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Association between atmospheric concentration of particulate matters and inpatient and outpatient visits for chronic respiratory diseases in Xiamen, China

Tao-Ling Zhong[1], Yi-Wei Zhang[2,3], Xiang-Yang Yao[2,3], Guang-Hui Xu[4], Hui Liu[4], Qiu-Shi Xu[4], Wei Sun[5], Zhi-Bin Li[6], Yun-Gang Yang[7], Jin-Zhun Wu[8], Chao Zheng[3], Qi-Yuan Li[1], Lin-Fu Zhou[9]

[1]National Institute of Data Science for Health and Medicine, School of Medicine, Xiamen University, Xiamen, Fujian 361102, China;
[2]Pulmonary Department, The First Affiliated Hospital of Xiamen University, Xiamen, Fujian 361000, China;
[3]The First Affiliated Hospital of Xiamen University Xinglin Branch, Xiamen, Fujian 361000, China;
[4]Xiamen Health and Medical Big Data Center, Xiamen, Fujian 361000, China;
[5]Xiamen Health Information Association, Xiamen, Fujian 361000, China;
[6]Epidemiology Research Unit, The First Affiliated Hospital of Xiamen University, Xiamen, Fujian 361000, China;
[7]Department of Pediatrics, The First Affiliated Hospital of Xiamen University, Xiamen, Fujian 361000, China;
[8]Xiamen Maternity and Child Care Hospital, Xiamen, Fujian 361000, China;
[9]Department of Respiratory and Critical Care Medicine, The First Affiliated Hospital, Nanjing Medical University, Nanjing, Jiangsu 210029, China.

Exposure to airborne particulate matters (fine particulate matter [PM2.5] and inhalable particulate matter [PM10]) causes acute exacerbation of chronic respiratory diseases and even death in some patients.[1,2] Here, we studied the association between airborne pollutants (PM2.5, PM10, ozone [O_3]), weather conditions (mean air temperature, wind force), and outpatient and inpatient visits for chronic respiratory diseases (bronchitis, emphysema and chronic obstructive pulmonary disease [COPD], bronchiectasis) in Xiamen, China.

We collected the inpatient and outpatient records for chronic respiratory diseases based on the International Classification of Diseases Tenth Revision of J40, J41, J42, J43, J44, and J47 from Xiamen Health and Medical Big Data Center. The records were dated between January 1, 2017 and December 31, 2019. The data were classified according to diagnoses: bronchitis (J40, J41, and J42), emphysema (J43) and COPD (J44), and bronchiectasis (J47). Each group was further divided by age (0–19, 20–39, and ≥40 years). Daily concentrations of air pollutants (PM2.5, PM10, and O_3) were obtained from the Ministry of Ecology and Environment. The daily weather data, including the average temperature and wind scale, were obtained from the TianQiHouBao (http://www.tianqihoubao.com), an online query of historical weather forecasts.

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Currently, the length of inpatient hospital admissions for medication and treatment of chronic respiratory diseases in each hospital is usually 14 days. For consistency, the 14-day moving average of the number of patients in each group was calculated as the outcome variable, and the 14-day moving average of PM2.5, PM10, O_3, average temperature, and wind force were used as the impact factors.

We used a univariate Poisson regression model to evaluate the effects of pollutants on inpatient and outpatient visits for respiratory diseases. The effect sizes of each pollutant are represented by the regression coefficients of the interquartile range (IQR). To accommodate the lag effects, we assessed the effects of each pollutant from 0 to 14 days, and reported the lag effects based on the highest effect size. To control for age effect, we divided the cohort into different age groups. The statistical analysis was conducted by R software version 3.6 (R Foundation, Vienna, Austria), with a two-sided *P* value of 0.05 as the threshold of significance.

We obtained the records of 238,455 outpatients and 8113 inpatients in Xiamen from 2017 to 2019 [Supplementary

Tao-Ling Zhong and Yi-Wei Zhang contributed equally to this study.

Correspondence to: Dr. Qi-Yuan Li, National Institute of Data Science for Health and Medicine, School of Medicine, Xiamen University, Xiamen, Fujian 361102, China
E-Mail: qiyuan.li@xmu.edu.cn;
Prof. Lin-Fu Zhou, 300 Guangzhou Road, Nanjing, Jiangsu 210029, China
E-Mail: lfzhou@njmu.edu.cn

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Tables 1 and 2, http://links.lww.com/CM9/A501]. Among all age groups, the proportion of male patients was higher than female patients (outpatient: 54.15% [129,135/238,455] male; inpatient: 73.97% [6001/8113] male). The average age was 55 ± 25 years for outpatients, and 66 ± 19 years for inpatients. As for the diagnoses, 64.25% (5213/8113) of inpatients were diagnosed with COPD (J44) and 26.39% (2141/8113) with bronchiectasis (J47); while 87.28% (208,119/238,455) of outpatients were diagnosed with acute or chronic bronchitis (J40) [Supplementary Figure 1, http://links.lww.com/CM9/A501].

From 2017 to 2019, both inpatient and outpatient visits for all three disease groups increased: J40 to J42 by 68.22%; J43 to J44 by 35.92%; and J47 by 33.93% [Supplementary Figure 2, http://links.lww.com/CM9/A501]. The average daily inpatient visit was 11.81, and the daily outpatient visit was 452.02. In the same period, the daily average concentration of PM2.5 in Xiamen ranged from 4 to 100 $\mu g/m^3$; and the average daily PM10 concentration ranged from 9 to 138 $\mu g/m^3$. The daily average concentration of O_3 ranged from 0 to 172 $\mu g/m^3$. As for the weather conditions, the average daily temperature ranged from 7°C to 32.5°C, and the wind speed ranged from 1.5 to 6.5 force [Supplementary Tables 2 and 3, http://links.lww.com/CM9/A501, Supplementary Figure 3, http://links.lww.com/CM9/A501].

Our data suggest that air pollutants influence both inpatient and outpatient visits for chronic respiratory diseases in Xiamen [Table 1]. The IQR increase in the concentration of PM2.5 correlates to a 13.71% increase ($P < 0.001$) in inpatient visits for emphysema and COPD among patients 40 years and above, with the highest effects at 14-day post-exposure. Moreover, IQR increase in PM10 correlates to a 16.91% ($P = 0.029$) increase in inpatient visits for bronchitis among patients aged ≤ 19 years old at 14 days post-exposure; and a 7.76% ($P < 0.001$) increase in inpatient visits for emphysema and COPD among patients ≥ 40 years old. On the other hand, IQR increase of O_3 was significantly associated with a 12.35% ($P = 0.019$) decrease in inpatient visits for bronchitis among patients of 0 to 19 years old, 10.33% ($P < 0.001$) decrease for emphysema and COPD, and 10.32% ($P < 0.001$) decrease

Table 1: Lagged effects of exposure to air pollutants on inpatient and outpatient visits for respiratory diseases.

Factors	Diagnosis	Age (years)	*n*	Regression coefficients of the interquartile range	Lower bound of the 95% CI	Upper bound of the 95% CI	*P* values	Percentage changes in patient visits (%)
Inpatient								
PM2.5	Emphysema, COPD	≥40	5303	0.129	0.100	0.158	<0.001	13.71
PM10	Bronchitis	0–19	313	0.156	0.016	0.296	0.029	16.91
PM10	Emphysema, COPD	≥40	5303	0.075	0.046	0.103	<0.001	7.76
O_3_8 h	Bronchitis	0–19	313	−0.132	−0.242	−0.022	0.019	−12.35
O_3_8 h	Emphysema, COPD	≥40	5303	−0.109	−0.131	−0.087	<0.001	−10.33
O_3_8 h	Bronchiectasis	0–19	23	−0.460	−0.778	−0.142	0.005	−36.87
O_3_8 h	Bronchiectasis	≥40	1929	−0.109	−0.151	−0.067	<0.001	−10.32
Outpatient								
PM2.5	Bronchitis	0–19	122,283	0.068	0.062	0.074	<0.001	7.04
PM2.5	Bronchitis	20–39	41,850	0.072	0.060	0.085	<0.001	7.51
PM2.5	Bronchitis	≥40	49,995	0.154	0.144	0.164	<0.001	16.61
PM2.5	Emphysema, COPD	0–19	415	−0.224	−0.314	−0.134	<0.001	−20.07
PM2.5	Emphysema, COPD	20–39	1033	0.122	0.052	0.192	<0.001	13.00
PM2.5	Emphysema, COPD	≥40	22,014	0.047	0.038	0.056	<0.001	4.85
PM2.5	Bronchiectasis	0–19	94	−0.178	−0.338	−0.018	0.029	−16.30
PM2.5	Bronchiectasis	≥40	7218	0.074	0.054	0.094	<0.001	7.65
PM10	Bronchitis	0–19	122,283	0.075	0.069	0.080	<0.001	7.73
PM10	Bronchitis	≥40	49,995	0.096	0.086	0.106	<0.001	10.06
PM10	Emphysema, COPD	0–19	415	−0.238	−0.326	−0.149	<0.001	−21.14
PM10	Emphysema, COPD	20–39	1033	0.076	0.007	0.145	0.031	7.91
PM10	Emphysema, COPD	≥40	22,014	0.024	0.015	0.033	<0.001	2.43
PM10	Bronchiectasis	0–19	94	−0.169	−0.326	−0.011	0.036	−15.53
PM10	Bronchiectasis	≥40	7218	0.037	0.018	0.057	<0.001	3.80
O_3_8 h	Bronchitis	0–19	122,283	0.061	0.057	0.066	<0.001	6.33
O_3_8 h	Bronchitis	20–39	41,850	−0.064	−0.073	−0.055	<0.001	−6.20
O_3_8 h	Bronchitis	≥40	49,995	−0.117	−0.125	−0.110	<0.001	−11.06
O_3_8 h	Emphysema, COPD	0–19	415	0.283	0.222	0.345	<0.001	32.76
O_3_8 h	Emphysema, COPD	≥40	22,014	−0.040	−0.047	−0.033	<0.001	−3.90
O_3_8 h	Bronchiectasis	20–39	1498	0.041	0.006	0.076	0.021	4.20
O_3_8 h	Bronchiectasis	≥40	7218	−0.043	−0.058	−0.028	<0.001	−4.21

CI: Confidence interval; COPD: Chronic obstructive pulmonary disease; O_3: Ozone; PM2.5: particulate matter; PM10: Inhalable particulate matter.

for bronchiectasis among those ≥ 40 years old at 14 days post-exposure [Table 1].

As for outpatient visits for chronic respiratory diseases [Table 1], increase in the IQR in PM2.5 concentration was associated with 7.04% increase ($P < 0.001$) for bronchitis among patients aged 0 to 19 years, 7.51% ($P < 0.001$) among patients aged 20 to 39 years, and 16.61% ($P < 0.001$) among patients aged ≥40 years old; 13.00% ($P < 0.001$) for emphysema and COPD among patients aged 20 to 39 years; and 7.65% ($P < 0.001$) for bronchiectasis among patients aged ≥ 40 years. In addition, IQR increase in PM10 concentration had a similar trend in the number of outpatient visits: 7.73% ($P < 0.001$) and 10.06% ($P < 0.001$) for bronchitis among patients aged 0 to 19 years and ≥40 years, respectively; 7.91% ($P = 0.031$) for emphysema and COPD among patients aged 20 to 39 years; and 3.80% ($P < 0.001$) for bronchiectasis among patients aged ≥40 years old. The strongest effects of PM2.5 and PM10 appear 14 days post-exposure.

In addition, exposure to O_3 was also significantly associated with the increase in outpatient visits: 6.33% ($P < 0.001$) for bronchitis among patients aged 0 to 19 years, 32.76% ($P < 0.001$) for emphysema and COPD aged 0 to 19 years, and 4.20% ($P = 0.021$) for bronchiectasis among patients aged 20 to 39 years [Table 1].

Regarding weather conditions, IQR increase of the average daily temperature was associated with reduced outpatient and inpatient visits for bronchitis (32.45% [$P < 0.001$] for outpatients aged ≥ 40 years old, and 48.05% [$P = 0.007$] for inpatients aged 20–39 years), whereas that of wind speed was significantly associated with increased outpatient and inpatient visits for bronchitis (19.69% [$P < 0.001$] for outpatients aged 0–19 years and 65.83% [$P = 0.002$] for inpatients aged 20–39 years) [Supplementary Table 4, http://links.lww.com/CM9/A501]. Furthermore, our data suggest that the effects of the weather conditions are strong instruments for air pollutants. For instance, wind appeared to influence the inpatient visits for bronchiectasis among patients aged ≥ 40 years, which was likely associated with the impacts of O_3 exposure (weak instruments $P < 0.001$, Wu-Hausman $P = 0.482$). Likewise, temperature likely influenced outpatient visits for emphysema and COPD among patients aged 20 to 39 years (weak instruments $P < 0.001$, Wu-Hausman $P = 0.266$), and bronchiectasis among patients aged 0 to 19 years (weak instruments $P < 0.001$, Wu-Hausman $P = 0.651$) by altering the concentration of PM2.5 [Supplementary Table 5, http://links.lww.com/CM9/A501].

Our data are consistent with prior studies showing that increasing hospital admissions for COPD, low lung function, and respiratory symptoms are associated with short-term exposure to particulate matter (PM).[3] PM causes acute exacerbation of chronic respiratory diseases by inducing and aggravating airway and lung inflammation.[4] Our previous study suggests the activities of Th17 cells are associated with PM exposure through modulation of interferon regulatory factor 4 and signal transducer and activator of transcription 3 and cause inflammatory responses in the respiratory tracts.[5] Our data suggest negative effects of O_3 exposure on inpatient visit for J40 to J42, J43 to J44, and J47. Such effects are attributed to the fact that most of inpatients are already diagnosed with relevant conditions with very limited outdoor activities, hence less affected by the ambient O_3 levels.

Overall, our study confirmed the relationship between air pollutants (PM2.5, PM10, O_3) and chronic respiratory diseases from a regional real-world database of electronic health records. Our findings can help facilitate the formulation of public-health policies and clinical management for better control of chronic respiratory diseases.

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Conflicts of interest

None.

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