Research Article

Pollution Level, Sources, and Lung Cancer Risk of PM₁₀-Bound Polycyclic Aromatic Hydrocarbons (PAHs) in Summer in Nanjing, China

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This study concentrated on the pollution level, sources, and lung cancer risk of PM₁₀-bound polycyclic aromatic hydrocarbons (PAHs) in summer in Nanjing, China. PM₁₀ samples were collected in summer of the year 2015 in Nanjing. 16 USEPA (United States Environmental Protection Agency) priority PAHs were extracted and analyzed after sampling. The mean concentrations of PAHs and BaP_{eq} were 7.49 ± 2.60 and 1.21 ± 0.24 ng/m³, respectively, being in a middle level among results from regions worldwide. According to the results of diagnostic ratios, PAHs originated mainly from traffic exhaust, especially diesel vehicle emissions. Owing to the inhalation exposure, the median values of incremental lung cancer risk (ILCR) were estimated to be 3.36×10^{-8} , 2.50×10^{-8} , 1.69×10^{-7} , 2.54×10^{-8} , 1.38×10^{-7} , 1.18×10^{-7} , 1.27×10^{-7} , and 1.11×10^{-7} for boys, male adolescents, male adults, male seniors, girls, female adolescents, female adults, and female seniors, respectively, indicating low potential lung cancer risk.

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a collective name of the organic compounds condensed by two or more benzene molecules or cyclopentadiene molecules. The USEPA fixed 16 parent PAHs as priority pollutants and these 16 compounds (16 USEPA priority PAHs) were widely concerning due to their carcinogenic properties and wide distribution in atmosphere. Besides their distribution in gas phase, PAHs are easy to adhere to atmospheric particulate matter like PM_{2.5} and PM₁₀, be inhaled, and stay on alveoli [1–3]. Researches have shown that PAHs in environment are mainly produced by human beings [4]. Vehicles, industrial production, and daily activities are important sources of

PAHs. Based on BaP equivalent (BaP_{eq}) in air, daily inhalation exposure (E) level and incremental lung cancer risk (ILCR) for human beings caused by particulate PAHs could be estimated. However, studies on ILCR caused by PAHs for population groups of different age and gender are limited.

Nanjing, lying on the southeast of China, is the capital city of Jiangsu Province. As a fast-developing industrial city, its population and economy are increasing rapidly, which has caused atmospheric pollution. Currently, most researches about particulate PAHs in Chinese cities focused on the main urban areas and the new urban areas are usually ignored, whereas the number of new urban districts has been increasing in recent years in China due to the rapid urban construction, with Nanjing being a typical example.

FIGURE 1: Sample location in Nanjing, China.

The objectives of this study were to investigate the pollution level of PM_{10} -bounded PAHs in summer in a new urban area of Nanjing, the main sources of PAHs in PM_{10} , and the ILCR caused by particulate PAHs for local population groups of different age and gender.

2. Materials and Methods

2.1. Sampling. The sampling site was located on the roof of a building in Nanjing Normal University, which is situated in one of the new urban districts of Nanjing, Jiangsu Province, China (Figure 1). The longitude and latitude position of the building is $32^{\circ}07'N$, $118^{\circ}54'E$ and the altitude is 20 m. The sampling period is from July 30th to September 13th in 2015, with two PM_{10} samples collected in each week. For each sampling, 24 h was included from 8:00 to 8:00 in the next day. Total of eleven PM_{10} samples were collected. During the sampling period, the mean temperature of air was 25.8 to 34.3°C . The weather was mostly sunny and cloudy, which means no raining conditions. In summer, the wind direction is based on south and southwest and the wind scale is from 3 to 5.

Daily PM_{10} samples were collected by an active air sampler (PM_{10} -300, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China; operating at a constant flow rate of $0.3 \text{ m}^3/\text{min}$), with glass fiber filters (GFFs) to collect particulate phase PAHs. Before sampling, the GFF was heated in a muffle furnace at 450°C for 4 hours. GFFs were then equilibrated in a desiccator (25°C , 40% RH) for 24 h and weighted before and after each sampling.

2.2. Sample Extraction and PAH Analysis. The GFF was extracted with 25 mL of a mixture of *n*-hexane and acetone

(1:1, v/v) by microwave extraction system (MES) (MARS2Xpress, CEM, USA). The tubes were heated to 100°C by microwave at the rate of $10^{\circ}\text{C}/\text{min}$ and held for 10 min. After the extraction, the extract was concentrated in water bath of $37^{\circ}\text{C}/\text{min}$ by using a rotatory evaporator (R-201, Shanghai, China). After concentration, extracts of particle phase PAHs were transformed to the alumina silica gel column for purification. The alumina silica gel column was eluted with 20 mL of *n*-hexane followed by 50 mL 1:1 mixture of *n*-hexane and dichloromethane at a rate of 2 mL/min. The eluted mixture from the column during cleanup was first concentrated to near dryness in the vacuum rotary evaporator (R-201, Shanghai, China) using a 37°C water bath. The residue was then transferred and diluted with *n*-hexane and brought to exactly 1.0 mL by nitrogen blowdown (Eyela MG-1000) at room temperature (25°C). The samples were sealed in vials and stored at -4°C before being analyzed.

Quantitative analysis of the air sample extracts was done by gas chromatography with mass spectrometer detector (QP2010, Shimadzu, Japan). A $30 \text{ m} \times 0.25 \text{ mm i.d.} \times 0.25 \mu\text{m}$ film thickness HP-5MS capillary column was used. GC temperature was programmed from an initial 50°C (maintain 1 min) at a rate of $15^{\circ}\text{C}/\text{min}$ up to 180°C and then at a rate of $5^{\circ}\text{C}/\text{min}$ up to 250°C with a final holding time of 20 min. Helium was used as the carrier gas. $1.0 \mu\text{L}$ aliquot of the extract was injected, while the injector port was held at 280°C and operated in splitless mode at a flow rate of 1.0 mL/min. The head column pressure was 30 kPa. The mass spectrometer was operated in scan mode with an electron impact ionization of 70 eV, an electron multiplier voltage of 1200 V, and an ion source of 230°C . Concentrations were determined for 16 individual PAHs in all samples. They were naphthalene (NAP), acenaphthene (ACE), acenaphthylene (ACY), fluorene (FLO), phenanthrene (PHE), anthracene (ANT), fluoranthene (FLA), pyrene (PYR), benz(a)anthracene (BaA), chrysene (CHR), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(a)pyrene (BaP), dibenz(a,h)anthracene (DahA), indeno(1,2,3-cd)pyrene (IcdP), and benzo(g,h,i)perylene (BgHiP).

2.3. Quality Control and Data Analysis. All solvents used were chromatography purity (Dikma, China). Alumina and silica gel (80–200 mesh; Dikma, China) were heated at 650°C in a muffle furnace (DLII-9, Beijing, China) for 10 h and kept in a sealed desiccator. Prior to use, the alumina and silica gel were reactivated at 130°C for 4 h immediately prior to use. All glassware was cleaned using an ultrasonic cleaner (KQ-500B, Kunshan, China) and heated to 400°C for 6 h.

Quantification was performed by the use of external calibrations which were obtained with PAH solutions at five concentration levels. The field and laboratory blanks were analyzed, and the concentrations of target PAHs in the field blanks were higher than those in the laboratory blanks. Concentrations in both blanks were more than one order of magnitude lower than those of real samples. All the results of samples were field blank corrected. Recovery of individual PAHs ranged from 66% to 103% with a mean value of 84%.

TABLE 1: Typical diagnostic ratios and corresponding judge criteria.

Ratio	Specific value	Source identification	References
ANT/(ANT + PHE)	<0.1	Petroleum	[5]
	>0.1	Combustion	
BaA/(BaA + CHR)	<0.2	Petroleum	[5]
	0.2–0.35	Mixed sources	
	>0.35	Combustion	
FLA/(FLA + PYR)	<0.4	Petroleum	[5]
	0.4–0.5	Petroleum combustion	
	>0.5	Grass, wood, & coal combustion	
IcdP/(IcdP + BghiP)	<0.2	Petroleum	[5]
	0.2–0.5	Petroleum combustion	
	>0.5	Grass, wood, & coal combustion	
BaP/BghiP	<0.6	Nontraffic exhaust	[6]
	>0.6	Traffic exhaust	[7]
FLO/(FLO + PYR)	<0.5	Gasoline vehicle emissions	[8]
	>0.5	Diesel vehicle emissions	

Data analyzed in the article were not corrected for recoveries. The detection limits were in the range of 4.81–44.1 pg/m³.

2.4. Source Identification. Diagnostic ratios were used to identify the primary sources of PAHs in diverse phases. Some authors have pointed out that PAH compounds differing in relative molecular mass can be used as tracers to distinguish main sources [5–7]. In this study, diagnostic ratios of ANT/(ANT + PHE), BaA/(BaA + CHR), FLA/(FLA + PYR), IcdP/(IcdP + BghiP), BaP/BghiP, and FLO/(FLO + PYR) were calculated to determine the sources of particulate PAHs. Typical diagnostic ratios and corresponding judge criteria taken from previous literature were listed in Table 1.

2.5. Risk Assessment. BaP equivalent concentration is often used in the estimation of inhalation exposure to PAHs and it was calculated according to

$$\text{BEC} = \sum_{i=1}^n C_i \times \text{TEF}_i, \quad (1)$$

where BEC is BaP_{eq} concentrations of PAHs; C_i is concentration of PAH congener i ; TEFs are the toxicity equivalency factor (TEF) of PAH congener [9].

The citizens in Nanjing were divided into eight population groups according to the age and gender: children (4–10 years), adolescents (11–17 years), adults (18–60 years), and seniors (61–70 years) of both males and females. Daily inhalation exposure (E) level for each population group was calculated based on

$$E = \text{BEC} \times \text{IR}, \quad (2)$$

where E is daily inhalation exposure level (ng/d), BEC_{*i*} is BaP_{eq} concentrations in the sampling site, and IR is inhalation rate (m³/d) [10–12]. We treated BEC and IR, which

followed lognormal and normal distribution, respectively, in (2) probabilistically.

The incremental lifetime cancer risk (ILCR) of population groups in Nanjing caused by PAHs inhalation exposure was calculated using

$$\text{ILCR} = \frac{\text{SF} \times E \times \text{EF} \times \text{ED} \times \text{CF}}{(\text{BW} \times \text{AT})}, \quad (3)$$

where ILCR is the incremental lifetime cancer risk of the inhalation exposure (dimensionless); SF is the cancer slope factor for BaP inhalation exposure (a lognormal distribution with a geometric mean of 3.14 (mg kg⁻¹ day⁻¹)⁻¹ and a geometric standard deviation of 1.80) [13]; E is the daily inhalation exposure level (ng/day); EF is the exposure frequency (day/year) (111 days for summer); ED is exposure duration (year) (for children: ED = 7; for adolescents: ED = 7; for adults: ED = 43; for seniors: ED = 10) [14]; CF is conversion factor (10⁻⁶ mg/ng); BW is body weight (kg) [15, 16]; AT is average lifespan for carcinogens (25550 day). We treated SF, E, and BW, which obeyed lognormal, lognormal, and normal distribution, respectively, in (3) probabilistically.

3. Results and Discussion

3.1. Pollution Level. Comparisons of PAHs concentrations in PM₁₀ among Nanjing and other regions are shown in Table 2. The mean concentrations of PAHs and BaP_{eq} were 7.49 ± 2.60 ng/m³ and 1.21 ± 0.24 ng/m³, respectively. The mean BaP_{eq} concentration was lower than 2.5 ng/m³, the daily limited standard of atmospheric BaP in the newest ambient air quality standard of China (GB3095-2012), whereas it was greater than 1 ng/m³, the European Union standard, indicating atmospheric PAHs pollution [17].

Compared with data from other regions (Table 2), the concentration of PAHs in summer in Nanjing was lower than that in Beijing, Shijiazhuang, and Guangzhou in summer.

TABLE 2: Comparisons of PAHs concentrations (ng/m^3) in PM_{10} among Nanjing and other regions.

Region	Sampling time	PM fractions	Concentrations of PAHs (ng/m^3)	BaP _{eq}	Amount of PAHs	References
Nanjing, China	Summer, 2015	PM_{10}	7.49	1.21	16	<i>This study</i>
Beijing, China	Summer, 2006	PM_{10}	60.05	—	18	[18]
Shijiazhuang, China	Summer, 2013	PM_{10}	26.9	—	14	[19]
Chengdu, China	Summer, 2012	PM_{10}	64.21	9.54	16	[10]
Taiyuan, China	Summer and autumn, 2009-2010	PM_{10}	63.8	13.79	16	[20]
Guangzhou, China	Summer, 2002	PM_{10}	26.01	—	16	[21]
Shanghai, China	Years 2011-2012	PM_{10}	36.9	5.4	16	[22]
Malaysia	Years 2013-2014	$\text{PM}_{2.5}$	2.79	0.57	16	[23]
Eastern Germany	Summer, 2006	PM_{10}	3.21	—	12	[24]
Veneto, Italy	Summer, 2011	PM_{10}	0.2	—	8	[25]
Kathmandu Valley, Nepal	Years 2013-2014	TSP	155	26.2	15	[26]
Ulsan, Korea	Summer, 2011	PM_{10}	21.9 ± 6.6	5.53	16	[27]
Kumasi, Ghana	Summer, 2011	PM_{10}	$3.0 \pm 3.5^{\text{PS}}$ $25 \pm 7.9^{\text{CC}}$	0.30 5.30	16	[28]

PS: pristine site; CC: city center.

Also, it was lower than that in Taiyuan in both summer and autumn and Shanghai in the whole year. For cities from all over the world, the concentration of PAHs in Nanjing was lower than that in Ulsan, the city center of Kumasi in summer, and Kathmandu Valley in the whole year. However, it was still higher than those in some areas, including Eastern Germany, Veneto, and the pristine site of Kumasi in summer and Malaysia in the whole year. BaP_{eq} concentration of PAHs in PM_{10} in this study was lower than that in Chengdu in summer, Taiyuan in both summer and autumn, and Shanghai in the whole year. As for other countries, it was higher than that in the pristine site of Kumasi in summer and Malaysia in the whole year, while it was lower than that in Ulsan, the city center of Kumasi in summer, and Kathmandu Valley in the whole year.

3.2. Source Identification. PAHs molecular diagnostic ratios have long been used as a tool for PAHs source identification purposes [5, 26, 29–32], whereas some molecular diagnostic ratios were suggested to be of limited use as a source identification tool [33, 34]. Comparisons of diagnostic ratio results among Nanjing and other regions are presented in Table 3.

For the ratio of ANT/(ANT + PHE) (Figure 2(a)), the values were all greater than 0.1, indicating combustion sources. Likewise, for the ratio of BaA/(BaA + CHR) (Figure 2(a)), the values were all greater than 0.35, indicating combustion processes. The above ratios both indicated combustion process. All kinds of combustion processes were common sources of particle PAHs, being similar with the results in Jilin, China, in the whole year, in Xuzhou, China, in summer, autumn, and winter, in Shenzhen, China, in summer, in Giza, Egypt, in summer, and in Kuala Lumpur, Malaysia, in spring (Table 3). Combustion can be viewed as the major source of the atmospheric PAHs in summer in Nanjing.

For the ratio of FLA/(FLA + PYR) (Figure 2(b)), the values were all greater than 0.5, indicating biomass and coal combustion. For the ratio of IcdP/(IcdP + BghiP) (Figure 2(b)), the values ranged from 0.31 to 0.60 with a mean of 0.51, primarily indicating biomass and coal combustion, along with petroleum combustion. The above ratios primarily indicated fuel combustion. Biomass and coal combustion is common in many developing regions (Table 3).

For the ratio of BaP/BghiP (Figure 2(c)), the values were all greater than 0.6, indicating traffic exhaust. The outcome may be explained by the results of FLA/(FLA + PYR) as traffic exhaust originates mainly from fuel combustion. With the development of traffic transportation, traffic exhaust has become a significant source of atmospheric PAHs (Table 3). For the ratio of FLO/(FLO + PYR) (Figure 2(c)), the values ranged from 0.35 to 0.64 with a mean of 0.56, primarily indicating diesel vehicle emissions with gasoline vehicle emissions attached. The outcome was similar with that in Xuzhou, China, in summer, autumn, and winter, Taichung, Taiwan, China, in the whole year, and Flanders, Belgium, in the whole year (Table 3). The above ratios indicated traffic exhaust, especially diesel vehicle emissions.

To summarize, atmospheric PAHs in PM_{10} in summer in Nanjing originated mainly from combustion processes. Among these, vehicle emissions were outstanding, especially diesel vehicle emissions.

3.3. Risk Assessment. The cumulative probability distributions of the calculated inhalation exposure to PAHs for diverse population groups in Nanjing are shown in Figure 3. In summer, the median BaP_{eq} concentrations of inhalation exposure in Nanjing were 10.72, 15.43, 22.43, 14.19, 10.44, 14.86, 16.82, and 12.87 ng/d for boys, male adolescents, male adults, male seniors, girls, female adolescents, female adults, and female seniors, respectively (Figure 3). The rankings of

TABLE 3: Comparisons among diagnostic ratios found in this study with other urban areas in the world.

Region	Sampling time	Object	Diagnostic ratios						References
			ANT/((ANT + PHE)	BaA/(BaA + CHR)	FLA/(FLA + PYR)	IcdP/(IcdP + BghiP)	BaP/BghiP	FLO/(FLO + PYR)	
Nanjing, China	Summer, 2015	PM ₁₀	0.12	0.43	0.53	0.51	1.06	0.56	This study
Jilin, China	Year, 2012	PM ₁₀	0.16	0.37	—	—	1.47	—	[35]
Beijing, China	Summer, 2006	PM ₁₀	0.11	0.27	0.46	0.20	—	—	[18]
Xuzhou, China	Summer and autumn, 2010	PM ₁₀	0.57	—	—	0.66	0.54	0.52	[36]
Xuzhou, China	Winter, 2010	PM ₁₀	0.44	—	—	0.56	1.16	0.52	[36]
Xian, China	Summer, 2009	Air	0.08 ± 0.04	0.29 ± 0.07	0.61 ± 0.01	0.55 ± 0.01	—	—	[37]
Shenzhen, China	Summer, 2010	PM ₁₀	0.26	—	—	0.48	0.42	—	[38]
Taichung, Taiwan, BS China	Years 2002-2003	Air	—	—	—	0.55	—	0.55	[39]
Giza, Egypt	Summer, 2007	Air	0.46	0.39	0.61	0.35	0.77	—	[40]
Dourados, Brazil	Year, 2010	Air	—	0.34 ± 0.07	—	—	0.88 ± 0.31	—	[29]
Kuala Lumpur, Malaysia	Spring, 2011	PM ₁₀	0.13	0.36	0.43	0.23	0.27	—	[30]
Delhi, India	Years 2009-2010	PM ₁₀	—	0.61 ± 0.05	0.53 ± 0.07	0.30 ± 0.12	1.10 ± 0.51	—	[41]
		Years 2001–2003	—	—	—	—	—	0.71	[8]

BS: background site.

FIGURE 2: Scatter diagrams for diagnostic ratios.

exposure levels according to age and gender were adults > adolescents > seniors > children and males > females, respectively, in accordance with the rankings of inhalation rate for all age and gender groups, respectively.

Researches concerning daily PAHs inhalation exposure level are limited. The median BaP_{eq} concentrations of inhalation exposure to total atmospheric PAHs in Taiwan, China, were 1590 and 1628 ng/d for children and adults, respectively. The data were much greater than the corresponding ones in this study as the samples in Taiwan contained 21 PAH compounds [13]. The median BaP_{eq} concentrations of inhalation exposure to total atmospheric PAHs in Taiyuan, China,

for diverse population groups were 81.7 ng/d to 265.0 ng/d [14], still being higher than the results in this study resulting from serious PAHs pollution in Taiyuan. The mean BaP_{eq} concentrations of inhalation exposure to total atmospheric PAHs in outdoor environments of Tianjin, China, were found to be 321.6 and 519.0 ng/d for children and adults, respectively, being much higher than the results in this study, resulting from serious PAHs pollution in Tianjin [42]. All the comparisons indicated that the daily inhalation exposure levels in Nanjing were relatively low.

The cumulative probability distributions of the calculated ILCR for different population groups in Nanjing in summer

FIGURE 3: Probability distributions of daily inhalation B[a]P_{eq} exposure in PM₁₀ in summer in Nanjing.

are presented in Figure 4. The median values of ILCR were estimated to be 1.26×10^{-7} , 9.08×10^{-8} , 6.07×10^{-7} , 9.52×10^{-8} , 1.36×10^{-7} , 9.69×10^{-8} , 5.53×10^{-7} , and 1.04×10^{-7} for boys, male adolescents, male adults, male seniors, girls, female adolescents, female adults, and female seniors, respectively (Figure 4). According to USEPA, the acceptable level of risk is less than one in a million chance of additional human cancer over a 70-year lifetime (ILCR = 10^{-6}), whereas the level of risk which is one in ten thousand or greater (ILCR = 10^{-4}) is considered serious and in this case more attention should be paid to the health problems. The median values of ILCR in Nanjing in summer were in the acceptable level. ILCR values at 84.02th, 87.42th, 59.88th, 87.32th, 83.40th, 87.06th, 61.18th, and 86.20th percentile for boys, girls, male adolescents, female adolescents, male adults, female adults, male seniors, and female seniors, respectively, were greater than 10^{-6} (Figure 4), indicating low potential carcinogenic risk. ILCR values were larger than 10^{-4} at 99.92th, 99.98th, 99.2th, 99.96th, 99.96th, 99.98th, 99.4th, and 99.98th percentile for the above groups, respectively (Figure 4), indicating significant cancer risk. With respect to age, the ranking of ILCR in decreasing order was as follows: adults, children, seniors, and adolescents for both males and females. The greatest ILCR values for adults resulted from the greatest daily inhalation exposure levels and exposure duration, despite their highest body weight. It is worth noting that although the daily inhalation exposure levels and exposure duration of children were the lowest, the lowest body weight of children made its ILCR values greater than those for both adolescents and seniors. Children are sensitive

to health risk and more attention should be paid. According to gender, females showed higher cancer risk in all age groups except the adults (Figure 4), which was not in accordance with exposure results (Figure 4). Although the exposure of females was less than that of males (Figure 4), the body weight of females was much lower, resulting in higher ILCR value (Figure 4).

Researches on lung cancer risk assessment for PAHs are limited. The mean values of ILCR caused by inhalation exposure to PM₁₀-bound PAHs were 7.23 and 7.43×10^{-4} for adults and children in Amritsar, India [43], being greater than the corresponding values in this study. The mean value of ILCR caused by PM₁₀-bound PAHs was estimated to be 3.01×10^{-7} for general citizens in an urban area of Kuala Lumpur, Malaysia [30], being higher than almost all groups in this study (Figure 4). The median values of ILCR caused by 16 PAHs in suburban area of Shanghai, China, were 7.72×10^{-7} , 4.76×10^{-7} , 3.79×10^{-6} , 7.41×10^{-7} , 4.63×10^{-7} , and 3.49×10^{-6} for girls, female adolescents, female adults, child boys, male adolescents, and male adults, respectively [44], being a little larger than the corresponding values in this study (Figure 4). The median values of ILCR caused by total PAHs in urban districts of Taiyuan, China, an industrial city, were estimated to be 2.08×10^{-6} , 1.56×10^{-6} , 1.03×10^{-5} , 1.60×10^{-6} , 2.14×10^{-6} , 1.58×10^{-6} , 9.26×10^{-6} , and 1.67×10^{-6} for boys, male adolescents, male adults, male seniors, girls, female adolescents, female adults, and female seniors, respectively [14], also being larger than the corresponding values in this study (Figure 4). Therefore, ILCR for residents in Nanjing was in a low level compared with results from regions worldwide.

FIGURE 4: Cumulative probability of respiratory incremental life time cancer risk for population groups in Nanjing in summer.

4. Conclusion

The mean BaP_{eq} concentration of PM_{10} -bound PAHs in summer in Nanjing was much less than the Chinese National Standard, whereas it was higher than the European Union standard, indicating PAHs pollution. Atmospheric PAHs in summer in Nanjing originated mainly from combustion processes, in which traffic exhaust (especially diesel vehicle emissions) contributed a lot. The rankings of inhalation exposure levels according to age and gender was adults > adolescents > seniors > children and males > females, respectively, in accordance with the rankings of inhalation rate for all age and gender groups, respectively. The median values of ILCR in Nanjing in summer were in the acceptable level. ILCR values for adults were greater than those for other age groups, indicating that adults might be the main objects in the process of lung cancer risk control. Children were sensitive to health risks of environmental pollution.

Competing Interests

The authors declare that there are no competing interests.

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