zhu, Z., & Zhao, Y. (2021). Severe Air Pollution and Psychological Distress in China: The Interactive Effects of Coping and Perceived Controllability. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.601964

Zou, B., Peng, F., Wan, N., Wilson, J. G., & Xiong, Y. (2014). Sulfur dioxide exposure and environmental justice: A multi–scale and source–specific perspective. *Atmospheric Pollution Research*, *5*(3), 491–499. https://doi.org/10.5094/APR.2014.058

Zundel, C. G., Ryan, P., Brokamp, C., Heeter, A., Huang, Y., Strawn, J. R., & Marusak, H. A. (2022). Air pollution, depressive and anxiety disorders, and brain effects: A systematic review. *NeuroToxicology*, *93*, 272–300. https://doi.org/10.1016/j.neuro.2022.10.011

Table 1

Descriptive statistics

Variable	**Sample**	**Anxiety M+SD**	**Depression M+SD**	**Stress M+SD**	**Perceived Pollution (%)**	**Actual Pollution (%)**
Total	16607	4.54 (4.62)	6.24 (5.55)	10.44 (2.55)	7.79	27.30
Age						
12-17	1505	4.76 (5.32)	6.58 (6.51)	10.7 (2.53)	6.25	23.79
18-59	11923	4.60 (4.62)	6.33 (5.49)	10.4 (2.56)	8.55	29.60
≥60	3179	4.20 (4.23)	5.74 (5.23)	10.47 (2.53)	5.66	20.35
Education						
High school	9185	4.28 (4.51)	5.89 (5.48)	10.44 (2.55)	7.23	23.67
University	6789	4.84 (4.68)	6.66 (5.53)	10.46 (2.56)	8.41	31.18
Postgraduate	633	5.05 (5.15)	6.85 (6.29)	10.3 (2.49)	9.32	38.39
Urbanization						
Urban	5230	4.74 (4.69)	6.52 (5.67)	10.73 (2.45)	9.02	28.68
Rural	11377	4.45 (4.58)	6.11 (5.49)	10.31 (2.58)	7.23	26.67
Gender						
Female	8139	4.51 (4.42)	6.14 (5.21)	10.47 (2.56)	6.38	28.69
Male	8468	4.57 (4.79)	6.34 (5.85)	10.41 (2.54)	9.15	25.97
Condition						
Clear of Pollution	11234	4.31 (4.48)	5.91 (5.40)	10.37 (2.55)	0	0
Exposure Illusion	4079	4.68 (4.67)	6.52 (5.58)	10.48 (2.56)	0	100
Exposure Neglect	839	5.51 (5.02)	7.50 (5.80)	10.81 (2.58)	100	0
Confirmed Pollution	455	7.11 (5.50)	9.73 (6.53)	11.22 (2.32)	100	100

Table 2

Descriptive statistics by difference pollution conditions (%)

Category	Clear of Pollution (n=11234)	Exposure Illusion (n=4079)	Exposure Neglect (n=839)	Confirmed Pollution (n=455)	χ^2 (p-value)
Age					6.55
12-17	9.74	7.77	6.32	9.01	(.364)
18-59	68.94	77.42	77.35	81.54	
≥60	21.32	14.81	16.33	9.45	
Education					4.97
High school	58.32	48.27	54.71	45.05	(.548)
University	38.47	46.48	41.72	48.57	
Postgraduate	3.20	5.25	3.58	6.37	
Urbanization					1.92
Urban	30.59	32.39	34.92	39.34	(.590)
Rural	69.41	67.61	65.08	60.66	
Gender					4.71
Female	48.70	52.68	39.69	40.88	(.194)
Male	51.30	47.32	60.31	59.12	

Table 3

Associations of pollution condition with depression, anxiety, and stress

	(1) Depression		(2) Anxiety		(3) Stress	
	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]
(Intercept)	0.44***		–1.57***		0.16*	
	(0.11)		(0.11)		(0.08)	
Exposure Neglect (Ref Control)	–0.06	0.94	**0.17***	**1.19**	0.10	1.10
	(0.06)	[0.84,1.05]	**(0.08)**	**[1.02, 1.38]**	(0.05)	[1.00,1.22]
Exposure Illusion (Ref Control)	**0.51*****	**1.66**	**0.43*****	**1.54**	**0.30*****	**1.35**
	(0.08)	**[1.43,1.94]**	**(0.10)**	**[1.28, 1.85]**	**(0.07)**	**[1.17,1.56]**
Confirmed Pollution (Ref Control)	**0.900*****	**2.46**	**0.96*****	**2.60**	**0.56*****	**1.76**
	(0.13)	**[1.92,3.15]**	**(0.12)**	**[2.04, 3.31]**	**(0.11)**	**[1.43,2.16]**
Age 18-59 (ref 12-18)	0.01	1.00	–0.40***	0.67	–0.22***	0.80
	(0.06)	[0.89,1.13]	(0.08)	[0.57, 0.78]	(0.06)	[0.72,0.90]
Age ≥60 (ref 12-18)	–0.05	0.95	–0.45***	0.64	–0.13*	0.88
	(0.07)	[0.84,1.09]	(0.09)	[0.53, 0.76]	(0.06)	[0.77,1.00]
Gender (ref female)	–0.12***	0.89	0.19***	1.21	0.06*	1.07
	(0.03)	[0.84,0.95]	(0.05)	[1.10, 1.32]	(0.032)	[1.00,1.13]
Urbanization (ref rural)	–0.20***	0.82	–0.24***	0.79	–0.36***	0.70
	(0.04)	[0.76,0.88]	(0.05)	[0.71, 0.88]	(0.036)	[0.65,0.75]
University (ref high school)	0.24***	1.27	0.20***	1.22	0.15***	1.16
	(0.04)	[1.18,1.37]	(0.05)	[1.09, 1.35]	(0.037)	[1.08,1.25]
Postgraduate (ref high school)	0.13	1.14	0.46***	1.58	0.11	1.11

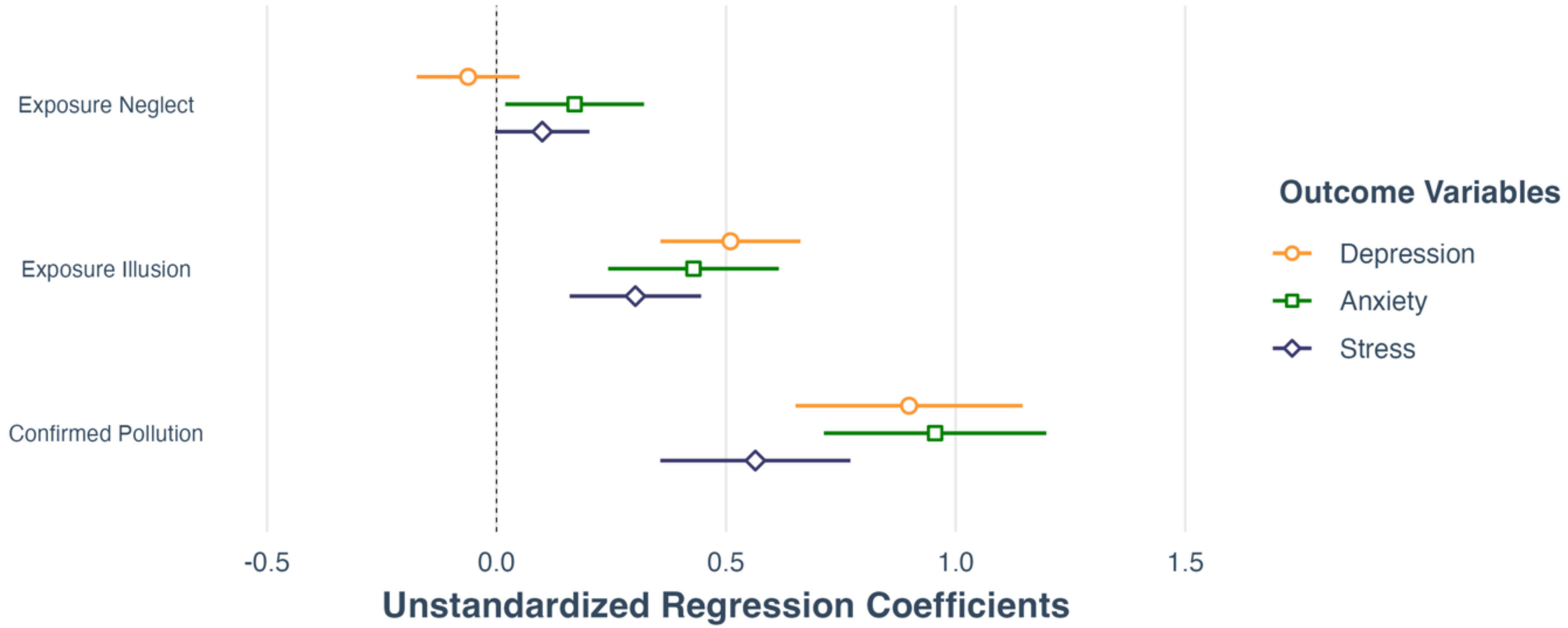
	(0.09)	[0.96,1.36]	(0.11)	[1.27, 1.98]	(0.09)	[0.94,1.31]
Marginal R^2	0.02		0.02		0.01	
Conditional R^2	0.08		0.06		0.03	

Note. Unstandardized regression coefficients (with standard errors in parentheses) and odds ratios (with 95% confidence intervals) are displayed.

* p < .05. ** p < .01. *** p < .001. Control means the group with no perceived pollution and no actual pollution.

Figure 1

Associations Between Pollution Conditions and Mental Health Outcomes (Depression, Anxiety, and Stress)



Note. The group with no perceived pollution and no actual pollution serves as the reference.

Appendix

Table S1

Sensitivity analysis based on continuous outcomes

	(1) Depression		(2) Anxiety		(3) Stress	
	Unstandardized	Standardized	Unstandardized	Standardized	Unstandardized	Standardized
(Intercept)	7.27***	0.19***	5.23***	0.15**	10.99***	0.22***
	(0.30)	(0.05)	(0.23)	(0.05)	(0.10)	(0.04)
Exposure Neglect (Ref Control)	0.05	0.01	0.09	0.02	0.03	0.01
	(0.15)	(0.03)	(0.12)	(0.03)	(0.07)	(0.03)
Exposure Illusion (Ref Control)	**1.42*** **	**0.26*** **	**1.11*** **	**0.24*** **	**0.43*** **	**0.17*** **
	(0.19)	**(0.03)**	**(0.16)**	**(0.04)**	**(0.09)**	**(0.04)**
Confirmed Pollution (Ref Control)	**2.92*** **	**0.53*** **	**2.30*** **	**0.50*** **	**0.76*** **	**0.30*** **
	(0.28)	**(0.05)**	**(0.24)**	**(0.05)**	**(0.13)**	**(0.05)**
Age 18-59 (ref 12-18)	–0.70***	–0.13***	–0.48***	–0.10***	–0.34***	–0.13***
	(0.16)	(0.03)	(0.13)	(0.03)	(0.07)	(0.03)
Age ≥60 (ref 12-18)	–0.90***	–0.16***	–0.63***	–0.14***	–0.34***	–0.13***
	(0.17)	(0.03)	(0.14)	(0.03)	(0.08)	(0.03)
Gender (ref female)	0.14	0.02	0.02	0.00	–0.07	–0.03
	(0.08)	(0.02)	(0.07)	(0.02)	(0.04)	(0.02)
Urbanization (ref rural)	–0.63***	–0.11***	–0.46***	–0.10***	–0.39***	–0.15***
	(0.10)	(0.02)	(0.08)	(0.02)	(0.05)	(0.02)
University (ref high school)	0.65***	0.12***	0.48***	0.10***	0.13**	0.05**

	(1) Depression		(2) Anxiety		(3) Stress	
	(0.10)	(0.02)	(0.08)	(0.02)	(0.05)	(0.02)
Postgraduate (ref high school)	0.72**	0.13**	0.61**	0.13**	–0.03	–0.01
	(0.23)	(0.04)	(0.19)	(0.04)	(0.11)	(0.04)
Marginal R^2	0.02		0.01		0.01	
Conditional R^2	0.08		0.06		0.03	

Note. Unstandardized regression coefficients and standardized regression coefficients are displayed, with standard errors in parentheses. * p < .05.

** p < .01. *** p < .001. Control means not perceived pollution with actual pollution.

Table S2

Sensitivity analysis based on classification points

	(1) Depression_10		(2) Anxiety_ 15		(3) Stress_ 13	
	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]
(Intercept)	–1.01***		–2.95***		–1.61***	
	(0.10)		(0.15)		(0.10)	
Exposure Neglect (Ref Control)	**0.13***	**1.14**	**0.36****	**1.44**	0.07	1.07
	(0.07)	**[1.00, 1.29]**	**(0.14)**	**[1.10, 1.89]**	(0.08)	[0.92, 1.24]
Exposure Illusion (Ref Control)	**0.46*****	**1.59**	**0.52****	**1.69**	**0.29****	**1.34**
	(0.08)	**[1.36, 1.86]**	**(0.18)**	**[1.19, 2.40]**	**(0.10)**	**[1.10, 1.63]**
Confirmed Pollution (Ref Control)	**0.89*****	**2.43**	**1.35*****	**3.86**	**0.53*****	**1.70**
	(0.11)	**[1.96, 3.03]**	**(0.19)**	**[2.65, 5.63]**	**(0.14)**	**[1.31, 2.21]**
Age 18-59 (ref 12-18)	–0.30***	0.74	–0.84***	0.43	–0.12	0.88
	(0.07)	[0.65, 0.85]	(0.14)	[0.33, 0.56]	(0.08)	[0.75, 1.04]
Age ≥60 (ref 12-18)	–0.33***	0.72	–1.37***	0.25	–0.11	0.90
	(0.08)	[0.62, 0.83]	(0.18)	[0.18, 0.36]	(0.09)	[0.75, 1.08]
Gender (ref female)	0.11**	1.11	0.18*	1.20	–0.18***	0.84
	(0.04)	[1.03, 1.20]	(0.09)	[1.00, 1.44]	(0.05)	[0.77, 0.92]
Urbanization (ref rural)	–0.23***	0.79	–0.21*	0.81	–0.16**	0.86
	(0.04)	[0.73, 0.86]	(0.10)	[0.66, 0.99]	(0.05)	[0.77, 0.95]
University (ref high school)	0.20***	1.22	0.30**	1.35	–0.04	0.96
	(0.05)	[1.12, 1.33]	(0.10)	[1.09, 1.66]	(0.05)	[0.86, 1.07]

Postgraduate (ref high school)	0.21*	1.24	0.64**	1.89	–0.18	0.83
	(0.10)	[1.01, 1.51]	(0.20)	[1.27, 2.82]	(0.13)	[0.64, 1.08]
Marginal R^2	0.02		0.07		0.01	
Conditional R^2	0.06		0.09		0.04	

Note. Unstandardized regression coefficients (with standard errors in parentheses) and odds ratios (with 95% confidence intervals) are displayed.

* p < .05. ** p < .01. *** p < .001. Control means not perceived pollution with actual pollution.

Table S3

Sensitivity analysis based on three-year pollution averages

	(1) Depression		(2) Anxiety		(3) Stress	
	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]
(Intercept)	0.37***		–1.60***		0.17*	
	(0.10)		(0.10)		(0.08)	
Exposure Neglect (Ref Control)	0.09	1.09	**0.18****	**1.20**	0.03	1.03
	(0.05)	[0.99, 1.20]	**(0.07)**	**[1.05, 1.37]**	(0.05)	[0.94, 1.13]
Exposure Illusion (Ref Control)	**0.62*****	**1.86**	**0.48*****	**1.61**	**0.27*****	**1.30**
	(0.08)	**[1.58, 2.20]**	**(0.10)**	**[1.32, 1.97]**	**(0.08)**	**[1.12, 1.52]**
Confirmed Pollution (Ref Control)	**0.71*****	**2.03**	**0.68*****	**1.96**	**0.53*****	**1.69**
	(0.11)	**[1.63, 2.51]**	**(0.12)**	**[1.55, 2.49]**	**(0.10)**	**[1.39, 2.05]**
Age 18-59 (ref 12-18)	0.01	1.01	–0.39***	0.67	–0.23***	0.80
	(0.06)	[0.90, 1.14]	(0.08)	[0.58, 0.79]	(0.06)	[0.71, 0.90]
Age ≥60 (ref 12-18)	–0.05	0.95	–0.47***	0.63	-0.14*	0.87
	(0.07)	[0.84, 1.08]	(0.09)	[0.52, 0.75]	(0.07)	[0.77, 0.99]
Gender (ref female)	–0.12***	0.89	0.19***	1.21	0.06	1.06
	(0.03)	[0.83, 0.95]	(0.05)	[1.10, 1.32]	(0.032)	[1.00, 1.13]
Urbanization (ref rural)	–0.21***	0.81	–0.25***	0.78	–0.36***	0.70
	(0.04)	[0.75, 0.87]	(0.05)	[0.70, 0.86]	(0.04)	[0.65, 0.75]
University (ref high school)	0.23***	1.26	0.18**	1.19	0.15***	1.17
	(0.04)	[1.17, 1.35]	(0.06)	[1.07, 1.33]	(0.04)	[1.08, 1.25]
Postgraduate (ref high school)	0.09	1.10	0.43***	1.53	0.11	1.11

	(0.09)	[0.92, 1.30]	(0.11)	[1.22, 1.92]	(0.09)	[0.94, 1.32]
Marginal R2	0.02		0.02		0.01	
Conditional R2	0.07		0.05		0.03	

Note. Unstandardized regression coefficients (with standard errors in parentheses) and odds ratios (with 95% confidence intervals) are displayed.

* p < .05. ** p < .01. *** p < .001. Control means not perceived pollution with actual pollution.

Table S4

Sensitivity analysis based on lower pollution thresholds

	(1) Depression		(2) Anxiety		(3) Stress	
	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]
(Intercept)	0.56***		–1.48***		0.19*	
	(0.11)		(0.12)		(0.08)	
Exposure Neglect (Ref Control)	**–0.21*** **	**0.81**	–0.06	0.94	–0.01	0.99
	(0.05)	**[0.73, 0.90]**	(0.07)	[0.82, 1.09]	(0.05)	[0.91, 1.09]
Exposure Illusion (Ref Control)	**0.66*** **	**1.94**	**0.42** **	**1.52**	**0.34** **	**1.41**
	(0.13)	**[1.50, 2.50]**	**(0.15)**	**[1.13, 2.04]**	**(0.12)**	**[1.12, 1.78]**
Confirmed Pollution (Ref Control)	**0.44*** **	**1.56**	**0.56*** **	**1.75**	**0.36*** **	**1.43**
	(0.09)	**[1.32, 1.85]**	**(0.10)**	**[1.43, 2.14]**	**(0.08)**	**[1.23, 1.67]**
Age 18-59 (ref 12-18)	–0.00	1.00	–0.41***	0.66	–0.22***	0.80
	(0.06)	[0.89, 1.12]	(0.08)	[0.57, 0.78]	(0.06)	[0.71, 0.90]
Age ≥60 (ref 12-18)	–0.05	0.95	–0.45***	0.64	–0.13*	0.88
	(0.07)	[0.83, 1.08]	(0.09)	[0.53, 0.76]	(0.06)	[0.77, 0.99]
Gender (ref female)	–0.11***	0.89	0.19***	1.21	0.06*	1.07
	(0.03)	[0.84, 0.95]	(0.05)	[1.10, 1.32]	(0.03)	[1.00, 1.13]
Urbanization (ref rural)	–0.19***	0.83	–0.23***	0.79	–0.36***	0.70
	(0.04)	[0.77, 0.89]	(0.05)	[0.72, 0.88]	(0.04)	[0.65, 0.75]
University (ref high school)	0.23***	1.26	0.20***	1.22	0.15***	1.16
	(0.04)	[1.17, 1.36]	(0.05)	[1.10, 1.36]	(0.04)	[1.08, 1.25]
Postgraduate (ref high school)	0.13	1.14	0.48***	1.61	0.12	1.12

	(0.09)	[0.96, 1.36]	(0.11)	[1.29, 2.01]	(0.09)	[0.95, 1.33]
Marginal R^2	0.02		0.02		0.01	
Conditional R^2	0.08		0.06		0.03	

Note. Unstandardized regression coefficients (with standard errors in parentheses) and odds ratios (with 95% confidence intervals) are displayed.

* p < .05. ** p < .01. *** p < .001. Control means not perceived pollution with actual pollution.

Table S5

Sensitivity analysis based on the population with no perceived pollution

	(1) Depression		(2) Anxiety		(3) Stress	
	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]
(Intercept)	0.45***		–1.53***		0.18*	
	(0.11)		(0.11)		(0.08)	
Actual Pollution (Ref Non-polluted)	–0.08	0.92	0.12	1.13	0.07	1.08
	(0.06)	[0.82, 1.03]	(0.08)	[0.96, 1.31]	(0.05)	[0.97, 1.20]
Age 18-59 (ref 12-18)	0.01	1.01	–0.40***	0.67	–0.22***	0.81
	(0.06)	[0.89, 1.14]	(0.08)	[0.57, 0.79]	(0.06)	[0.72, 0.91]
Age ≥60 (ref 12-18)	–0.04	0.96	–0.49***	0.61	–0.11	0.90
	(0.07)	[0.84, 1.09]	(0.09)	[0.51, 0.74]	(0.07)	[0.79, 1.03]
Gender (ref female)	–0.12***	0.88	0.19***	1.21	0.05	1.06
	(0.03)	[0.83, 0.94]	(0.05)	[1.10, 1.33]	(0.03)	[0.99, 1.13]
Urbanization (ref rural)	–0.21***	0.81	–0.29***	0.75	–0.38***	0.68
	(0.04)	[0.75, 0.88]	(0.06)	[0.67, 0.83]	(0.04)	[0.63, 0.73]
University (ref high school)	0.22***	1.25	0.17**	1.19	0.14***	1.15
	(0.04)	[1.16, 1.35]	(0.06)	[1.06, 1.33]	(0.04)	[1.06, 1.24]
Postgraduate (ref high school)	0.11	1.12	0.52***	1.67	0.11	1.12
	(0.09)	[0.93, 1.34]	(0.12)	[1.33, 2.11]	(0.09)	[0.93, 1.33]
Marginal R^2	0.01		0.02		0.01	
Conditional R^2	0.07		0.05		0.03	

Note. Unstandardized regression coefficients (with standard errors in parentheses) and odds ratios (with 95% confidence intervals) are displayed.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table S6

Sensitivity analysis based on the population with perceived pollution

	(1) Depression		(2) Anxiety		(3) Stress	
	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]	Coefficient (SE)	Odds ratio [95% CI]
(Intercept)	0.68*		–1.50***		0.30	
	(0.27)		(0.29)		(0.25)	
Actual Pollution (Ref Non-polluted)	**0.64*****	**1.90**	**0.70*****	**2.01**	**0.37***	**1.45**
	(0.16)	**[1.39, 2.59]**	**(0.17)**	**[1.44, 2.82]**	**(0.15)**	**[1.08, 1.95]**
Age 18-59 (ref 12-18)	–0.11	0.90	–0.52*	0.59	–0.27	0.76
	(0.25)	[0.55, 1.46]	(0.26)	[0.36, 0.98]	(0.23)	[0.48, 1.20]
Age ≥60 (ref 12-18)	–0.10	0.90	–0.17	0.84	–0.44	0.65
	(0.29)	[0.52, 1.58]	(0.30)	[0.47, 1.52]	(0.27)	[0.38, 1.09]
Gender (ref female)	–0.02	0.98	0.17	1.19	0.16	1.18
	(0.13)	[0.76, 1.26]	(0.14)	[0.90, 1.58]	(0.12)	[0.94, 1.48]
Urbanization (ref rural)	–0.12	0.89	0.24	1.27	–0.15	0.86
	(0.14)	[0.68, 1.16]	(0.16)	[0.94, 1.73]	(0.13)	[0.67, 1.10]
University (ref high school)	0.48***	1.61	0.35*	1.42	0.24	1.27
	(0.14)	[1.22, 2.12]	(0.16)	[1.04, 1.92]	(0.13)	[0.99, 1.63]
Postgraduate (ref high school)	0.37	1.45	–0.00	1.00	0.04	1.04
	(0.32)	[0.77, 2.71]	(0.35)	[0.51, 1.97]	(0.28)	[0.60, 1.81]
Marginal R^2	0.05		0.05		0.02	
Conditional R^2	0.07		0.09		0.05	

Note. Unstandardized regression coefficients (with standard errors in parentheses) and odds ratios (with 95% confidence intervals) are displayed.

* $p < .05$. ** $p < .01$. *** $p < .001$.