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Analysis

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Urbanites' mental health undermined by air pollution

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Supplementary Note 1

(1) *Baidu search data and mental health-related queries (MHQs)*

Baidu (www.baidu.com) is a dominant search engine in China, accounting for approximately 70% of the market share in mainland China in 2019. We partner with Baidu to collect all of its search queries and keep the geotagged queries—that is, queries whose users consented to share their location (latitude and longitude) when requesting queries. We select a group of search terms that are related to two common mental health problems—*depression* and *anxiety*—which are defined by World Health Organization (WHO) as follows [1].

- **Depressive disorders:** *are characterized by sadness, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, feelings of tiredness, and poor concentration.*
- **Anxiety disorders:** *refer to a group of mental disorders characterized by feelings of anxiety and fear, including generalised anxiety disorder (GAD), panic disorder, phobias, social anxiety disorder, obsessive-compulsive disorder (OCD) and post-traumatic stress disorder (PTSD).*

As per this description, we identify the keywords used to filter MHQs (Panel A in Supplementary Table 2) following the below processes (Supplementary Fig. 2).

(1) Select a group of English keywords from the definitions of WHO on *depressive disorder* and *anxiety disorder*;

(2) Translate the English keywords into Chinese keywords and then look for synonyms for the Chinese keywords as much as possible through online synonyms tools (e.g., https://hanyu.baidu.com, https://wantwords.net, and https://tool.mingdawoo.com);

(3) Filter the queries including the selected Chinese keywords from Baidu.

(4) Randomly sample 1,000 queries from the above filtered data and manually check whether each of these 1,000 queries is an MHQ or not. If the positive ratio (i.e., the ratio of MHQs) is higher than 90%, we then obtain the final group of keywords; otherwise, we go to Steps (5) and (6) to exclude those keywords with low positive ratios.

(5) Randomly sample 100 queries for each Chinese keyword.

(6) Manually check the positive ratio of each Chinese keyword based on the filtered queries in Step (5). Then, we (i) keep the Chinese keywords with a positive ratio higher than 90%; (ii) remove the Chinese keywords with a positive ratio lower than 10%; (iii) add the prefix for other Chinese keywords to improve the filtering accuracy. Next, turn to Steps (3) and (4) to re-filter the queries and validate the accuracy again.

The exclusive words in set **B** of Supplementary Table 2 are also determined during the processes. When we manually check queries in Step (4), we read each query and identify the exclusive words. For example, a query like "depression pictures (抑郁的图片)" cannot reflect the mental health status of the user. Therefore, to filter out these types of queries, we add the exclusive word "picture (图片)" in set **B**. Other words in set **B** are determined in a similar procedure.

The above processes can ensure the credibility and accuracy of our filtering rules (the positive ratio for the keywords in Supplementary Table 2 is 95.1%). Finally, based on the filtering rule in Equation (1) in the main manuscript and keywords in Supplementary Table 2, we obtain 360 million geotagged search queries related to mental health from 252 cities from 1 March 2019 to 31 December 2019.

(2) *Haodf and online doctor consultation data*

Haodf is a leading online health care platform in China which provides online doctor consultation for patients. On Haodf, patients can communicate with real doctors by online text or telephone, and doctors give advice, diagnosis, and treatment plan for patients. As of October 2021, Haodf has 240,000 registered physicians with more than 74 million patients.

We collect the doctor consultation data in 2019 from Haodf (https://www.haodf.com/opendata /home). To filter mental health-related cases (MHCs), we select typical mental disorders—*depressive disorder, anxiety disorder, disturbed sleep, insomnia, panic disorder, PTSD, and disturbed appetite.* We then aggregate the data to the city level. Given that online consultation cases in small cities are scarce, we select the top 80 cities based on the rank of the total number of online consultations for mental disorders, where the daily average MHCs is higher than one, to avoid the issue of data sparsity. This also can ensure the coverage rate of Haodf on cities' population to some degree. The highest one (i.e., Beijing) has 7,776 consultation cases and the lowest one (i.e., Handan) has 331 cases in 2019. Eventually, we obtain 65,421 MHCs in 80 cities during our sample period.

(3) *Measurement validation*

The internet search engine data provide ample information regarding the interests, concerns, and intentions of users, which enables us the opportunities to evaluate health trends in a local area. For example, Tefft [2] used the public Google Trends (the aggregated search volume of queries over time on specific keywords) to measure mental health and examined the impact of the unemployment rate on people's mental health. Brodeur et al. [3] used Google Trends to measure population well-being and investigated the impact of lockdowns caused by COVID-19 on well-being. Some other studies have utilized the search data to predict the trends of diseases such as dengue [4] and influenza [5]. In the same vein, we utilize the volume of MHQs in a city as a proxy for mental health status of the whole population in that city. We adopt two methods to validate the effectiveness of this measurement.

First, we leverage the real MHCs on Haodf and estimate the association between MHQs on Baidu and MHCs on Haodf. We aggregate the daily MHQs and daily MHCs to weekly-level data considering the data sparsity of Haodf. The Spearman's correlation reveals that the volume of MHQs on Baidu is positively associated with MHCs on Haodf ($\rho = 0.70,\ p < 0.01$, see Fig. 2 in the main manuscript). The R-square of the fitted line in Fig. 2 in the main manuscript is 0.55, suggesting the high interpretation power of MHQs to the variation of MHCs (55%). Moreover, we conduct regressions to examine the relationship between MHQs and MHCs. Since people are more likely to use the online doctor consultation on a day with poor air quality, we controlled for the AQI in the regression. The results in Supplementary Table 1 indicate that MHQs are positively associated with MHCs after including weather controls, AQI, city fixed effects, and week fixed effects. This demonstrates the effectiveness of our measurement.

Second, we use the text of search terms to examine whether or not those typing in the search queries are likely to be experiencing mental health issues. Specifically, we use top-10 frequent queries that are most likely reflect mental health issues (termed as high-MHQs):

- 1. What to do with insomnia ("失眠怎么办");
- 2. Depression self-assessment ("抑郁症自测");
- 3. What to do if I can't sleep ("睡不着怎么办");
- 4. How to fight depressive disorder ("抑郁症怎么治疗");

- 5. How to fight anxiety disorder by myself ("焦虑症的自我治疗");
- 6. Anxiety self-assessment ("焦虑症自测");
- 7. Symptoms of depressive disorder ("抑郁症的表现");
- 8. Symptoms of anxiety disorder ("焦虑症的表现");
- 9. What to do if I'm irritable ("脾气暴躁易怒怎么办");
- 10. What medicine to take for depression ("抑郁症吃什么药").

We calculate the search volume of these high-MHQs in each city and aggregate them to the city-day level. Next, we test the correlation relationship between MHQs and high-MHQs. As shown in Supplementary Fig. 3, we find a highly correlated relationship between MHQs and high-MHQs (Spearman's correlation is 0.90 and $p < 0.01$). The R-square of the fitted line in Supplementary Fig. 3 is 0.78, suggesting the high interpretation power of MHQs to the variation of high-MHQs (78%). This result further demonstrates the effectiveness of our measurement.

Taken together, our measurement can capture the mental health status of the population in a city.

(4) *Summary statistics*

We report summary statistics of mental health, air pollution, and weather variables during our sample period in Supplementary Table 3. The average MHQs is 4,730, where the depression-related queries are 3,547 and the anxiety-related queries are 1,289. The average AQI is 57 with a standard deviation of 34. The average $PM_{2.5}$ concentration is 32 $\mu g/m^3$, which violates the WHO standard of 25 $\mu g/m^3$. Supplementary Figs. 4 and 5 present the daily trends of average AQI and $PM_{2.5}$ in China from 1 March 2019 to 31 December 2019.

Supplementary Note 2

(1) *The short-term effects of air pollution on mental health*

We report the full results of real-time exposure to air pollution on mental health in the first two columns of Supplementary Table 4 (including coefficients of control variables). In Columns (3) and (4), we include the quadratic term of temperature to absorb the non-linear effects of temperature on human mental health. The results are consistent.

In our main manuscript, we mainly focus on the impact of AQI and $PM_{2.5}$, which are the most common factors when analysing the impact of air pollution. In fact, except for $PM_{2.5}$, there are several other criteria pollutants—PM_{10}, SO_2, CO, NO_2, and O_3. These pollutants can also harm human health. In this part, we discuss the effects of these pollutants on human mental health.

Supplementary Table 5 reports the results. We find that SO_2 has a marginal effect on people's mental health (the coefficient is statistically significant at 10% level). $PM_{2.5}$, PM_{10}, NO_2, CO, and O_3 are remarkably associated with mental health. The coefficients suggest that a one standard deviation increase in $PM_{2.5}$, PM_{10}, CO, NO_2, and O_3 results in a 0.0033, 0.0026, 0.0044, 0.0033, and 0.0072 standard deviation increase in MHQs, respectively. According to the Chinese Environment Report [6], $PM_{2.5}$, PM_{10}, and O_3 are primary pollutants and account for 78.8%, 19.8%, and 2.0%, respectively, during the heavily polluted days for 337 major cities in 2019. Therefore, $PM_{2.5}$ has a more extensive effect on people's mental health in China than O_3, even though O_3 has a stronger effect from the perspective of statistics.

(2) *The effects of air pollution versus extreme storm*

We compare the impact of air pollution with an extreme storm—*Typhoon Lekima*, which had the most severe influence in China in 2019. Typhoon Lekima covered nine provinces (i.e., Hebei, Liaoning, Jiling, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, and Shandong), killed 71 people, and caused nationwide damage that brought a loss exceeding RMB 65.37 billion (approximately US$9.26 billion) [7]. Therefore, we examine the effects both of air pollution and the extreme storm on people's mental health. We replace the date fixed effects in Equation (2) in the main manuscript with day-of-month fixed effects and include event dummies, referring to the research by Zheng et al. [8]. Considering that the impact of typhoons on mental health may last for a long time, we analyse the impact within two weeks after the typhoon landed in mainland China.

The results are reported in Supplementary Table 6. We find that both coefficients of AQI and $PM_{2.5}$ are positive and significant. This indicates that a one standard deviation increase in $PM_{2.5}$ concentration (AQI) will increase the volume of MHQs by 0.0067 (0.0077) standard deviation. For the extreme storm, we find that *Typhoon Lekima* has a significantly positive relationship with MHQs. The coefficient of *Typhoon Lekima* in Column (2) indicates that Typhoon Lekima (August 10 to 24) is associated with a 0.0141 standard deviation increase in the search volume of MHQs. While the impact of $PM_{2.5}$ on mental health issues is smaller than the typhoon ($0.0067 < 0.0141$), we should notice that severe air pollution occurs frequently in China, as opposed to extreme storms. During the sample period, 53.0% of cities' daily $PM_{2.5}$ concentrations exceeded the WHO limitation (25 $\mu g/m^3$).

Supplementary Note 3

(1) *Robustness checks I—Instrumental variable*

The formation and dissipation of air pollution are heavily affected by meteorological conditions [9]. We, therefore, construct the instrumental variable (IV)—*neighbour*—by combining the wind direction with the air pollution level of neighbouring areas following prior research [8] (see Methods). The logic is that the wind blows air pollutant emissions from neighbouring regions to the destination city and this brings exogenous variation to the destination city's air pollution [8, 10]. The IV is an ideal instrumental variable as it is unlikely to influence the destination city's social and economic activities, except for varying the city's air pollution. To validate the robustness of the IV estimations, we have conducted additional analyses from the following three different aspects.

a. Check for different weights

In the main manuscript, we first set w_{ijt} in Equation (4) equal to 1 for the upwind direction and 0 otherwise. This means that the city's air quality is determined by air pollution of grids from the dominant wind direction rather than any other direction. The results are reported in Panel A of Supplementary Table 7. Here, we set w_{ijt} as 0.8 for grids in the upwind direction and 0.2 for the other directions (the downwind direction is still excluded). The results are reported in Panel B of Supplementary Table 7. The coefficients of AQI and $PM_{2.5}$ remain statistically significant. We also conduct a series of weak IV tests for the *neighbour* (i.e., Cragg-Donal Wald test, Kleibergen-Paap rk Wald test, and Anderson-Rubin test). All results reject the null hypothesis of the weak instrument.

b. Check for different scopes

When constructing the IV, we exclude the neighbour grid cells within 120 km and outside 300 km from the local city i (i.e., $d_{ij} \in (120, 300]\, km$). Here, we test whether our results still hold when varying the thresholds of neighbour grid cells. We use five different scopes: (100, 300] km, (150, 300] km, and (200, 300] km, (120,400] km, and (120,500] km. The corresponding results are reported in Supplementary Table 8. For all five thresholds, the second stage results are robust; no matter for AQI or $PM_{2.5}$, the coefficients are positive and statistically significant at the 1% level.

c. Check for different data sources

We also use the monitoring station $PM_{2.5}$ data to construct the IV. As the distribution of air quality monitoring stations is relatively sparse, we group 16 wind directions into four 90-degree bins following Deryugina et al. [11] to calculate the IV. Supplementary Table 9 reports the results with different scopes. We find the results in all models are quite similar to those using 16 wind directions and satellite-based $PM_{2.5}$ data. We also group the wind directions into eight 45-degree bins to calculate the IV and re-estimate the effects. The results are reported in Supplementary Table 10. We find that the coefficients of AQI and $PM_{2.5}$ in all scopes remain positive and significant. This indicates that our IV estimations are robust no matter using station-based or satellite-based $PM_{2.5}$ data.

In summary, the IV regression results are stable and robust. This helps us address the potential endogeneity and identify the causal effect of air pollution on people's mental health.

(2) *Robustness checks II—MHQs ratio*

In our baseline regression, we use the natural logarithm of MHQs in a local city as the proxy for the mental health status of people living in that city. Now, we use the ratio of MHQs accounting for all queries in a day to measure mental health (i.e., $MHQs\ ratio = MHQs/Total\ queries$). Panel A of Supplemental Table 11 reports similar results.

(3) *Robustness checks III—Control for day-of-week and season fixed effects*

We include the day-of-week fixed effects and quarter fixed effects to absorb the possible interference from different weekdays and seasons. Panel B of Supplementary Table 11 shows that the results are qualitatively unchanged.

(4) *Robustness checks IV—Removing duplicated queries*

A user might search similar queries in a short time many times. For example, a user might simultaneously search "depression self-assessment," "the symptoms of depression," or "depressive disorder" to learn the depression-related information. To avoid the possible interference of these duplicated queries, we remove duplicated queries of each user in one day. Specifically, we only count an effective query if a user searches many MHQs in one day. In this way, we obtain 76 million MHQs and re-estimate the impact of air pollution on mental health based on Equation (2). The results are quite similar (see Panel C of Supplementary Table 11).

(5) *Robustness checks V—Two-way cluster standard errors*

To account for spatial autocorrelation in pollution, we conduct a robustness check by using a two-way cluster standard error—that is, simultaneously clustering by cities and days. This helps us capture the unspecified correlations between observations for the same city on different days, as well as the unspecified correlations between observations for different cities on the same day. The results are reported in Panel D of Supplementary Table 11. We find that the impact of air pollution (AQI and $PM_{2.5}$) remains positive and significant on MHQs.

(6) *Robustness checks VI—Control for Baidu users*

As the usage ratio of Baidu in different regions may affect MHQs, we conduct a robustness analysis by controlling for *Baidu users* measured by the number of users who used the Baidu search engine on a day in a city. The results are reported in Panel E of Supplementary Table 11. We find that the coefficients of AQI and $PM_{2.5}$ remain significant and positive.

(7) *Robustness checks VII—Weather controls*

We include five weather variables in all our regressions to control for the possible influence of weather conditions on mental health. The weather data are collected from the China Meteorological Data Service Centre, which provides daily meteorological data from 699 meteorological stations. We calculate the distance between each city and all meteorological stations and then use the meteorological data of the nearest station as a proxy for the city weather conditions. However, the nearest meteorological station for a few cities could be distant. To ensure the value of weather conditions from meteorological stations is highly related to the true value of that city, we exclude cities where the distance to the nearest meteorological station is more than 40 km. This causes our sample cities to reduce to 252 from 324.

To ensure that this restriction does not impact our results, we conduct three robustness checks by: (i) removing weather controls; (i) cancelling the restriction; (iii) using different restrictions (e.g., removing cities where the distance is more than 30 km or 50 km). The results are presented in Supplementary Table 12. We find that all coefficients of AQI and $PM_{2.5}$ from Panels A to D are positive and significant, thereby demonstrating the robustness of our results.

(8) *Robustness checks VIII—Placebo test*

We also conduct a placebo test to verify the robustness of our results. Specifically, we use the search volume of exclusive words in Panel B of Supplementary Table 2 as the dependent variable and examine the impact of air pollution on these false search queries. The results are reported in Supplementary Table 13. We find that although the coefficient of AQI is marginally significant (10% level) in Column (1), both AQI and $PM_{2.5}$ are not significant when using IV specifications in Columns (3)-(6). This suggests that our main results are robust to the choices of "irrelevant" words. Air pollution does not impact these false queries.

Supplementary Note 4

(1) *Long-term effects of AQI*

In our main manuscript, we mainly focus on the cumulative effects of $PM_{2.5}$ on mental health. In this part, we report the cumulative effects of air pollution based on the AQI. Similar to $PM_{2.5}$, we estimate the long-term exposure to air pollution measured by the AQI using four windows, i.e., 7-day, 14-day, 30-day, and 60-day. Supplementary Table 23 represents the results. In addition, we also analyse heterogeneous effects of the AQI based on demographic and socioeconomic characteristics. The results of heterogeneous effects with respect to gender, education, age, and marriage are reported in Supplementary Fig. 6 (see details in Supplementary Table 24-27). The results of heterogeneous effects with respect to economic development (GDP per capita), health resources (the number of hospitals), living conditions (the area of green land), and sports facilities (the number of gyms) are reported in Supplementary Fig. 7 (see details in Supplementary Table 28-31). In general, the results are consistent with $PM_{2.5}$.

Supplementary Note 5

(1) *The comparison between depression and anxiety*

In the main manuscript, we find that air pollution has statistically significant impacts on both depression- and anxiety-related queries, but the likelihood of suffering depression is higher for long-term exposure to air pollution. The results might be attributed to the much broader keywords of depression than anxiety. To mitigate this concern, we compare the impact of air pollution on *depression* and *anxiety* based on three groups of specific terms: sadness vs. anxiety, disturbed sleep vs. fear, and depressive disorder vs. anxiety disorder. The results are reported in Supplementary Table 32. We find that the impacts of long-term exposure to air pollution on depression-related queries remain higher than anxiety-related queries (0.0192 vs. 0.0142 in Panel A, 0.0210 vs. 0.0092 in Panel B, and 0.0097 vs. 0.0012 in Panel C). Therefore, the results further demonstrate that the likelihood of suffering depression is higher for long-term exposure to air pollution.

Supplementary Note 6

(1) *Exploring the impact of specific keywords*

We first classify all selected keywords into two types: symptom-related keywords (i.e., sadness, loss of pleasure or interest, guilt of low self-worth, disturbed sleep, disturbed appetite, tiredness, anxiety, and fear) and disease-related keywords (i.e., depressive disorder, anxiety disorder, panic disorder, phobias, social anxiety disorder, obsessive-compulsive disorder, post-traumatic stress disorder). We re-run our main regressions using the two types of queries. The results are reported in Supplementary Table 33. We find that the transitory exposure to air pollution significantly impacts symptom-related queries (Column (1) in Panel A), but not disease-related queries (Column (1) in Panel B). The long-term exposure to air pollution leads to significant increases in both symptom- and disease-related queries (see Columns (2)–(5) in Supplementary Table 33). The results indicate that short-term exposure to air pollution can induce symptoms of mental issues, but long-term exposure leads to severe mental illnesses, such as depressive disorder.

Further, we investigate the impact of air pollution on MHQs based on the search volume of each keyword. Supplementary Table 34 report the results. We find that the increase of MHQs as the exposure to air pollution is mainly derived from the queries that are related to: symptoms-related keywords—*sadness*, *disturbed sleep*, *tiredness*, *anxiety*, and *fear*, and disease-related keywords—*depressive disorder* and *anxiety disorder*. The findings suggest that the selected keywords used to filter out MHQs are effective and related to mental health. This also further convinces us that air pollution undermines the public's mental health—that is, inducing mental health-related symptoms and leading to mental illnesses.

References

[1] World Health Organization. Depression and other common mental disorders: Global health estimates. *World Health Organization* (2017).

[2] Tefft, N. Insights on unemployment, unemployment insurance, and mental health. *J. Heal. Econ.* **30**, 258–264 (2011).

[3] Brodeur, A., Clark, A. E., Fleche, S. & Powdthavee, N. Covid-19, lockdowns and well-being: Evidence from Google trends. *J. Public Econ.* **193**, 104346 (2021).

[4] Liu, K. et al. Using Baidu search index to predict Dengue outbreak in China. *Sci. Reports* **6**, 1–9 (2016).

[5] Ginsberg, J. et al. Detecting influenza epidemics using search engine query data. *Nature* **457**, 1012–1014 (2009).

[6] *Chinese Environment Report (2019).* https://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/202006/P020200602509464172096.pdf. (Accessed 6 June 2022).

[7] *China Climate Bulletin (2019).* http://zwgk.cma.gov.cn/zfxxgk/gknr/qxbg/202102/t20210224_2756250.html. (Accessed 6 June 2022).

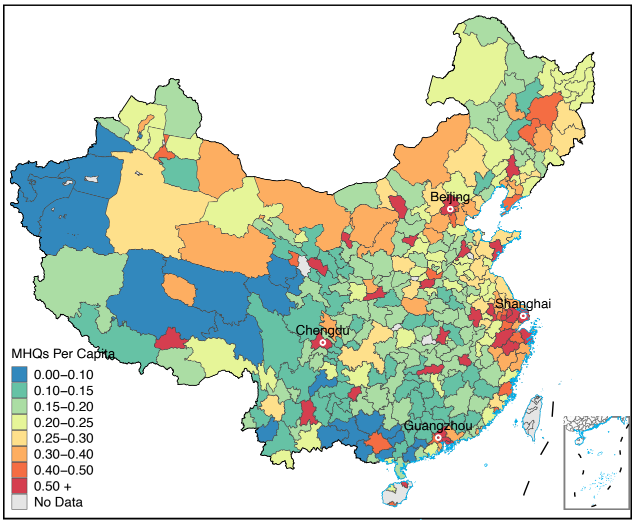
[8] Zheng, S., Wang, J., Sun, C., Zhang, X. & Kahn, M. E. Air pollution lowers Chinese urbanites' expressed happiness on social media. *Nat. Hum. Behav.* **3**, 237–243 (2019).

[9] Arain, M. et al. The use of wind fields in a land use regression model to predict air pollution concentrations for health exposure studies. *Atmospheric Environ.* **41**, 3453–3464 (2007).

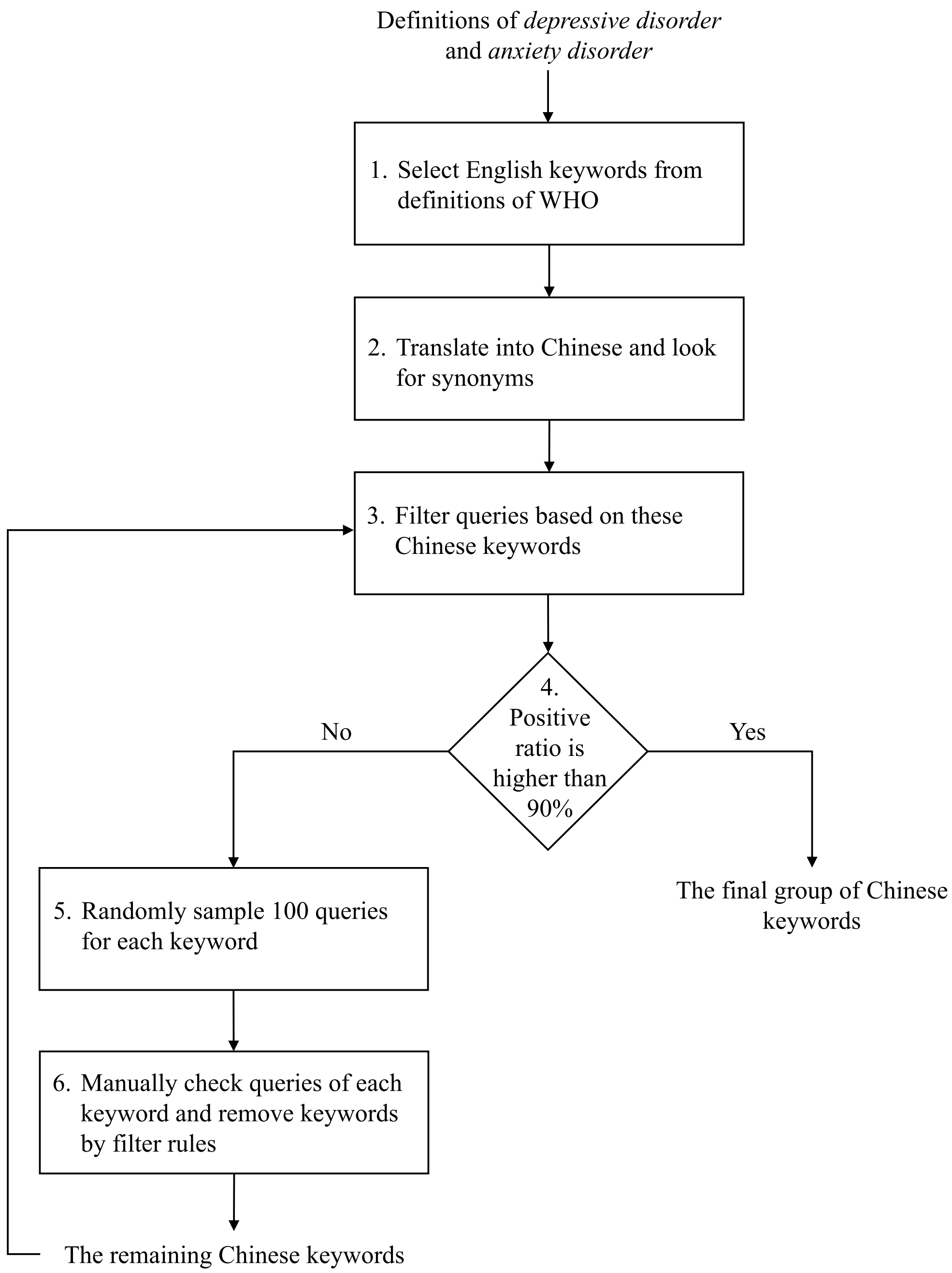
[10] Zhang, Q. et al. Transboundary health impacts of transported global air pollution and international trade. *Nature* **543**, 705–709 (2017).

[11] Deryugina, T., Heutel, G., Miller, N. H., Molitor, D., & Reif, J. The mortality and medical costs of air pollution: Evidence from changes in wind direction. *Am. Econ. Rev.* **109**, 4178-4219 (2019).

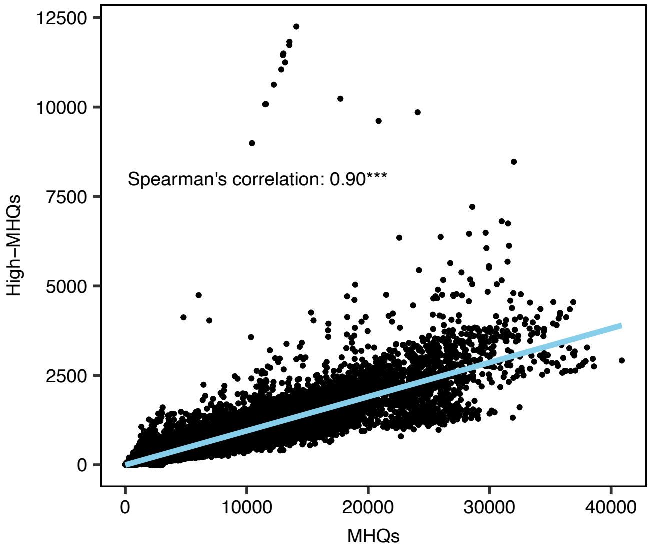
Supplementary Figures



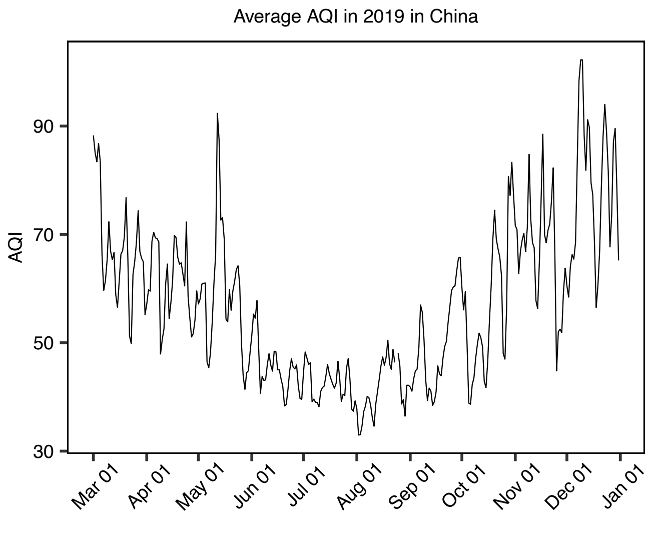
Supplementary Fig. 1. The density distribution of MHQs per capita in China. The spatial distribution of geotagged search queries about mental health on Baidu. Four major cities are marked—Beijing, Shanghai, Guangzhou, and Chengdu.



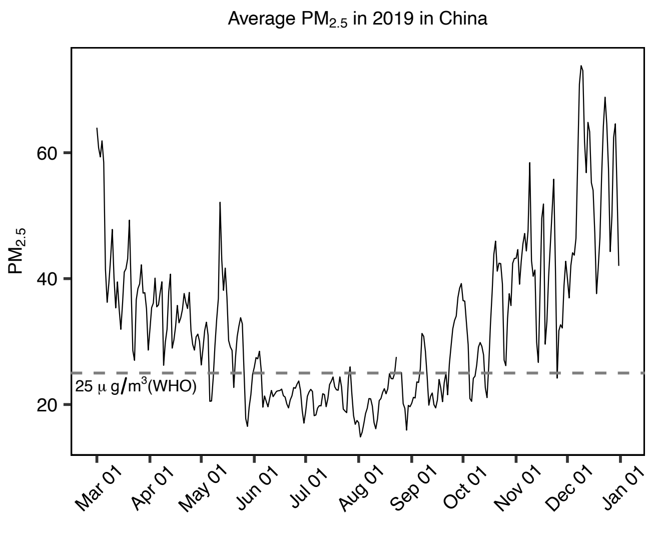
Supplementary Fig. 2. The processes of determining keywords.



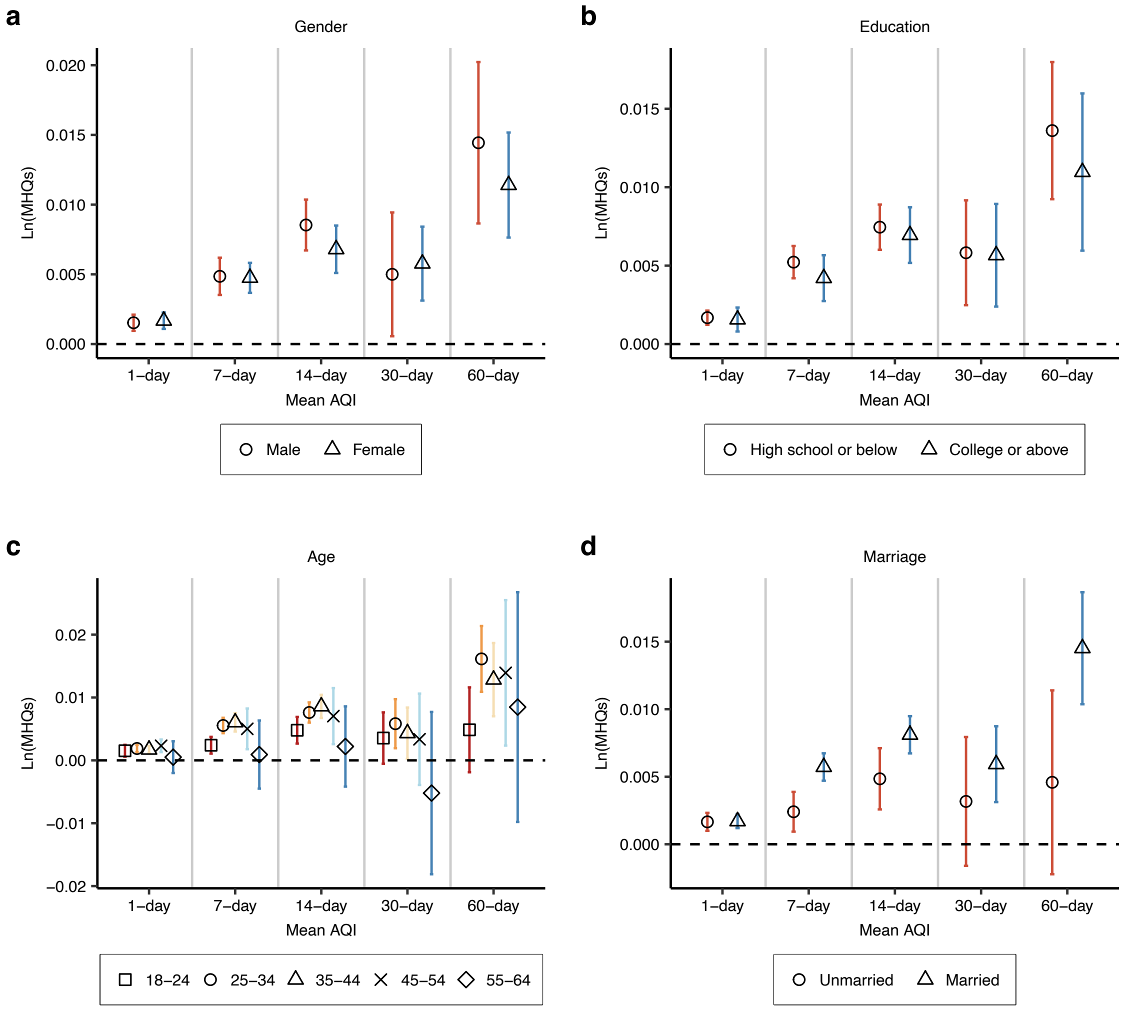
Supplementary Fig. 3. The correlation between MHQs and High-MHQs. Each dot in the figure represents the daily city value of MHQs and High-MHQs. The blue line is the linear fitted of these dots ($R^2 = 0.78$), and the grey error band depicts the 95% confidence interval. $^{***}p < 0.001$ (two-sided test).



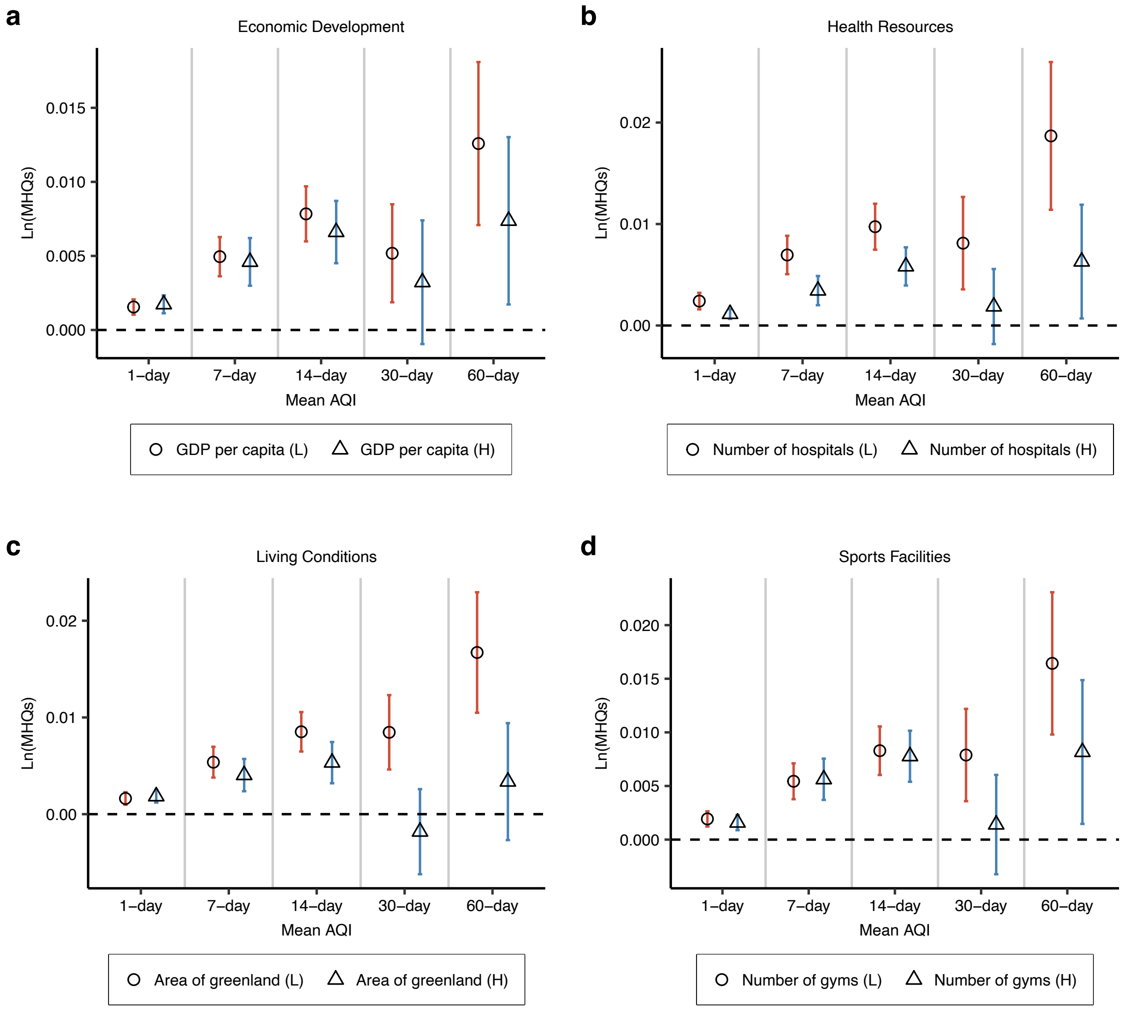
Supplementary Fig. 4. Daily AQI in China. 1 March 2019 – 31 December 2019.



Supplementary Fig. 5. Daily $PM_{2.5}$ in China, 1 March 2019 – 31 December 2019



Supplementary Fig. 6. The heterogeneous effects on mental health by gender, education, age, and marriage (AQI). The points represent the estimated coefficients of the cumulative effects of AQI (i.e., $\frac{1}{k}\sum_{n=0}^{k-1}$ AQI) from Supplementary Tables 24-27; the error bars depict 95% confidence intervals. **a**, The heterogeneous effects of AQI on mental health for the male subsample (N = 75,758) and female subsample (N = 75,787). **b**, The heterogeneous effects of AQI on mental health for the high school or below subsample (N = 75,772) and the college or above subsample (N = 75,775). **c**, The heterogeneous effects of AQI on mental health for different age cohorts—18-24 (N = 75,727), 25-34 (N = 75,757), 35-44 (N = 75,578), 45-44 (N = 74,676), and 55-64 (N = 59,142). **d**, The heterogeneous effects of $PM_{2.5}$ on mental health for the married group (N = 75,793) and unmarried groups (N = 75,701).



Supplementary Fig. 7. The heterogeneous effects on mental health by economic development, health resources, living conditions, and cultural and sports facilities (AQI). The points represent the estimated coefficients of the cumulative effects of AQI (i.e., $\frac{1}{k}\sum_{n=0}^{k-1}$ AQI) from Supplementary Table 28-31; the error bars depict 95% confidence intervals. We used the median values to separate the high (H) group from the low (L) group for each pair of heterogeneity analyses. **a**, The heterogeneous effects of economic development measured by GDP per capita (N = 35,068 for the H subsample, N = 34,675 for the L subsample). **b**, The heterogeneous effects of health resources measured by the number of hospitals (N = 32,976 for the H subsample, N = 32,541 for the L subsample). **c**, The heterogeneous effects of living conditions measured by the areas of green land (N = 32,356 for the H subsample, N = 32,243 for the L subsample). **d**, The heterogeneous effects of cultural and sports facilities measured by the number of gyms (N = 29,330 for the H subsample, N = 28,919 for the L subsample).

Supplementary Tables

Supplementary Table 1. The relationship between MHQs and MHCs

Dependent variable	Ln(MHCs + 1)	Ln(MHCs + 1)
	(1)	(2)
Ln(MHQs)	0.482***	0.112**
	(0.000)	(0.036)
AQI	0.001***	0.000
	(0.000)	(0.642)
Controls	✓	✓
City fixed effects	✓	✓
Week fixed effects		✓
Observations	3,101	3,101
Adjusted R^2	0.76	0.82

The table reports the regression results by employing OLS. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 2. The selected terms to filter MHQs

		Panel A. Set **A**	
Depression	Symptoms	Sadness (lower mood)	压抑、抑郁、忧郁、[心情/心里/心理]*郁闷、[心情/心里/心理]*失落、[心情/心里/心理/情绪]*低落
		Loss of pleasure or interest	[心情/心里/心理]*烦闷、心烦意乱
		Guilt or low self-worth	无助、[生活/人生]*无奈、对*绝望、前景暗淡、[心态/情绪/精神/间歇性]*崩溃
		Disturbed sleep	失眠、睡眠障碍、睡不着
		Disturbed appetite	饮食障碍、食欲不振、厌食、暴食、饮食失调
		Tiredness	感到疲倦、无力疲倦、身心疲惫、乏困、没精神、没有精神
	Diseases	Depressive disorder	抑郁症
Anxiety	Symptoms	Anxiety	焦虑、烦躁、焦躁、易怒、[脾气/情绪/心情]*暴躁
		Fear	[心情/心里/心理]*恐惧、心慌
	Diseases	Anxiety disorder	焦虑症
		Panic disorder	惊恐障碍、恐慌症、惊恐性障碍
		Phobias	恐怖症、恐惧症
		Social anxiety disorder	社会交流障碍、社会焦虑症
		Obsessive-compulsive disorder	强迫症、OCD
		Post-traumatic stress disorder	创伤后精神紧张性障碍、创伤后应激障碍、PTSD
		Panel B. Set **B**	
Exclusive words		Word, sentence, phrase, paragraph, article, poetry, idiom, and fiction	说说、句子、造句、文章、文言文、古文、诗、片段、短语、成语、短句、作文、小说、全文、语句、话
		English, Japanese, translation	英语、翻译、英文、日语
		Figure, movie, music, and video	图片、壁纸、配图、电影、视频、歌、曲、图
		Emoji, signature, and screen-name	表情包、签名、网名
		Animals such as cat, dog, fish, etc.	动物、猫、狗、金毛、泰迪、莎莫耶、哈士奇、鸡、鸭、鱼、兔、羊、鼠、牛、鸽子、鹦鹉、猪、蜥、马
		Others	近义词、反义词、下载、txt、漫画、百度云、免费阅读、系列、上一句、下一句、上句、下句、读后感、读音、拼音、意思、答案、生肖、雪莉、热依扎、具荷拉、杨阳、演员、明星、歌星

Note: To obtain MHQs from all daily search queries of Baidu users, each phrase or word in third column of the above table are translated into Chinese, and we then select a series of synonyms or abbreviations of these Chinese words as our filtering keywords for MHQs. The whole keywords in Set **A** consists of two types of terms: symptom-related keywords and disease-related keywords.

Supplementary Table 3. Variable definitions and summary statistics

Variables	Definitions	N	Mean	S.D.	Min	Max
Panel A. Mental Health						
MHQs	The volume of mental health-related queries on Baidu search engine	76052	4729.97	7440.27	6	167798
Ln(MHQs)	The natural logarithm of mental health-related queries on Baidu search engine	76052	7.75	1.21	1.80	12.00
MHCs	The mental health-related consultations on Haodf.com	24400	2.70	3.95	0.00	49.00
Ln(MHQs of Depression)	The natural logarithm of depressive disorders-related queries on Baidu search engine	70316	7.45	1.21	0.693	12
Ln(MHQs of Anxiety)	The natural logarithm of anxiety disorders-related queries on Baidu	70280	6.39	1.28	0.00	9.97
Panel B. Air Pollution						
AQI	Daily air quality index/10	76052	5.66	3.44	0.78	50.00
$PM_{2.5}$	Daily mean value of $PM_{2.5}$ concentration ($10\mu g/m^3$)	76052	3.22	2.63	0.19	134.90
Panel C. Weather Conditions						
Temperature	Mean temperature ($^\circ C$)	76052	17.00	9.66	-30.70	35.2
Wind Speed	Mean wind speed (m/s)	76052	2.17	1.14	0.00	18.50
Sunshine	Mean sunshine (hours)	76052	5.85	4.15	0.00	15.60
Precipitation	Total number of rain fall (mm)	76052	2.79	9.82	0.00	289.10
Humidity	Mean of relative humidity (1%)	76052	67.20	19.10	5.00	100.00

Supplementary Table 4. The short-term impact of air pollution on mental health

Dependent variable	Ln(MHQs)	Ln(MHQs)	Ln(MHQs)	Ln(MHQs)
	(1)	(2)	(3)	(4)
AQI	0.0016***		0.0013***	
	(0.0000)		(0.0000)	
$PM_{2.5}$		0.0015***		0.0011***
		(0.0008)		(0.0065)
Temperature	0.0059***	0.0060***	0.0024***	0.0025***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Temperature^2			0.0001***	0.0001***
			(0.0000)	(0.0000)
Wind speed	-0.0005	-0.0005	-0.0002	-0.0002
	(0.3975)	(0.4365)	(0.7827)	(0.7871)
Sunshine	-0.0024***	-0.0024***	-0.0029***	-0.0029***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Precipitation	0.00008	0.00007	0.00015***	0.0001**
	(0.1785)	(0.2359)	(0.0082)	(0.0128)
Humidity	0.0525***	0.0489***	0.0585***	0.0561***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Controls	✓	✓	✓	✓
City-month fixed effects	✓	✓	✓	✓
Date fixed effects	✓	✓	✓	✓
Observations	76,052	76,052	76,052	76,052
Adjusted R^2	0.99	0.99	0.99	0.99

The table reports the regression results by employing OLS. Control variables include daily mean temperature, total number of sunshine hours, mean humidity, total precipitation, and mean wind speed. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 5. Impact of different air pollutants

	$PM_{2.5}$ (1)	PM_{10} (2)	SO_2 (3)	CO (4)	NO_2 (5)	O_3 (6)
The effects on Ln(MHQs)	0.0015***	0.00052**	0.0028*	0.00017***	0.0027***	0.0028***
	(0.0008)	(0.0468)	(0.0729)	(0.0000)	(0.0002)	(0.0000)
Adjusted R^2	0.99	0.99	0.99	0.99	0.99	0.99
Observations	76,052	76,046	76,051	76,049	76,051	76,049

The table reports the regression results by employing OLS, where *AirPollution* is measured by $PM_{2.5}$, PM_{10}, SO_2, CO, NO_2, and O_3. All regressions in this table include control variables, city-month fixed effects, and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 6. Impact of air pollution and an extreme storm

Dependent variable	Ln(MHQs) (1)	Ln(MHQs) (2)
AQI	0.0027***	
	(0.0000)	
$PM_{2.5}$		0.0031***
		(0.0000)
Typhoon Lekima	0.0171***	0.0172***
(August 10 to 24)	(0.0072)	(0.0071)
Controls	✓	✓
City-month fixed effects	✓	✓
Day-of-month fixed effects	✓	✓
Observations	76,052	76,052
Adjusted R^2	0.99	0.99

The table reports the regression results by employing OLS. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 7. The instrumental estimated of air pollution on mental health, grid scope: (120,300] km

Dependent variable	AQI	Ln(MHQs)	$PM_{2.5}$	Ln(MHQs)
	Stage 1	Stage 2	Stage 1	Stage 2
Panel A. $w_{ijt} = 1$				
AQI		0.0042***		
		(0.0000)		
$PM_{2.5}$				0.0050***
				(0.0000)
Neighbour	0.0525***		0.0446***	
	(0.0000)		(0.0000)	
Observations	71,404	71,404	71,404	71,404
Adjusted R^2	0.57	0.99	0.56	0.99
Joint test of excluded instruments:	$F(1,245) =$ 802.91, Prob>F=0.00		$F(1,245) =$ 840.70, Prob>F=0.00	
Weak IV tests:				
Cragg-Donald Wald F statistic	6781.59		8057.71	
Kleibergen-Paap Wald rk F statistic	802.91		840.70	
Anderson-Rubin Wald test	34.04		34.04	
Panel B. $w_{ijt} = 0.8$				
AQI		0.0038***		
		(0.0000)		
$PM_{2.5}$				0.0045***
				(0.0000)
Neighbour	0.4668***		0.3914***	
	(0.0000)		(0.0000)	
Observations	74,244	74,244	74,244	74,244
Adjusted R^2	0.63	0.99	0.62	0.99
Joint test of excluded instruments:	$F(1,245) =$ 1434.97, Prob>F=0.00		$F(1,245) =$ 1388.78, Prob>F=0.00	
Weak IV tests:				
Cragg-Donald Wald F statistic	19152.75		22710.97	
Kleibergen-Paap Wald rk F statistic	1434.97		1388.78	
Anderson-Rubin Wald test	50.52		50.52	

The table reports the regression results by employing 2SLS. All regressions in this table include control variables, city-month fixed effects, and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 8. Robustness check of different distance thresholds in IV

	(100,300] km	(120,300] km	(150,300] km	(200,300] km	(120,400] km	(120,500] km
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A. AQI			
2^{nd} stage: AQI	0.0041***	0.0042***	0.0045***	0.0049***	0.0049***	0.0059***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	71,717	71,404	70,789	69,053	71,577	71,752
1^{st} stage: Neighbour	0.0549***	0.0525***	0.0487***	0.0423***	0.0449***	0.0376***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
			Panel B. $PM_{2.5}$			
2^{nd} stage: $PM_{2.5}$	0.0049***	0.0050***	0.0053***	0.0057***	0.0057***	0.0069***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	71,717	71,404	70,789	69,053	71,577	71,752
1^{st} stage: Neighbour	0.0467***	0.0446***	0.0415***	0.0360***	0.0383***	0.0321***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

The table reports the regression results by employing 2SLS. All regressions in this table include the control variables, city-month fixed effects, and data fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 9. IV construction using station-based $PM_{2.5}$ data and four 90-degree bins of wind direction

	(100,300] km	(120,300] km	(150,300] km	(200,300] km	(120,400] km	(120,500] km
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A. AQI			
2^{nd} stage: AQI	0.0030***	0.0030***	0.0027***	0.0030***	0.0025***	0.0031***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0003)	(0.0000)
Observations	70,981	66,222	66,186	63,298	68,534	70,900
1^{st} stage: Neighbour	0.0551***	0.0698***	0.0637***	0.0565***	0.0631***	0.0534***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
			Panel B. $PM_{2.5}$			
2^{nd} stage: $PM_{2.5}$	0.0038***	0.0038***	0.0033***	0.0037***	0.0031***	0.0039***
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0005)	(0.0000)
Observations	70,981	66,222	66,186	63,298	68,534	70,900
1^{st} stage: Neighbour	0.0439***	0.0549***	0.0517***	0.0461***	0.0515***	0.0425***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

The table reports the regression results by employing 2SLS. All regressions in this table include control variables, city-month fixed effects, and data fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 10. IV construction using station-based $PM_{2.5}$ data and eight 45-degree bins of wind direction

	(100,300] km	(120,300] km	(150,300] km	(200,300] km	(120,400] km	(120,500] km
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A. AQI			
2^{nd} stage: AQI	0.0033***	0.0029***	0.0033***	0.0035***	0.0031***	0.0035***
	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
Observations	60,464	59,515	57,958	52,348	64,394	66,668
1^{st} stage: Neighbour	0.0550***	0.0567***	0.0501***	0.0443***	0.0511***	0.0421***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
			Panel B. $PM_{2.5}$			
2^{nd} stage: $PM_{2.5}$	0.0041***	0.0035***	0.0041***	0.0043***	0.0039***	0.0043***
	(0.0000)	(0.0002)	(0.0000)	(0.0001)	(0.0001)	(0.0002)
Observations	60,464	59,515	57,958	52,348	64,394	66,668
1^{st} stage: Neighbour	0.0444***	0.0461***	0.0404***	0.0360***	0.0408***	0.0344***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

The table reports the regression results by employing 2SLS. All regressions in this table include control variables, city-month fixed effects, and data fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 11. Robustness checks II-VI

Panel A. Using MHQs ratio to replace Ln(MHQs)		
AQI	0.00012***	
	(0.0000)	
$PM_{2.5}$		0.00011***
		(0.0032)
Observations	76,052	76,052
Panel B. Including day-of-week and quarter fixed effects		
AQI	0.0016***	
	(0.0000)	
$PM_{2.5}$		0.0015***
		(0.0008)
Observations	76,052	76,052
Panel C. Removing duplicated queries		
AQI	0.0017***	
	(0.0000)	
$PM_{2.5}$		0.0018***
		(0.0000)
Observations	76,052	76,052
Panel D. Two-way cluster standard errors		
AQI	0.0016***	
	(0.0001)	
$PM_{2.5}$		0.0015**
		(0.0102)
Observations	76,052	76,052
Panel E. Control for Baidu users		
AQI	0.0016***	
	(0.0000)	
$PM_{2.5}$		0.0015**
		(0.0011)
Ln(Baidu users)	0.6500***	0.6500***
	(0.0000)	(0.0000)
Observations	76,052	76,052

The table reports the regression results by employing OLS. All regressions in the above table include controls, city-month fixed effect, date fixed effects. Robust standard errors are clustered at the city level, except for Panel D. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 12. Robustness checks VII—Weather controls

Panel A.Removing Weather Controls		
AQI	0.0025***	
	(0.0000)	
$PM_{2.5}$		0.00032***
		(0.0000)
Controls	–	–
Observations	97,673	97,673
Cities	324	324
Panel B. Cancel the Restrictions		
AQI	0.0017***	
	(0.0000)	
$PM_{2.5}$		0.0017***
		(0.0000)
Controls	✓	✓
Observations	97,673	97,673
Cities	324	324
Panel C. Removing Distance More Than 30 km		
AQI	0.0015***	
	(0.0000)	
$PM_{2.5}$		0.0014***
		(0.0018)
Controls	✓	✓
Observations	69,395	69,395
Cities	230	230
Panel D. Removing Distance More Than 50 km		
AQI	0.0015***	
	(0.0000)	
$PM_{2.5}$		0.0015***
		(0.0003)
Controls	✓	✓
Observations	84,229	84,229
Cities	279	279

The table reports the regression results by employing OLS. All regressions in the above table include city-month fixed effect and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 13. Robustness checks VIII—Placebo test

Dependent variable: Ln(False Queries)	OLS		IV $d_{ij} \in (120, 300]\,km$		IV $d_{ij} \in (120, 500]\,km$	
	(1)	(2)	(3)	(4)	(5)	(6)
AQI	0.00022*		-0.00005		0.0008	
	(0.0785)		(0.8998)		(0.1764)	
$PM_{2.5}$		0.00017		-0.00006		0.0009
		(0.3017)		(0.8998)		(0.1759)
Controls	✓	✓	✓	✓	✓	✓
City-month fixed effects	✓	✓	✓	✓	✓	✓
Date fixed effects	✓	✓	✓	✓	✓	✓
Observations	75,899	75,899	71,251	71,251	71,599	71,599
Adjusted R^2	0.99	0.99	0.99	0.99	0.99	0.99

Columns (1) and (2) present the regression results by employing OLS on Equation 2. Columns (3)–(6) present the second-stage regression results by employing 2SLS on Equation 2, where the IV is *neighbour*. Here, d_{ij} is the distance between city i and grid j; $w_{ijt} = 1.0$ when calculating the IV (see details in Methods and Supplementary Note 3). Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 14. Heterogeneous effects of air pollution on mental health by gender

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Male Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0077***	0.0115***	0.0140***	0.0207***
		(0.0000)	(0.0000)	(0.0002)	(0.0000)
$PM_{2.5}$	0.0016***	-0.0004	0.0003	0.0011**	0.0011**
	(0.0006)	(0.4279)	(0.5034)	(0.0442)	(0.0149)
Observations	75,758	75,758	75,758	75,758	75,758
Panel B. Female Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0050***	0.0080***	0.0081***	0.0133***
		(0.0002)	(0.0000)	(0.0000)	(0.0000)
$PM_{2.5}$	0.0015**	0.0002	0.0006	0.0012*	0.0012*
	(0.0180)	(0.7013)	(0.2299)	(0.0585)	(0.0568)
Observations	75,787	75,787	75,787	75,787	75,787
Panel C. Gender Differences					
Chow test (F value)	0.84	22.31***	18.17***	23.87***	30.28***

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 15. Heterogeneous effects of air pollution on mental health by education

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. High School or Below Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0067***	0.0093***	0.105***	0.0152***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
$PM_{2.5}$	0.0017***	-0.00004	0.0007*	0.0013***	0.0014***
	(0.0000)	(0.9286)	(0.0629)	(0.0042)	(0.0005)
Observations	75,772	75,772	75,772	75,772	75,772
Panel B. College or Above Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0051***	0.0087***	0.0103***	0.0155***
		(0.0003)	(0.0000)	(0.0000)	(0.0000)
$PM_{2.5}$	0.0013*	-0.00005	0.0003	0.0009	0.0009
	(0.0963)	(0.9339)	(0.6491)	(0.2619)	(0.2420)
Observations	75,775	75,775	75,775	75,775	75,775
Panel C. Education Differences					
Chow test (F value)	0.07	0.04	0.28	0.07	2.96*

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 16. Heterogeneous effects of air pollution on mental health by age

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. 18-24					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0037***	0.0069***	0.0080**	0.0108**
		(0.0000)	(0.0000)	(0.0088)	(0.0311)
$PM_{2.5}$	0.0013	0.0004	0.0005	0.0010	0.0011
	(0.1601)	(0.7166)	(0.5699)	(0.3144)	(0.2781)
Observations	75,727	75,727	75,727	75,727	75,727
Panel B. 25-34					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0068***	0.0092***	0.0090***	0.0189***
		(0.0000)	(0.0000)	(0.0002)	(0.0000)
$PM_{2.5}$	0.0020***	0.00008	0.0009**	0.0016***	0.0015***
	(0.0001)	(0.8763)	(0.0333)	(0.0024)	(0.0028)
Observations	75,757	75,757	75,757	75,757	75,757
Panel C. 35-44					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0064***	0.0105***	0.0092***	0.0145***
		(0.0000)	(0.0000)	(0.0016)	(0.0004)
$PM_{2.5}$	0.0017***	-0.00001	0.0005	0.0013**	0.0013**
	(0.0005)	(0.9779)	(0.3164)	(0.0127)	(0.0057)
Observations	75,578	75,578	75,578	75,578	75,578
Panel D. 45-54					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0059**	0.0081**	0.0090	0.0121
		(0.0480)	(0.0417)	(0.1185)	(0.1748)
$PM_{2.5}$	0.0022***	0.0006	0.0012	0.0018**	0.0019**
	(0.0027)	(0.5709)	(0.1685)	(0.0177)	(0.0120)
Observations	74,676	74,676	74,676	74,676	74,676
Panel E. 55-64					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		-0.0009	0.0038	0.0006	0.0130
		(0.8227)	(0.3997)	(0.9564)	(0.3217)
$PM_{2.5}$	0.0004	0.0006	-0.000005	0.0004	0.0001
	(0.8433)	(0.7875)	(0.9982)	(0.8526)	(0.9467)
Observations	59,142	59,142	59,142	59,142	59,142
Panel F. Age Differences					
Chow test (F value)	3.94***	4.07***	5.41***	8.60***	12.76***

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 17. Heterogeneous effects of air pollution on mental health by marriage

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Unmarried Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0035***	0.0067***	0.0075***	0.0081*
		(0.0001)	(0.0002)	(0.0089)	(0.0720)
$PM_{2.5}$	0.0019***	0.0009	0.0011*	0.0016**	0.0017**
	(0.0081)	(0.1697)	(0.0732)	(0.0339)	(0.0187)
Observations	75,701	75,701	75,701	75,701	75,701
Panel B. Married Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0067***	0.0097***	0.0100***	0.0170***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
$PM_{2.5}$	0.0015***	-0.0003	0.0004	0.0011*	0.0011*
	(0.0097)	(0.5308)	(0.4304)	(0.0655)	(0.0519)
Observations	75,793	75,793	75,793	75,793	75,793
Panel C. Marriage Differences					
Chow test (F value)	9.13***	19.65***	18.70***	19.49***	26.68***

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 18. Heterogeneous effects of air pollution on mental health by economic development

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. GDP Per Capita (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0070***	0.0111***	0.0102***	0.0157***
		(0.0000)	(0.0000)	(0.0001)	(0.0001)
$PM_{2.5}$	0.0019***	0.0001	0.0006	0.0015***	0.0015***
	(0.0000)	(0.7866)	(0.1228)	(0.0006)	(0.0004)
Observations	35,068	35,068	35,068	35,068	35,068
Panel B. GDP Per Capita (High)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0060***	0.0090***	0.0063**	0.0117***
		(0.0001)	(0.0000)	(0.0442)	(0.0068)
$PM_{2.5}$	0.0018***	0.0004	0.0009**	0.0016***	0.0016***
	(0.0001)	(0.2634)	(0.0401)	(0.0006)	(0.0007)
Observations	34,675	34,675	34,675	34,675	34,675
Panel C. High and Low Differences					
Chow test (F value)	0.03	1.16	1.68	2.51*	3.65**

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we do not include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 19. Heterogeneous effects of air pollution on mental health by health resources

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Number of Hospitals (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0090***	0.0128***	0.0121***	0.0207***
		(0.0000)	(0.0000)	(0.0006)	(0.0001)
$PM_{2.5}$	0.0029***	0.0007	0.0015**	0.0025***	0.0025***
	(0.0000)	(0.1870)	(0.0108)	(0.0001)	(0.0001)
Observations	32,976	32,976	32,976	32,976	32,976
Panel B. Number of Hospitals (High)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0046***	0.0083***	0.0064**	0.0113***
		(0.0000)	(0.0000)	(0.0221)	(0.0057)
$PM_{2.5}$	0.0012***	0.0001	0.0003	0.0010**	0.0009**
	(0.0027)	(0.7823)	(0.4223)	(0.0152)	(0.0160)
Observations	32,541	32,541	32,541	32,541	32,541
Panel C.High and Low Differences					
Chow test (F value)	5.18**	4.68**	7.53***	10.31***	18.46***

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we do not include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 20. Heterogeneous effects of air pollution on mental health by living conditions

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Area of Green Land (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0073***	0.0117***	0.0138***	0.0200***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
$PM_{2.5}$	0.0022***	0.0004	0.0009*	0.0017***	0.0017***
	(0.0001)	(0.4399)	(0.0821)	(0.0028)	(0.0022)
Observations	32,356	32,356	32,356	32,356	32,356
Panel B. Area of Green Land (High)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0053***	0.0076***	0.0018	0.0069
		(0.0000)	(0.0000)	(0.5833)	(0.1211)
$PM_{2.5}$	0.0019***	0.0006	0.0010**	0.0018***	0.0017***
	(0.0001)	(0.1573)	(0.0172)	(0.0001)	(0.0002)
Observations	32,243	32,243	32,243	32,243	32,243
Panel C. High and Low Differences					
Chow test (F value)	0.15	1.80	4.28**	5.92***	8.11***

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we do not include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 21. Heterogeneous effects of air pollution on mental health by sports facilities

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Number of Gyms (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0076***	0.0120***	0.0135***	0.0200***
		(0.0000)	(0.0000)	(0.0002)	(0.0000)
$PM_{2.5}$	0.0024***	0.0006	0.0011*	0.0019***	0.0018***
	(0.0001)	(0.3083)	(0.0526)	(0.0018)	(0.0019)
Observations	29,330	29,330	29,330	29,330	29,330
Panel B. Number of Gyms (High)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0070***	0.0098***	0.0054*	0.0124**
		(0.0000)	(0.0000)	(0.0853)	(0.0144)
$PM_{2.5}$	0.0016***	-0.0001	0.0005	0.0014***	0.0014**
	(0.0023)	(0.8827)	(0.3466)	(0.0090)	(0.0120)
Observations	28,919	28,919	28,919	28,919	28,919
Panel C. High and Low Differences					
Chow test (F value)	3.84*	2.62*	3.77**	5.08***	6.02***

The table reports the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we do not include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 22. Effects of air pollution on mental health by disease classification

	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Dependent variable: Ln(MHQs of Depression)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0060***	0.0095***	0.0103***	0.0159***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
$PM_{2.5}$	0.0017***	0.00007	0.0006	0.0013**	0.0013***
	(0.0003)	(0.8582)	(0.1088)	(0.0101)	(0.0075)
Observations	70,316	70,316	70,316	70,316	70,316
Panel B. Dependent variable: Ln(MHQs of Anxiety)					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$		0.0062***	0.0079***	0.0087***	0.0066**
		(0.0000)	(0.0000)	(0.0001)	(0.0477)
$PM_{2.5}$	0.0014***	-0.0003	0.0005	0.0011*	0.0012**
	(0.0003)	(0.6271)	(0.3038)	(0.0527)	(0.0147)
Observations	70,280	70,280	70,280	70,280	70,280

The table reports the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 23. AQI—Long-term effects of air pollution on mental health

Dependent variable: Ln(MHQs)	7-day	14-day	30-day	60-day
	(1)	(2)	(3)	(4)
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI	0.0049***	0.0070***	0.0049***	0.0104***
	(0.0006)	(0.0008)	(0.0015)	(0.0022)
AQI	0.0003	0.0009***	0.0014***	0.0014***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Observations	76,052	76,052	76,052	76,052
Adjusted R^2	0.99	0.99	0.99	0.99

This table represents the regression results by employing OLS on Equation (3). All regressions include weather controls, city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 24. AQI—Heterogeneous effects of air pollution on mental health by gender

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Male Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0049***	0.0085***	0.0050*	0.0144***
		(0.0000)	(0.0000)	(0.0641)	(0.0001)
AQI	0.0015***	0.0003	0.0006*	0.0014***	0.0012***
	(0.0000)	(0.4627)	(0.0841)	(0.0002)	(0.0006)
Observations	75,758	75,758	75,758	75,758	75,758
Panel B. Female Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0048***	0.0068***	0.0058***	0.0114***
		(0.0000)	(0.0000)	(0.0004)	(0.0000)
AQI	0.0017***	0.0005	0.0009***	0.0015***	0.0014***
	(0.0000)	(0.1827)	(0.0037)	(0.0001)	(0.0001)
Observations	75,787	75,787	75,787	75,787	75,787
Panel C. Gender Differences					
Chow test (F value)	0.46	15.61***	39.69***	46.69***	52.71***

This table represents the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 25. AQI—Heterogeneous effects of air pollution on mental health by education

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. High School or Below Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0052***	0.0075***	0.0058***	0.0136***
		(0.0000)	(0.0000)	(0.0044)	(0.0000)
AQI	0.0017***	0.0004	0.0009***	0.0015***	0.0014***
	(0.0000)	(0.2490)	(0.0013)	(0.0000)	(0.0000)
Observations	75,772	75,772	75,772	75,772	75,772
Panel B. College or Above Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0042***	0.0070***	0.0057***	0.0110***
		(0.0000)	(0.0000)	(0.0046)	(0.0004)
AQI	0.0016***	0.0005	0.0008*	0.0014***	0.0013***
	(0.0009)	(0.2587)	(0.0720)	(0.0058)	(0.0068)
Observations	75,775	75,775	75,775	75,775	75,775
Panel C. Education Differences					
Chow test (F value)	0.22	0.38	0.13	0.12	2.73*

This table represents the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 26. AQI—Heterogeneous effects of air pollution on mental health by age

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. 18-24					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0024***	0.0048***	0.0036	0.0049
		(0.0031)	(0.0002)	(0.1524)	(0.2358)
AQI	0.0015**	0.0009*	0.0010*	0.0014**	0.0014**
	(0.0078)	(0.0951)	(0.0865)	(0.0154)	(0.0141)
Observations	75,727	75,727	75,727	75,727	75,727
Panel B. 25-34					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0056***	0.0076***	0.0058**	0.0161***
		(0.0000)	(0.0000)	(0.0142)	(0.0000)
AQI	0.0019***	0.0005	0.0011**	0.0017***	0.0015***
	(0.0000)	(0.2531)	(0.0018)	(0.0000)	(0.0001)
Observations	75,757	75,757	75,757	75,757	75,757
Panel C. 35-44					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0061***	0.0086***	0.0043*	0.0128***
		(0.0000)	(0.0000)	(0.0823)	(0.0003)
AQI	0.0017***	0.0002	0.0008**	0.0016***	0.0014***
	(0.0000)	(0.6448)	(0.0291)	(0.0000)	(0.0001)
Observations	75,578	75,578	75,578	75,578	75,578
Panel D. 45-54					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0050**	0.0070***	0.0034	0.0140**
		(0.0111)	(0.0097)	(0.4470)	(0.0481)
AQI	0.0023***	0.0010*	0.0016**	0.0022***	0.0020***
	(0.0002)	(0.0832)	(0.0072)	(0.0004)	(0.0005)
Observations	74,676	74,676	74,676	74,676	74,676
Panel E. 55-64					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0009	0.0022	-0.0052	0.0085
		(0.7789)	(0.5683)	(0.5060)	(0.4445)
AQI	0.0005	0.0003	0.0003	0.0006	0.0003
	(0.7385)	(0.8471)	(0.8532)	(0.6617)	(0.8183)
Observations	59,142	59,142	59,142	59,142	59,142
Panel F. Age Differences					
Chow test (F value)	6.66***	7.72***	8.05***	9.76***	13.84***

This table represents the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 27. AQI—Heterogeneous effects of air pollution on mental health by marriage

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Unmarried Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0024***	0.0049***	0.0032	0.0046
		(0.0074)	(0.0005)	(0.2731)	(0.2668)
AQI	0.0017***	0.0011***	0.0011***	0.0016***	0.0016***
	(0.0001)	(0.0044)	(0.0036)	(0.0002)	(0.0001)
Observations	75,701	75,701	75,701	75,701	75,701
Panel B. Married Subsample					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0057***	0.0081***	0.0059***	0.0145***
		(0.0000)	(0.0000)	(0.0006)	(0.0000)
AQI	0.0017***	0.0003	0.0008***	0.0015***	0.0014***
	(0.0000)	(0.4714)	(0.0047)	(0.0000)	(0.0000)
Observations	75,793	75,793	75,793	75,793	75,793
Panel C. Marriage Differences					
Chow test (F value)	14.17***	40.02***	28.28***	22.36***	27.23***

This table represents the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 28. AQI—Heterogeneous effects of air pollution on mental health by economic development

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. GDP Per Capita (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0050***	0.0078***	0.0052**	0.0126***
		(0.0000)	(0.0000)	(0.0000)	(0.0001)
AQI	0.0016***	0.0003	0.0007**	0.0014***	0.0013***
	(0.0000)	(0.3063)	(0.0244)	(0.0108)	(0.0002)
Observations	35,068	35,068	35,068	35,068	35,068
Panel B. GDP Per Capita (High)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0046***	0.0066***	0.0032	0.0074**
		(0.0000)	(0.0015)	(0.2086)	(0.0350)
AQI	0.0017***	0.0007**	0.0011***	0.0016***	0.0016***
	(0.0000)	(0.0157)	(0.0000)	(0.0000)	(0.0000)
Observations	34,675	34,675	34,675	34,675	34,675
Panel C.High and Low Differences					
Chow test (F value)	0.16	1.75	2.17	2.43*	3.72**

This table represents the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we don't include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 29. AQI—Heterogeneous effects of air pollution on mental health by health resources

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Number of Hospitals (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0070***	0.0100***	0.0081**	0.0187***
		(0.0000)	(0.0000)	(0.0038)	(0.0000)
AQI	0.0024***	0.0008*	0.0014***	0.0021***	0.0020***
	(0.0000)	(0.0666)	(0.0034)	(0.0000)	(0.0001)
Observations	32,976	32,976	32,976	32,976	32,976
Panel B. Number of Hospitals (High)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0034***	0.0058***	0.0019	0.0063*
		(0.0001)	(0.0000)	(0.4122)	(0.0687)
AQI	0.0011***	0.0004	0.0006*	0.0011***	0.0010***
	(0.0002)	(0.1955)	(0.0452)	(0.0003)	(0.0006)
Observations	32,541	32,541	32,541	32,541	32,541
Panel C.High and Low Differences					
Chow test (F value)	2.63	2.43*	4.55**	6.80***	14.40***

This table represents the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we don't include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 30. AQI—Heterogeneous effects of air pollution on mental health by living conditions

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Area of Green Land (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0054***	0.0085***	0.0085**	0.0167***
		(0.0000)	(0.0000)	(0.0004)	(0.0000)
AQI	0.0016***	0.0004	0.0008**	0.0014***	0.0013***
	(0.0001)	(0.2938)	(0.0380)	(0.0007)	(0.0011)
Observations	32,356	32,356	32,356	32,356	32,356
Panel B. Area of Green Land (High)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0040***	0.0053***	-0.0018	0.0034
		(0.0001)	(0.0001)	(0.4830)	(0.3734)
AQI	0.0018***	0.0009***	0.0013***	0.0019***	0.0018***
	(0.0000)	(0.0048)	(0.0004)	(0.0000)	(0.0000)
Observations	32,243	32,243	32,243	32,243	32,243
Panel C.High and Low Differences					
Chow test (F value)	0.10	2.06	4.39**	6.17***	7.93***

This table represents the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we don't include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 31. AQI—Heterogeneous effects of air pollution on mental health by sport facilities

Dependent variable: Ln(MHQs)	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Number of Gyms (Low)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0054***	0.0083***	0.0079***	0.0164***
		(0.0000)	(0.0000)	(0.0031)	(0.0001)
AQI	0.0019***	0.0007*	0.0011***	0.0017***	0.0016***
	(0.0000)	(0.0851)	(0.0086)	(0.0001)	(0.0002)
Observations	29,330	29,330	29,330	29,330	29,330
Panel B. Number of Gyms (High)					
$\frac{1}{k}\sum_{n=0}^{k-1}$ AQI		0.0056***	0.0078***	0.0014	0.0082**
		(0.0000)	(0.0000)	(0.6285)	(0.0510)
AQI	0.0016***	0.0003	0.0007*	0.0015***	0.0014***
	(0.0003)	(0.4533)	(0.0620)	(0.0005)	(0.0010)
Observations	28,919	28,919	28,919	28,919	28,919
Panel C.High and Low Differences					
Chow test (F value)	0.97	1.06	2.40*	3.78**	4.24**

This table represents the regression results by employing OLS. All regressions include weather controls, city-month fixed effects, and date fixed effects. Note that we don't include city-month fixed effects when conducting Chow test. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 32. Effects of air pollution on mental health—depression vs. anxiety

	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Sadness vs. Anxiety					
Sadness (Lower Mood):					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0010	0.0053***	0.0090***	0.0046	0.0192***
	(0.1209)	(0.0000)	(0.0000)	(0.2775)	(0.0161)
Anxiety:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0023**	0.0058***	0.0073**	0.0098***	0.0142**
	(0.0174)	(0.0051)	(0.0330)	(0.0073)	(0.0259)
Panel B. Disturbed Sleep vs. Fear					
Disturbed Sleep:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0025***	0.0073***	0.0116***	0.0128***	0.0210***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Fear:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0014***	0.0049***	0.0056***	0.0050	0.0093
	(0.0073)	(0.0000)	(0.0001)	(0.2141)	(0.1563)
Panel C. Depressive Disorder vs. Anxiety Disorder					
Depressive Disorder:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0007	0.0042***	0.0065***	0.0057**	0.0097**
	(0.1901)	(0.0051)	(0.0014)	(0.0112)	(0.0219)
Anxiety Disorder:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0009	0.0085***	0.0091***	0.0075	0.0012
	(0.3254)	(0.0000)	(0.0001)	(0.1106)	(0.8745)

This table represents the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 33. Effects of air pollution on mental health by query classification

	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Dependent variable: Ln(Symptom-related MHQs)					
$\frac{1}{k}\sum_{n=0}^{k-1}\mathrm{PM}_{2.5}$		0.0064***	0.0095***	0.0106***	0.0176***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\mathrm{PM}_{2.5}$	0.0020***	0.0003	0.0009***	0.0016***	0.0016***
	(0.0000)	(0.4020)	(0.0095)	(0.0011)	(0.0003)
Observations	76,052	76,052	76,052	76,052	76,052
Panel B. Dependent variable: Ln(Disease-related MHQs)					
$\frac{1}{k}\sum_{n=0}^{k-1}\mathrm{PM}_{2.5}$		0.0050***	0.0073***	0.0061**	0.0072*
		(0.0001)	(0.0001)	(0.0044)	(0.0713)
$\mathrm{PM}_{2.5}$	0.0004	-0.0009**	-0.0004	0.0002	0.0002
	(0.4612)	(0.0405)	(0.3573)	(0.7662)	(0.6862)
Observations	76,023	76,023	76,023	76,023	76,023

This table represents the regression results by employing OLS. All regressions include city-month fixed effects and date fixed effects. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).

Supplementary Table 34. Effects of air pollution on mental health—specific keywords

	1-day (1)	7-day (2)	14-day (3)	30-day (4)	60-day (5)
Panel A. Symptom-related keywords					
A1. *Sadness (Lower Mood)*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0010	0.0053***	0.0090***	0.0046	0.0192**
	(0.1209)	(0.0000)	(0.0000)	(0.2775)	(0.0161)
A2. *Loss of Pleaseure or Interest*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	-0.0010	0.0038	0.0080**	0.0091	0.0163
	(0.5472)	(0.1742)	(0.0227)	(0.2461)	(0.1793)
A3. *Guilt of Low Self-Worth*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	-0.0007	0.0016	0.0025	0.0060	0.0068
	(0.5946)	(0.4545)	(0.3559)	(0.2801)	(0.4324)
A4. *Disturbed Sleep*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0025***	0.0073***	0.0116***	0.0128***	0.0210***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
A5. *Disturbed Appetite*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0012	0.0038	0.0042	-0.0012	-0.0024
	(0.4138)	(0.2090)	(0.2772)	(0.8623)	(0.8218)
A6. *Tiredness*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0066***	0.0062	0.0042***	0.0127**	0.0247***
	(0.0000)	(0.1306)	(0.0015)	(0.0136)	(0.0073)
A7. *Anxiety*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0023**	0.0058***	0.0073**	0.0098***	0.0142**
	(0.0174)	(0.0051)	(0.0330)	(0.0073)	(0.0259)
A8. *Fear*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0014***	0.0049***	0.0056***	0.0050	0.0093
	(0.0073)	(0.0000)	(0.0001)	(0.2141)	(0.1563)
Panel B. Disease-related keywords					
B1. *Depression Disorder*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0007	0.0042***	0.0065***	0.0057**	0.0097**
	(0.1901)	(0.0051)	(0.0014)	(0.0112)	(0.0219)
B2. *Anxiety Disorder*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0009	0.0085***	0.0091***	0.0075	0.0012
	(0.3254)	(0.0000)	(0.0001)	(0.1106)	(0.8745)
B3. *Panic Disorder*					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	-0.0008	-0.0028	0.0194*	-0.0369*	0.0016
	(0.8384)	(0.7063)	(0.0638)	(0.0546)	(0.9521)
B4. *Phobias*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0019	0.0056**	0.0049	-0.0036	-0.0054
	(0.1239)	(0.0376)	(0.2296)	(0.6562)	(0.5752)
B5. *Social Anxiety Disorder*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0704	-1.0227**	-0.5203	-0.8387	-0.4702
	(0.6576)	(0.0344)	(0.1728)	(0.1365)	(0.5390)
B6. *Obsessive-Compulsive Disorder*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	0.0013	0.0055*	0.0061	0.0007	-0.0045
	(0.3950)	(0.0603)	(0.1147)	(0.9316)	(0.7076)
B7. *Post-Traumatic Stress Disorder*:					
$\frac{1}{k}\sum_{n=0}^{k-1} PM_{2.5}$	-0.0034	0.0012	-0.0111*	-0.0279*	-0.0073
	(0.1636)	(0.8134)	(0.0867)	(0.0215)	(0.6654)

This table represents the regression results by employing OLS. All regressions include city-month fixed effects, date fixed effects, and weather controls. Robust standard errors are clustered at the city level. P values are reported in parentheses. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$ (two-sided test).