Lung Cancer Hot Spots and Environmental Risk Factors: A Spatial Analysis in the Atrium Health Wake Forest Baptist Comprehensive Cancer Center Catchment Area

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1. Background
Lung cancer remains the leading cause of cancer-related malignancy and mortality, but its burden varies by race, geography, and environmental exposure within the Atrium Health Wake Forest Baptist Comprehensive Cancer Center (AHWFBCCC) catchment area. The catchment area consists of counties of three states: North Carolina (NC), Virginia (VA), and West Virginia (WV). According to the state cancer profile, the age-adjusted lung cancer incidence and mortality rates in NC (62.6 per 100,000 and 37.7 per 100,000) and in WV (76.1 per 100,000 and 49.1 per 100,000) are significantly higher compared to the national age-adjusted incidence and mortality rates (53.1 per 100,000 and 32.4 per 100,000).

2. Goals
Our goal was to identify lung and bronchus cancer hot spots within the AHWFBCCC catchment area and examine their association with environmental risk factors ($PM_{2.5}$, indoor radon, and ground-level ozone) and patient travel distance.

3. Solutions and Methods
Upon IRB approval, we obtained de-identified lung and bronchus cancer data (International Classification of Diseases Version 10 [ICD-10]: C32.3, C340, C341, C342, C343, C348, C349, C779) from the Wake Cancer Registry, spanning 2000-2022. The dataset included 8,609 cases, of which 6,633 were deceased, and 1,976 were survivors based on the first date of diagnosis. We calculated the age-adjusted incidence and mortality rates and perform spatial analysis using ArcGIS Pro employing Getis-Ord-GI* to identify statistically significant clusters of hot and cold spots and validated using Moran's I (z-score = 3.438, p = 0.0005) to confirm the significant spatial autocorrelation.

4. Outcomes
We examined the association between lung cancer hot spots and environmental risk factors—$PM_{2.5}$, ground-level ozone, and indoor radon—while accounting for gender, race, and smoking history. These metrics illustrate spatial clusters of features with notably high and low values, facilitating the extraction of hot and cold spots, respectively, along with their corresponding Zone Improvement Plan (zip) codes within the census tract. The spatial analysis revealed 24 zip codes across 23 census tracts as high-risk areas with 99 percent confidence. In total, 29 high-risk zip codes were identified based on elevated $PM_{2.5}$ (>10 μg/m³), indoor radon (exceeding 4 pCi/L), and ground level ozone (>0.04-0.05 ppm). These hot spots were strongly associated with lung and bronchus cancer incidence and mortality, particularly among populations stratified by race, gender, and smoking history.

5. Lessons Learned and Future Directions
Our findings, which highlight existing geographic disparities and identified hot spots, provide critical insight for targeted intervention and public health strategies to reduce the lung cancer burden in the AHWFBCCC catchment area.