Postprint of an Association Study on Air Pollutant Exposure and Dyslipidemia in Middle-aged and Elderly Adults in Western Hunan Mining Areas

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Abstract

Background: Dyslipidemia has become a global public health issue; however, research on the relationship between air pollution and dyslipidemia remains limited.

Objective: To explore the association between air pollutant exposure and dyslipidemia among middle-aged and elderly residents in the western Hunan mining area.

Methods: A cluster random sampling method was employed from 2018 to 2019, with communities or villages as sampling units, to select 1,965 residents aged 45 years and older from the western mining areas of Hunan Province as study subjects. Demographic characteristics, lifestyle factors, medical history, and blood lipid indicators [total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-c), and high-density lipoprotein cholesterol (HDL-c)] were collected through questionnaire surveys, physical examinations, and laboratory tests. Based on air pollution data released by meteorological authorities, the inverse distance weighting interpolation method was used to estimate air pollutant concentrations in the mining area. Individual daily intake of air pollutants (total ADD) was then estimated using the Air Quality Composite Index (AQCI). Unconditional logistic regression analysis was performed to examine the relationship between total ADD and blood lipid levels.

Results: Among the 1,965 participants, 498 cases of dyslipidemia were identified, yielding a prevalence of 25.3%. The abnormal rates for TC, TG, HDL-c, and LDL-c were 12.9%, 10.6%, 5.4%, and 8.8%, respectively. Total ADD ranged from 0.53 to 1.83 (m^3/kg/day). After adjusting for gender, age, smoking, alcohol consumption, education level, income, body mass index (BMI), hypertension, and diabetes, compared with the Q1 group for total ADD levels, the Q2, Q3, and Q4 groups exhibited significantly increased risk of abnormal TG [OR (95% CI): 2.61 (1.38, 4.93), 3.42 (1.51, 7.73), and 5.12 (1.77, 14.85), respectively]. The Q4 group also showed increased risk of abnormal TC [OR (95% CI): 2.62 (1.02, 6.75)].

Conclusion: Air pollutant exposure is associated with abnormal TC and TG.

Full Text

Association between Air Pollutant Exposure and Dyslipidemia in Middle-aged and Elderly People in Western Mining Area of Hunan Province

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Abstract

Background: Dyslipidemia has become a major global public health concern, yet reports on the relationship between air pollution and dyslipidemia remain scarce. **Objective:** To explore the association between air pollutant exposure and dyslipidemia among middle-aged and elderly individuals in the western mining areas of Hunan Province. **Methods:** A total of 1,965 residents aged 45 years and older from western Hunan mining areas were selected through cluster random sampling from 2018 to 2019, using communities or villages as sampling units. Demographic characteristics, lifestyle factors, disease history, and lipid indicators [total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-c), and high-density lipoprotein cholesterol (HDL-c)] were obtained through questionnaires, physical examinations, and laboratory tests. Air pollution data released by meteorological departments were used to estimate pollutant concentrations in the mining areas via inverse distance weighting interpolation. Individual average daily dose (ADD) of air pollutants was then estimated based on the Air Quality Comprehensive Index (AQCI). Unconditional logistic regression was employed to analyze the relationship between ADD and lipid levels. **Results:** Among the 1,965 participants, 498 cases of dyslipidemia were identified, yielding a prevalence rate of 25.3%. The abnormal rates for TC, TG, HDL-c, and LDL-c were 12.9%, 10.6%, 5.4%, and 8.8%, respectively. The range of ADD was 0.53–1.83 (m^3/kg/day). After adjusting for sex, age, smoking, alcohol consumption, education level, income, body mass index (BMI), hypertension, and diabetes, individuals in Q2, Q3, and Q4 groups showed significantly higher risks of TG abnormality compared with the Q1 group [OR (95%CI) values of 2.61 (1.38, 4.93), 3.42 (1.51, 7.73), and 5.12 (1.77, 14.85), respectively]. The Q4 group also exhibited a significantly higher risk of TC abnormality [OR (95%CI) = 2.62 (1.02, 6.75)]. **Conclusion:** Air pollutant exposure is associated with abnormal TC and TG levels.

Keywords: Air pollutants; Dyslipidemia; Middle-aged and elderly people; Mining area

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A World Health Organization report indicates that ambient air pollution causes 3 million premature deaths globally in both urban and rural areas, with 88% occurring in low- and middle-income countries [?]. Data show that in 2010, ambient air pollution in China resulted in 1.234 million deaths and 250 million disability-adjusted life years (DALYs) lost, making it the fourth leading disease burden in the country [?]. Long-term exposure to air pollutants is associated with cardiovascular disease morbidity and mortality [?], potentially through mechanisms such as systemic inflammation and oxidative stress [?]. These mechanisms can lead to or accompany intermediate diseases and symptoms (e.g., hypertension, dyslipidemia, obesity) known as metabolic risk factors for cardiovascular disease.

Dyslipidemia is a chronic metabolic disease characterized by abnormalities in any of the following blood lipid indicators: total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-c), and high-density lipoprotein cholesterol (HDL-c) [?, ?]. When combined with risk factors such as smoking and obesity, dyslipidemia increases the risk of coronary heart disease (CHD) and atherosclerosis (ASHD). While numerous studies have explored relationships between air pollutants and cardiometabolic risk factors like obesity and hypertension [?, ?], research on the association between air pollutants and dyslipidemia remains limited. This study therefore investigates this relationship among middle-aged and elderly individuals in mining areas.

1.1 Study Subjects

The study was conducted in two mining areas in western Hunan, primarily engaged in realgar and lead-zinc mining and smelting with over ten years of operational history [?, ?]. The mining and smelting processes generate particulate matter and CO, while realgar smelting additionally produces SO_2. Using cluster random sampling with communities or villages as sampling units, we selected residents aged 45 years and older [?] who had lived locally for at least five years with annual residence exceeding six months. After excluding participants without lipid indicator values and outliers (defined as values beyond mean ± 5 standard deviations for lipid indicators, height, weight, etc.), 1,965 individuals were included in the final analysis.

1.2.1 Exposure Measurement

Accounting for the lag effect between exposure and outcome, we collected two years of air pollutant concentration data from monitoring stations prior to the survey period via the real-time air quality monitoring website (http://www.aqistudy.cn). Pollutant concentrations in the western Hunan mining areas were estimated using inverse distance weighting interpolation based on data from the three nearest monitoring stations, with the formula [?, ?] as follows:

(cid:2871) (cid:3036)(cid:2880)(cid:2869) (cid:2871) (cid:3036)(cid:2880)(cid:2869)
C(cid:2919) (cid:2870)) d(cid:2919) (cid:2870)) d(cid:2919)

To assess individual comprehensive exposure to air pollutants, we used the Air Quality Comprehensive Index (AQCI) to estimate individual average daily dose (ADD). AQCI is a dimensionless index describing urban ambient air quality that integrates pollution levels of six pollutants: $PM_{2\cdot5}$, PM_{10}, SO_2, NO_2, CO, and O_3, with higher values indicating greater pollution severity. The monthly AQCI calculation method [?, ?] is:

AQCI = Ii =

Where: Ci represents the concentration of pollutant i (mg/m^3 for CO, g/m^3 for others; monthly mean for $PM_{2\cdot5}$, PM_{10}, SO_2, and NO_2; specific percentile concentrations for CO and O_3); Si represents the annual average secondary standard for pollutant i [?] (same units as Ci; daily average secondary standard for CO; 8-hour average secondary standard for O_3).

Individual average daily dose (ADD) was then estimated by substituting AQCI averages for concentration values. The ADD calculation formula [?] is:

IR × C ED × EF × AT × BW

Where: ADD represents the average daily dose during the two years preceding the survey (m^3/kg/day); ADD represents the average daily dose in year n (m^3/kg/day); Ci represents the annual average AQCI in year n; IR represents inhalation rate (m^3/day); EF represents exposure frequency (days/year); ED represents exposure duration (years); BW represents body weight (kg); AT represents average exposure time (days). Exposure parameter values are shown in Table 1 .

1.2.2 Survey Methods

Trained interviewers collected information on demographic characteristics, lifestyle factors, medical history, and medication use through face-to-face interviews using standardized questionnaires. All physical examinations and laboratory tests were conducted by physicians from Xiangya Hospital of Central South University, the Third Xiangya Hospital of Central South University, and Hunan Provincial Institute for Occupational Disease Prevention. The study was approved by the Ethics Committee of Xiangya Hospital of Central South University, and all participants provided informed consent.

1.2.3 Variable Definitions

Dyslipidemia was defined according to the *Chinese Guidelines for the Prevention and Treatment of Dyslipidemia in Adults* [?] as meeting any of the following criteria: TC $\geq$ 6.2 mmol/L, TG $\geq$ 2.3 mmol/L, HDL-C $<$ 1.0 mmol/L, or LDL-C $\geq$ 4.1 mmol/L.

Hypertension was defined according to the *Chinese Guidelines for the Prevention and Treatment of Hypertension* [?] as systolic blood pressure (SBP) $\geq$ 140 mmHg and/or diastolic blood pressure (DBP) $\geq$ 90 mmHg without antihypertensive medication, or prior hypertension diagnosis with current medication use (even if blood pressure $<$ 140/90 mmHg).

Diabetes was defined according to the *Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2017 Edition)* [?] as fasting plasma glucose (FPG) $\geq$ 7.0 mmol/L on physical examination or prior diabetes diagnosis.

Smoking status: Current smoking was defined as consuming at least one cigarette daily for over six months; former smoking as previous smoking with current cessation; never smoking as no tobacco consumption throughout life.

Alcohol consumption: Current drinking was defined as consuming alcoholic beverages at least once weekly for over six months; former drinking as previous alcohol use with current cessation; never drinking as no alcohol consumption throughout life.

1.3 Data Analysis

Statistical analysis was performed using SPSS 26.0 and Excel 2010. Continuous variables following normal distribution were expressed as mean $\pm$ standard deviation (SD), while non-normally distributed or unknown distribution variables were presented as median (interquartile range, IQR). Categorical variables were expressed as percentages. Chi-square tests were used to compare dyslipidemia prevalence across different characteristics. Using lipid abnormality as the dependent variable and ADD [categorized into Q1 (0.5–0.7 m^3/kg/day), Q2 (0.7–0.9 m^3/kg/day), Q3 (0.9–1.1 m^3/kg/day), and Q4 ($>$ 1.1 m^3/kg/day)] as the independent variable, unconditional logistic regression analysis was conducted after controlling for sex, age, smoking, alcohol consumption, education level, income, BMI, hypertension, and diabetes.

2.1 Air Pollutant Levels in Mining Areas

The annual average AQCI values for the two western Hunan mining areas were 3.40 and 3.64, respectively. In the realgar mining area, annual average concentrations were: $PM_{2\cdot5}$ 36.63 g/m^3, PM_{10} 54.93 g/m^3, SO_2 9.35 g/m^3, NO_2 15.39 g/m^3, CO 1.93 mg/m^3, and O_3 125.33 g/m^3. In the lead-zinc mining area, corresponding values were: $PM_{2\cdot5}$ 36.59 g/m^3, PM_{10} 64.48 g/m^3, SO_2 7.72 g/m^3, NO_2 13.83 g/m^3, CO 0.98 mg/m^3, and O_3 113.71 g/m^3. The annual average $PM_{2\cdot5}$ concentrations in both mining areas exceeded the National Ambient Air Quality Standards (Grade II) [?].

2.2 Characteristics of the Study Population

As shown in Table 2 , among the 1,965 middle-aged and elderly participants, 498 cases of dyslipidemia were detected (prevalence 25.3%), including 264 males (53.0%) and 234 females (48.0%). Univariate analysis revealed statistically significant differences in dyslipidemia prevalence across age groups, BMI categories, smoking status, ADD levels, and hypertension status (all $P < 0.05$).

2.3 Dyslipidemia Across Different ADD Levels

The abnormal rates for TG, TC, HDL-c, and LDL-c were 10.6%, 12.9%, 5.4%, and 8.8%, respectively. Significant differences in TG and HDL-c abnormality rates were observed across ADD quartiles ($P < 0.05$), as presented in Table 3 .

2.4 Logistic Regression Analysis of ADD and Dyslipidemia

Logistic regression analysis revealed that when adjusting for age and sex (Model 1), TG and HDL-c abnormality rates decreased with increasing ADD levels (both P-trend < 0.05). However, after adjusting for relevant confounders (Model 2 or Model 3), TG and TC abnormality rates increased with ADD levels (both P-trend < 0.05). Compared with the Q1 group, participants in Q2, Q3, and Q4 groups showed significantly higher risks of TG abnormality, while the Q4 group exhibited significantly higher risk of TC abnormality (Table 4).

3 Discussion

With improving living standards, the incidence of dyslipidemia has risen annually. A 2019 study reported a global dyslipidemia prevalence of approximately 15.2%, establishing it as a major global public health issue [?]. Investigating dyslipidemia risk factors is therefore crucial, yet reports on the association between air pollutants and dyslipidemia remain limited.

Our study, conducted in two western Hunan mining areas, found that annual average $PM_{2\cdot5}$ concentrations exceeded National Ambient Air Quality Standards (Grade II), consistent with findings from a rare earth mining area study in Baotou, northern China [?]. The remaining five air pollutants in our mining areas were within Grade II standards, differing from Phenny Mwaanga et al.' s report [?] that SO_2 and particulate matter (PM) dominate mining area air pollution. This discrepancy may be attributed to our study areas' focus on realgar and lead-zinc mining. Although realgar smelting produces SO_2, environmental remediation efforts initiated in 2012 have yielded some success, resulting in reduced SO_2 concentrations.

Our results show a 25.3% dyslipidemia prevalence among middle-aged and elderly residents in western Hunan mining areas, higher than global [?] and Mianyang elderly population [?] rates but lower than Chinese adult [?] and Zhangjiagang middle-aged and elderly [?] rates. This suggests dyslipidemia may be associated with regional economic development, health awareness, dietary habits, and other factors, with air pollution representing just one influencing factor.

An Iranian national study [?] found positive correlations between Air Quality Index (AQI) and both TG and TC. A rural Chinese study in Henan [?] reported positive associations between $PM_{2\cdot5}$ and TC. Research based on 11,623 adult participants [?] demonstrated that each 11.1 g/m^3 increase in PM_{10} was associated with a 2.42% increase in TG (95%CI: 1.09–3.76%) and a 1.43% increase in TC (95%CI: 1.21–1.66%). Additionally, Cai et al. [?] found PM_{10} and NO_2 were associated with higher TG levels [1.90% (95%CI: 1.50–2.40%) and 2.20% (95%CI: 1.60–2.70%), respectively] in a study of 144,082 participants.

Our findings demonstrate positive associations between daily air pollutant intake and TG and TC levels among middle-aged and elderly individuals, consistent with the aforementioned studies. The relationship between air pollutants and dyslipidemia, along with its underlying mechanisms, warrants attention. Particularly, dose-response relationships between different exposure levels and dyslipidemia require further in-depth investigation; this study represents an exploratory attempt.

This study linked ambient air pollutant exposure to population health outcomes (dyslipidemia) by surveying middle-aged and elderly mining area residents, collecting two years of monitoring station data, and applying inverse distance weighting interpolation, AQCI, and ADD calculations. The results demonstrate air pollutant exposure impacts dyslipidemia among middle-aged and elderly individuals, providing a reference basis for future research.

Several limitations should be acknowledged. First, although we adjusted for dyslipidemia-related factors including age, sex, smoking, alcohol consumption, BMI, and hypertension, we did not consider other relevant factors such as diet, which may introduce residual confounding. Second, we lacked time-activity pattern data for indoor and outdoor activities, preventing precise individual exposure estimation and potentially causing exposure misclassification. Third, as a cross-sectional study, we cannot establish causal relationships between air pollutant exposure and dyslipidemia.

Author Contributions: Feng Shuidong contributed to manuscript review, editing, and revision. Li Junyan was responsible for original draft preparation, formal analysis, and revision. Deng Shuxiang, Cao Mengyue, Chen Limou, Tang Yan, Tang Peng, and Liu Jun contributed to formal analysis and manuscript review. Shen Minxue supervised investigation, data curation, and resource provision. Yang Fei supervised investigation, data curation, funding acquisition, conceptualization, project administration, and manuscript review. All authors approved the final manuscript.

Conflict of Interest: All authors declare no competing interests.

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