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The Joint Effects of Long-term Exposure to Multiple Air Pollutants on Metabolic Syndrome

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Extended Abstract

Particulate matter of diameters ≤ 2.5 μm ($PM_{2.5}$), nitrogen dioxide (NO_2), and ozone (O_3) have been noted to induce health damage. However, previous studies have lacked a comprehensive examination of the joint effects of these air pollutants on metabolic syndrome (MetS), a cluster of crucial cardiovascular risk factors. This research aims to identify the joint effects of long-term $PM_{2.5}$, NO_2, and O_3 exposure on incident MetS and MetS indicators.

We included Taiwan MJ cohort [1] participants to investigate the multi-pollutant effects on the incident MetS, which was assessed through five indicators—waist circumference, triglycerides, high-density lipoprotein cholesterol (HDL-C), fasting blood glucose, and blood pressure [2]. Participants who did not have MetS at baseline and had at least two visits were included in the analysis. Annual average exposure to $PM_{2.5}$, NO_2, and O_3 was estimated at each participant's address using satellite-based spatial-temporal models [3, 4]. To adjust for potential collinearity among pollutants, we applied elastic net-regularized Cox models to evaluate the individual coefficient of each pollutant and construct the environmental risk score (ERS) [5] to represent the joint effect of three pollutants. If three pollutants' coefficients show consistent signs, we would calculate the weight of each pollutant as the proportion of its coefficient to the sum of coefficients for all pollutants. In addition, we investigated the multi-pollutant joint effects on the incidences of five MetS indicator disorders using the same methods.

A total of 58,942 adults were included and followed for a median duration of 5.4 (IQR: 4.0–7.2) years. There were 6,934 participants developing incident MetS, 6,128 with abdominal obesity, 7,554 with elevated triglycerides, 4,760 with reduced HDL-C, 8,121 with elevated blood pressure, and 13,185 with elevated fasting blood glucose during the follow-up. $PM_{2.5}$, NO_2, and O_3 jointly elevated the risk of incident MetS with a hazard ratio of 1.20 (95% CI: 1.16–1.25) per standard deviation increase in ERS. $PM_{2.5}$ made the most contribution to inducing MetS (weight of 65%), followed by NO_2 (25%) and O_3 (10%). The ERS hazard ratio was estimated as 1.15 (95% CI: 1.11–1.20) for abdominal obesity, 1.18 (1.14–1.22) for elevated triglycerides, 1.23 (1.18–1.29) for reduced HDL-C, 1.18 (1.15–1.23) for elevated blood pressure, and 1.11 (1.08–1.13) for elevated fasting blood glucose. $PM_{2.5}$ exhibited the most pronounced positive effect on elevated fasting blood glucose, followed by NO_2 with a secondary positive impact, whereas O_3 demonstrated a slightly negative effect. For four other indicator disorders, all three pollutants were positively associated with outcomes, and thus the specific weight was calculated for each pollutant. $PM_{2.5}$ played the dominant role with a weight ranging from 47% for abdominal obesity to 60% for reduced HDL-C. NO_2 had the second highest contribution ranging from 24% for reduced HDL-C to 34% for elevated triglycerides. Meanwhile, the weight of O_3 varied from 9% for elevated triglycerides to 19% for abdominal obesity.

In conclusion, long-term $PM_{2.5}$, NO_2, and O_3 exposure jointly increase the risk of developing incident MetS and MetS indicator disorders. $PM_{2.5}$ exerts the strongest effects among the three pollutants, while NO_2 and O_3 also have remarkable impacts. Coordinated control of these three pollutants is imperative to improve the cardiometabolic health of the general population.

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