# Discussion

Environmental management and public health protection benefit from the comprehensive study of Beijing's air quality data which produces important specific findings. The current research proves air pollution in Beijing develops through intricate links between human-produced emissions along with environmental elements and geographical considerations which need complex analytical techniques to understand and foretell pollution patterns.

## 6.1 Pollution Determinants and Atmospheric Processes

Meteorological variables established themselves as the major element which accounted for forty-three percent of PM2.5 pattern variations by maintaining various causal relationships. During winter inversions in the atmosphere created steady conditions that enclosed pollution nearer to the ground, causing PM2.5 counts to reach 2.1 times more than summer averages. The wind patterns had a powerful effect by carrying industrial emissions from Hebei province when winds blew from the north, while clean air from industrial areas reached the northern regions when winds came from the south. Research investigations determine that d 3.5 m/s became a fundamental limit for wind speed, which requires enhancing air pollution dispersion.

Research findings demonstrated that daytime PM2.5 measurements peaked twice in the periods 08:00 to 10:00 and 18:00 to 20:00 due to traffic activities in the study area. Studies showed particulate counts decreased steeply throughout weekend days by 12-15%, which established industrial and construction activities as major worsening factors for particulate pollution (Pebesma and Bivand, 2023). Monitoring stations throughout the entire city displayed uniform daily patterns, indicating that both emissions from different sources and atmospheric processes operate in unison across the region.

## 6.2 Public Health Implications

Health risks connected to the research findings emerge as serious concerns. The population of Beijing encounters unsafe air quality regularly because 68% of the measured PM2.5 levels surpass the WHO's acceptable standard of 25 μg/m³ within 24 hours. Excessive air pollution reached a dangerous level when 22% of the collected measurements reached 75 μg/m³ because this pollution intensity has been scientifically proven to increase death rates from respiratory problems and cardiovascular conditions. The cold season auto-generated multiple dangerous conditions (PM2.5 > 150 μg/m³) across multiple days because of temperature inversion occurrences. A spatial analysis showed the city had severe inequalities regarding population exposure levels. The average annual PM2.5 measurements in the business district of Aotizhongxin came to 92.3 μg/m³, which showed a 47% difference from background stations that were measured in rural areas. The identified hotspots demand priority intervention to safeguard inhabitants residing in these areas. Lag effects were discovered through the research since pollution remained elevated by 48-72 hours even after weather conditions became better, indicating that contaminants accumulated within the urban setting.

## 6.3 Model Performance and Applications

The XGBoost model achieved an R² of 0.93 when tested on the prediction framework due to its effective predictive capabilities. The model achieved high accuracy in detecting extreme pollution conditions, reaching 83% success with predictions made 12 hours before actual exceedances by reaching 75 μg/m³ PM2.5 levels. The predicted performance from the provided model surpasses traditional chemical transport models since it achieves R² values of 0.93 in comparison to their standard 0.65-0.75 prediction range.

The results from the feature importance analysis provided important conclusions relevant for policy decisions:

Research findings show that NO2 and PM2.5 do not follow traditional linear patterns because the two pollutants create combined effects when making dust particles.

Temperature levels related to PM2.5 concentration follow an upward then downward pattern that defines when pollution reaches its maximum rate.

The way the wind blows highlights the significance of nearby pollution sources coming from different regions.

Through its user-friendly interface the system made analytical insights accessible to all users including stakeholders who were not specialized in the technical aspects. They could now examine pollution patterns and conduct experimentations for potential pollution reduction strategies. The system has a modular structure which enables unceasing integration of new data sources alongside model improvement features.