**Interactive effects of meteorological factors and particulate pollutants on childhood asthma: a time series analysis in Shanghai, China**

**Yi Hu1**#**, Dan Wu1**#**, Yabin Hu2, Shenghui Li3, Shijian Liu2, Jianguo Tan4, Yong Yin5, Chonghuai Yan6, Xiaolei Wang7, Hui Lu1,7, Guangjun Yu1,8\*, Shilu Tong2, 9-11**

1 Center for Biomedical Informatics, Shanghai Children’s Hospital, Shanghai Jiao Tong University, Shanghai, China

2 Department of Clinical Epidemiology and Biostatistics, Shanghai Children’s Medical Center, School of Medicine, Shanghai Jiao Tong University, Shanghai, China

3 School of Public Health, Shanghai Jiao Tong University, Shanghai, China

4 Shanghai Climate Center, Shanghai, China

5 Department of Respiratory Medicine, Shanghai Children’s Medical Center, School of Medicine, Shanghai Jiao Tong University, Shanghai, China

6 Shanghai Key Laboratory of Environmental and Child Health, Xinhua Hospital, Shanghai Jiao tong University School of Medicine, Shanghai, China

7 SJTU-Yale Joint Center for Biostatistics and Data Science, Department of Bioinformatics and Biostatistics, Shanghai Jiao Tong University, Shanghai China

8 Shanghai Engineering Research Center for Big Data in Pediatric Precision Medicine, Shanghai, China

9 School of Public Health, Institute of Environment and Population Health, Anhui Medical University, Hefei, China

10 Center for Global Health, School of Public Health, Nanjing Medical University, Nanjing, China

11 School of Public Health and Social Work, Queensland University of Technology, Brisbane, Australia

# These authors contributed equally to this work

**Correspondence:** Guangjun Yu, Center for Biomedical Informatics, Shanghai Children’s Hospital, Shanghai Jiao Tong University, No.24, Lane 1400, Beijing West Road, Shanghai, China. Telephone: +86 21 62797512-83205. E-mail: gjyu@shchildren.com.cn

**Captions of Additional file 1**

**Fig. S1** The distributions of daily data on meteorological factors, PM and outpatient visits for childhood asthma during 2007-2017

**Table S1** The spearman correlations coefficients among daily outpatient visits for childhood asthma in total and in sex and age subgroups

**Fig. S2** Subgroup analyses of meteorological factors and PM on childhood asthma by sex

**Fig. S3** Subgroup analyses of meteorological factors and PM on childhood asthma by age

**Fig. S4** Sensitivity analyses of meteorological factors and PM on childhood asthma by alternative *df* of calendar time

**Fig. S5** Sensitivity analyses of meteorological factors and PM on childhood asthma by alternative *df* for meteorological factors and PM

**Table S2** Interactive effects between meteorological factors and PM on childhood asthma in sex subgroup

**Table S3** Interactive effects between meteorological factors and PM on childhood asthma in age subgroup

**Table S4** Interactive effects between meteorological factors and PM on childhood asthma in sensitivity analyses of alternative *df* for calendar time

**Table S5** Interactive effects between meteorological factors and PM on childhood asthma in sensitivity analyses of alternative *df* for meteorological factors and PM

****

**Fig. S1** The distributions of daily data on meteorological factors, PM and outpatient visits for childhood asthma during 2007-2017

**Table S1** The spearman correlations coefficients among daily outpatient visits for childhood asthma in total and in sex and age subgroups

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Outpatient visits for**  **childhood asthma** | **Outpatient visits for childhood asthma** | | | | |
| **Total** | **Boys** | **Girls** | **Children age ≤ 5 years old** | **Children age 6-18 years olds** |
| Total | 1.000 | 0.997\*\* | 0.988\*\* | 0.988\*\* | 0.953\*\* |
| Boys | - | 1.000 | 0.972\*\* | 0.988\*\* | 0.942\*\* |
| Girls | - | - | 1.000 | 0.969\*\* | 0.954\*\* |
| Children age ≤ 5 years old | - | - | - | 1.000 | 0.896\*\* |
| Children age 6-18 years olds | - | - | - | - | 1.000 |

\*\* p < 0.01

C:\Users\dell\Desktop\Journal of Environmental Chemical Engineering\性别分层.tif

**Fig. S2** Subgroup analyses of meteorological factors and PM on childhood asthma by sex. Meteorological factor or PM corresponding to the minimum risk of outpatient visits for childhood asthma was selected as reference for null hypothesis line, the black line indicated the relative RR, and the gray area represented the 95%CI. For boys: (A) Mean temperature; (B) Mean relative humidity; (C) Mean air pressure; (D) PM2.5; (E) PM10. For Girls: (F) Mean temperature; (G) Mean relative humidity; (H) Mean air pressure; (I) PM2.5; (J) PM10.

C:\Users\dell\Desktop\Journal of Environmental Chemical Engineering\年龄分层-V2.0.tiff

**Fig. S3** Subgroup analyses of meteorological factors and PM on childhood asthma by age. Meteorological factor or PM corresponding to the minimum risk of outpatient visits for childhood asthma was selected as reference for null hypothesis line, the black line indicated the relative RR, and the gray area represented the 95%CI. For children aged ≤ 5 years old: (A) Mean temperature; (B) Mean relative humidity; (C) Mean air pressure; (D) PM2.5; (E) PM10. For children aged 6-18 years old: (F) Mean temperature; (G) Mean relative humidity; (H) Mean air pressure; (I) PM2.5; (J) PM10.

**C:\Users\dell\Desktop\Journal of Environmental Chemical Engineering\时间敏感性-v1.0.tif**

**Fig. S4** Sensitivity analyses of meteorological factors and PM on childhood asthma by alternative *df* of calendar time. Meteorological factor or PM corresponding to the minimum risk of outpatient visits for childhood asthma was selected as reference for null hypothesis line, the black line indicated the relative RR, and the gray area represented the 95%CI. (A) Mean temperature; (B) Mean relative humidity; (C) Mean air pressure; (D) PM2.5; (E) PM10 .

****

**Fig. S5** Sensitivity analyses of meteorological factors and PM on childhood asthma by alternative *df* for meteorological factors and PM. Meteorological factor or PM corresponding to the minimum risk of outpatient visits for childhood asthma was selected as reference for null hypothesis line, the black line indicated the relative RR, and the gray area represented the 95%CI. (A) Mean temperature; (B) Mean relative humidity; (C) Mean air pressure; (D) PM2.5 ; (E) PM10 .

**Table S2** Interactive effects between meteorological factors and PM on childhood asthma in sex subgroup

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sex** | **PM** | **Mean temperature** |  | **Mean relative humidity** |  | **Mean air pressure** |
| **RERI (95%CI)** |  | **RERI (95%CI)** |  | **RERI (95%CI)** |
| Boys | PM2.5 | -0.13 (-0.14, -0.12) |  | -0.02 (-0.03, -0.00) |  | 0.15 (0.12, 0.17) |
|  | PM10 | -0.06 (-0.07, -0.04) |  | -0.03 (-0.05, -0.02) |  | 0.09 (0.07, 0.12) |
| Girls | PM2.5 | -0.13 (-0.15, -0.11) |  | 0.01 (-0.00, 0.03) |  | 0.00 (-0.05, 0.05) |
|  | PM10 | -0.09 (-0.11, -0.08) |  | -0.04 (-0.05, -0.02) |  | 0.04 (0.00, 0.09) |

a meteorological factors and PM were divided into binary variables according to the cutoff points from DLNM models in which daily value ≤ the cutoff was assigned with 0 while > the cutoff was assigned with 1. The cutoff points of meteorological factors and PM in sex subgroups were presented in Fig. S2.

**Table S3** Interactive effects between meteorological factors and PM on childhood asthma in age subgroup

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Age** | **PM** | **Mean temperature** |  | **Mean relative humidity** |  | **Mean air pressure** |
| **RERI (95%CI)** |  | **RERI (95%CI)** |  | **RERI (95%CI)** |
| ≤ 5 years old | PM2.5 | -0.13 (-0.15, -0.12) |  | -0.03 (-0.04, -0.02) |  | 0.03 (0.00, 0.07) |
|  | PM10 | -0.05 (-0.07, -0.03) |  | -0.05 (-0.06, -0.04) |  | 0.09 (0.06, 0.13) |
| 6-18 years old | PM2.5 | -0.09 (-0.11, -0.07) |  | 0.02 (0.01, 0.04) |  | 0.07 (0.04, 0.11) |
|  | PM10 | -0.03 (-0.05, -0.02) |  | 0.02 (0.00, 0.03) |  | 0.09 (0.07, 0.13) |

a meteorological factors and PM were divided into binary variables according to the cutoff points from DLNM models in which daily value ≤ the cutoff was assigned with 0 while > the cutoff was assigned with 1. The cutoff points of meteorological factors and PM in age subgroups were presented in Fig. S3.

**Table S4** Interactive effects between meteorological factors and PM on childhood asthma in sensitivity analyses of alternative *df* for calendar time

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***df*** | **PM** | **Mean temperature** |  | **Mean relative humidity** |  | **Mean air pressure** |
| **RERI (95%CI)** |  | **RERI (95%CI)** |  | **RERI (95%CI)** |
| 5 *df*/year\*11 | PM2.5 | -0.16 (-0.17, -0.15) |  | -0.01 (-0.02, 0.00) |  | 0.01 (-0.02, 0.04) |
| 9 *df*/year\*11 |  | -0.16 (-0.17, -0.15) |  | -0.01 (-0.03, -0.00) |  | 0.10 (0.09, 0.12) |
| 13 *df*/year\*11 |  | -0.14 (-0.15, -0.13) |  | 0.00 (-0.01, 0.02) |  | 0.10 (0.09, 0.12) |
| 5 *df*/year\*11 | PM10 | -0.07 (-0.08, -0.06) |  | -0.03 (-0.05, -0.03) |  | 0.02 (0.00, 0.06) |
| 9 *df*/year\*11 |  | -0.08 (-0.09, -0.06) |  | -0.18 (-0.19, -0.17) |  | 0.19 (0.17, 0.21) |
| 13 *df*/year\*11 |  | -0.03 (-0.05, -0.00) |  | -0.36 (-0.39, -0.33) |  | 0.10 (0.07, 0.13) |

a meteorological factors and PM were divided into binary variables according to the cutoff points from DLNM models in which daily value ≤ the cutoff was assigned with 0 while > the cutoff was assigned with 1. The cutoff points of meteorological factors and PM in age subgroups were presented in Fig. S4.

**Table S5** Interactive effects between meteorological factors and PM on childhood asthma in sensitivity analyses of alternative *df* for meteorological factors and PM

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***df*** | **PM** | **Mean temperature** |  | **Mean relative humidity** |  | **Mean air pressure** |
| **RERI (95%CI)** |  | **RERI (95%CI)** |  | **RERI (95%CI)** |
| 5 *df* | PM2.5 | -0.13 (-0.14, -0.11) |  | -0.01 (-0.02, 0.00) |  | 0.09 (0.06, 0.13) |
| 7 *df* |  | -0.13 (-0.14, -0.11) |  | -0.01 (-0.02, -0.00) |  | 0.09 (0.08, 0.10) |
| 9 *df* |  | -0.12 (-0.13, -0.11) |  | 0.02 (0.01, 0.03) |  | 0.11 (0.10, 0.12) |
| 5 *df* | PM10 | -0.09 (-0.10, -0.08) |  | -0.03 (-0.04, -0.02) |  | 0.06 (0.03, 0.09) |
| 7 *df* |  | -0.06 (-0.07, -0.05) |  | -0.08 (-0.09, -0.07) |  | 0.07 (0.06, 0.08) |
| 9 *df* |  | -0.05 (-0.06, -0.04) |  | -0.01 (-0.02, 0.00) |  | 0.09 (0.08, 0.10) |

a meteorological factors and PM were divided into binary variables according to the cutoff points from DLNM models in which daily value ≤ the cutoff was assigned with 0 while > the cutoff was assigned with 1. The cutoff points of meteorological factors and PM in age subgroups were presented in Fig. S5.