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The Influence of Long-Term Exposure to Nitrogen Dioxide on Cardiovascular Event Risks in CKD Patients using Machine Learning-based Ultra-High-Resolution Air Pollution Forecasts

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Objectives : Chronic kidney disease (CKD) elevates the risk of major adverse cardiovascular events (MACE), a leading cause of death in these patients. Nitrogen dioxide (NO_2), a major air pollutant, is linked to increased cardiovascular harm in the general population, yet its impact on individuals with CKD is not well-documented. This research aims to assess the effect of long-term NO_2 exposure on the risk of MACE in CKD patients.
Methods : A retrospective cohort study was conducted, involving 51,473 CKD patients from medical centers affiliated with Seoul National University, who visited between 2001 and 2016, with follow-up data collected until February 28, 2023. Participants were selected based on an initial eGFR ≥30mL/min/1.73m^2 and no previous MACE history. NO_2 exposure levels were estimated using machine learning-based ultra-high-resolution air pollution forecasts. The primary outcome was the incidence of MACE, defined by the occurrence of acute myocardial infarction, ischemic stroke, cardiovascular death, or revascularization, as recorded in electronic medical records. The association between NO_2 exposure and MACE was analyzed using a time-varying Cox proportional hazards model.
Results : A total of 44,613 individuals were included in the study, with 3,758 experiencing MACE. After adjusting for factors like age, sex, BMI, and smoking status, it was found that CKD patients exposed to higher NO_2 concentrations had an increased risk of MACE, particularly those with eGFR <60 mL/min/1.73m² (Hazard Ratio [HR], 1.118; 95% Confidence Interval [CI], 1.012-1.234; p-value, 0.027 and older adults aged 65 and above (HR, 1.011; 95% CI, 1.002-1.019; p-value, 0.001).
Conclusions : Chronic NO_2 exposure significantly correlates with an elevated risk of cardiovascular events in CKD patients, highlighting a critical public health concern. This underscores the importance of addressing air pollution as a factor in managing cardiovascular risk among CKD patients, especially for the elderly and those with reduced kidney function.