# The Effect of Air Pollution on Respiratory and Cardiovascular Mortality in Makkah, Saudi Arabia, During the Hajj Events and COVID-19 Outbreak

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## Abstract:

**Introduction:** Air pollution continues to be a worldwide concern affecting both the environment and public health, yet its impact during cultural events remains largely overlooked. This study examines the link between specific air pollutants (PM10, NO2, O3, SO2) and mortality rates from cardiovascular and respiratory diseases during the Hajj season in Makkah, Saudi Arabia, over the period from 2018 to 2022.

**Methods:** Log-linear time series models were used to analyse the association between monthly air pollutant levels and mortality from cardiovascular and respiratory diseases. The analysis accounted for seasonal variations and trends, and an interaction model was applied to examine how Hajj cultural events and the COVID-19 pandemic influenced the relationship between air pollution and mortality.

**Results:** A larger association was determined between NO2 and cardiovascular mortality during Hajj (RR:1.17, 95% CI: 1.05-1.30) compared to non-Hajj periods (RR: 1.02, 95%CI 0.99-1.05). The increased risk of respiratory mortality associated with NO2 during the Hajj events was higher (RR:1.24, 95% CI: 1.09-1.40) compared with the period with no Hajj events (RR:1.04, 95%CI 0.99-1.09). The study also found that exposure to increased levels of O3 also significantly impacted respiratory (RR:1.19, 95% CI: 0.96-1.48) and cardiovascular mortality (RR:1.35, 95% CI:1.15-1.59) during Hajj events while an inverse association was observed between O3 and respiratory (RR:0.92, 95% CI: 0.89-0.96) and cardiovascular (RR:0.97, 95% CI: 0.94-0.99) mortality during non-Hajj periods. During COVID-19, the study showed that $NO_2$ was a significant risk factor for respiratory (RR: 1.04,95% CI: 0.97-1.14) but not for cardiovascular (RR: 0.99,95% CI 0.92-1.07) mortality, while $O_3$ revealed reduced relative risks for both respiratory (RR:0.77,95% CI:0.71-0.84) and cardiovascular mortality (RR:0.89,95%CI:0.83-0.96).

**Conclusion:** This study provides valuable insights into environmental health in Makkah, Saudi Arabia, emphasizing the need for policies to address air pollution during the Hajj pilgrimage to protect the health of residents and pilgrims.