Spatial Analysis of Residential Radon Exposure and Cancer Incidence in Kentucky

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1. Background
Radon is the second leading cause of lung cancer in the United States. The U.S. Environmental Protection Agency Radon Zones Map classifies many Kentucky counties as having moderate to high radon potential. The Kentucky Geological Survey further provides a statewide radon potential map that integrates household radon test results to characterize geographic variation in exposure.

Kentucky has one of the highest cancer burdens in the U.S. There is a strong need to identify if radon is associated with other cancers. Cancers among adolescents and young adults (AYA) are an increasing concern in Kentucky and nationwide. Thyroid cancer incidence has risen rapidly, highlighting the importance of identifying modifiable risk factors for thyroid cancer. Evaluating whether geographic variation in radon exposure is associated with these cancer sites can help prioritize prevention and earlier detection strategies. Together, studying the association between radon exposure and cancer incidence can support targeted testing and mitigation, inform interventions, and help explain regional cancer disparities.

2. Goals
This study is a population-based geospatial epidemiologic analysis that utilizes secondary radon exposure data with cancer incidence. The objective is to characterize radon exposure patterns in Kentucky and identify association with cancer incidence at the census tract level and to provide evidence to highlight high-risk areas for radon mitigation and cancer prevention efforts.

3. Solutions and Methods
Thyroid cancer and all AYA cancer from 2010 to 2022 were provided by the Kentucky Cancer Registry. Geospatial analysis was utilized by comparing radon measurement by household data collected through the University of Kentucky Geological Survey at the census-tract level. The estimates of radon measurement at census tract were quantified utilizing 3rd quartile (3Q). Hot and cold radon clusters were identified using Getis-Ord Gi approach. Multivariate Negative Binomial models were used to estimate the association between radon exposure and cancer incidence while controlling other confounders, including age, race, gender, rural region, Area Deprivation Index, and smoking rate.

4. Outcomes
Included in our analysis were 8,752 adults with thyroid cancer and 14,452 AYA (39 ≥ age≥ 20) with all cancers. Additionally, 217,499 households were accessed for radon exposure. Hot spot analysis of radon exposure by census tract with Nearest Neighborhood method with 3Q radon estimates identified 323 tracts in the cold spot and 208 in the hot spot. In the negative binomial model, the incidence rate ratio (IRR) of thyroid cancer was significantly greater for the hot spot area (1.12, 95% CI 1.02-1.23, p=0.014) compared to the cold spot. Meanwhile, the IRR of AYA cancer was significantly greater for the hot spot area (1.11, 95% CI 1.03-1.23, p=0.011) compared to the cold spot.

5. Lessons Learned and Future Directions
Our findings indicate that residence in areas with higher radon exposure is associated with significantly increased incidence of thyroid cancer and all cancers among AYA. These results suggest that radon may

contribute to cancer risk beyond lung cancer and highlight the importance of radon as a potential modifiable environmental risk factor for thyroid and AYA cancers. Future studies using individual-level exposure data and longitudinal designs are needed to confirm these associations, clarify potential biological mechanisms, and inform evidence-based interventions aimed at reducing radon-related cancer burden in vulnerable populations.