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Predicting the Impact of PM2.5 Exposure on Kidney Transplant Recipients: A Machine Learning Approach to Assessing Clinical Outcomes

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Objectives : Previous investigations have explored the adverse health effects of particulate matter (PM) air pollution on clinical outcomes for kidney diseases. The impact of fine particulate matter (PM2.5) on kidney transplant (KT) recipients, however, is not fully understood in terms of predictive analysis. This study aims to address this gap by employing a machine learning model to predict PM 2.5 levels and assess their association with clinical outcomes in KT recipients.
Methods : A high-resolution ensemble prediction model was crafted using machine learning techniques by the collaborative effort of the Busan National University and Seoul National University team, drawing on historical air pollution data to forecast PM2.5 levels. This multicenter investigation encompassed 5,266 KT recipients across three tertiary hospitals in Korea, spanning from January 2002 to December 2020. We assessed the relationship between the predicted concentrations of PM2.5 by machine learning and the risk of all-cause mortality and death-censored graft failure (DCGF) through Cox proportional hazards analyses.
Results : The machine learning models accurately predicted the PM2.5 concentrations. Over a median follow-up period of 5.7 years, the annual mean PM2.5 concentration following kidney transplantation was 24.69 ± 3.53 μg/m^3. After adjusting for potential confounding variables, elevated predicted levels of PM2.5 were significantly associated with heightened risks of all-cause mortality (hazard ratio [HR], 1.560; 95% confidence interval [CI], 1.495 – 1.627) and DCGF (HR, 1.573; 95% CI, 1.517 – 1.631). Further subgroup analyses by gender and age heightened that PM2.5 levels contributed to an increased the risk of mortality and DCGF in KT recipients.
Conclusions : The findings affirm that predicted PM2.5 concentrations via machine learning are significantly tied to DCGF and all-cause mortality in KT recipients. These insights advocate for the utilization of predictive analytics in facilitating robust health risk management and the implementation of preventive strategies moving forward.