Spatial Analysis of Residential Radon Exposure and Cancer Incidence in Kentucky

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Introduction

Radon is the second leading cause of lung cancer in the United States[1]. The U.S. Environmental Protection Agency (EPA) Radon Zones Map classifies many Kentucky counties as having moderate to high radon potential.

Kentucky has one of the highest cancer burdens in the United States[2]. 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. There is a strong need to identify if radon is associated with these cancers.

Objective

The objective is to characterize radon exposure patterns in Kentucky and identify associations between AYA/Thyroid cancer incidence and clusters of radon exposures.

Study Population and Method

Population: Invasive Thyroid cancer and all AYA cancer cases in KY from 2010 to 2022 were accessed from the Kentucky Cancer Registry.

Radon Exposure and Measurement: Household radon data collected through the University of Kentucky Geological Survey[3]. Radon measurement at census tract were quantified utilizing 3rd quartile (3Q)[4]

Statistical Method:

- Geospatial analysis, a Getis-Ord Gi* approach, was used to identify hot and cold radon clusters.
- Negative Binomial Regression model was used to identify associations between radon clusters and incidence rates, adjusted for age, race, sex, rural region, Area Deprivation Index, and smoking rate.

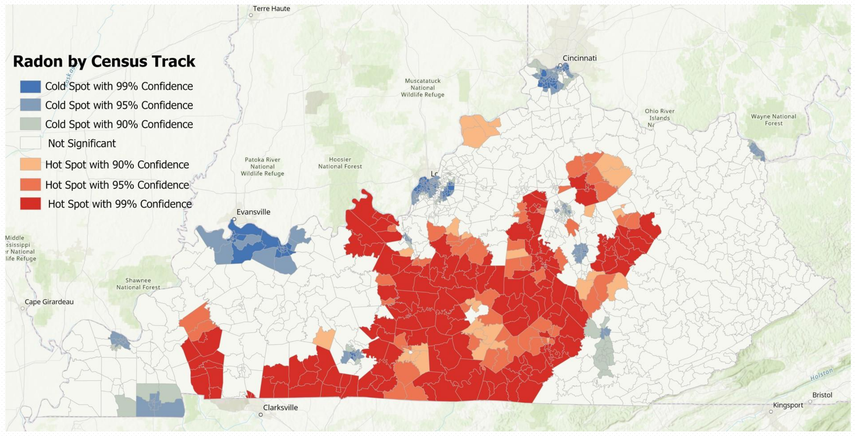
Results

Table 1. Census tract case counts and geographic characteristics overall and by radon exposure

Character	Overall	Cold radon	Hot Radon
Tracts, n	1306	323	208
AYA cases, n	14452	3925	1369
Thyroid cases, n	8752	1948	1107
Rural tracks, %	44.78%	11.51%	76.92%
ADI high tracks, %	21.58%	15.47%	18.13%
Smoking rate, %			
Q1 tracks	46.44%	76.26%	19.30%
Q2 tracks	22.23%	20.14%	28.65%
Q3 tracks	17.73%	3.6%	29.24%
Q4 tracks	13.60%	0%	22.81%

ADI: state-level Area Deprivation Index (Decile Ranking 9-10 define as high); Smoking rate: quartile 1 to 4 from lowest to highest rate; Age, race, sex are census track level; Smoking rate are obtained from BRFSS county level

Figure 1. Hot and Cold Radon Spots Map



Source: https://breathe.uky.edu/radon/radon-data
Software: ArcGIS Pro 3.5.3

Table 2. Association between Radon exposure and All Cancer Sites for AYA

	IRR (95% CI)	P-value
Radon (Hot vs. Cold)	1.11 (1.03-1.23)	0.01
Urban vs. Rural	1.02 (0.96-1.08)	0.54
ADI (High vs. Cold)	1.00 (0.95-1.07)	0.90
Race (Black vs. White)	1.51 (1.39-1.65)	<.0001
Sex (Female vs Male)	1.55 (1.48-1.62)	<.0001
Age group (30-39) vs (20-29)	2.04 (1.94-2.14)	<.0001
Smoking rate		
Quartile 2 vs Quartile 1	1.01 (0.91-1.13)	0.81
Quartile 3 vs Quartile1	0.97 (0.87-1.09)	0.62
Quartile 4 vs Quartile 1	1.03 (0.93-1.14)	0.61

Table 3. Association between Radon exposure and Thyroid Cancer

	IRR (95% CI)	P-value
Radon (Hot vs. Cold)	1.12 (1.02-1.23)	0.01
Urban vs. Rural	1.00 (0.94-1.07)	1.00
ADI (High vs. Low)	1.03 (0.96-1.09)	0.46
Race (Black vs. White)	2.01 (1.80-2.25)	<.0001
Sex (Female vs Male)	1.60 (1.51-1.69)	<.0001
Age group		
(55-64) vs (20-29)	1.86 (1.75-1.98)	<.0001
(65-74) vs (20-29)	2.34 (2.18-2.50)	<.0001
(75+) vs (20-29)	2.33 (2.10-2.57)	<.0001
Smoking rate		
Quartile 2 vs Quartile 1	1.03 (0.96-1.11)	0.39
Quartile 3 vs Quartile1	1.04 (0.97-1.12)	0.25
Quartile 4 vs Quartile 1	1.04 (0.96-1.13)	0.34

ADI: state-level Area Deprivation Index (Decile Ranking 9-10 define as high); Smoking rate: quartile 1 to 4 from lowest to highest rate; IRR: incidence rate ratio

Conclusions & Discussion

We observed a statistically significant positive association between radon exposure and the incidence of thyroid cancer in adults and overall cancer in adolescents and young adults (AYA).

Future study direction:

- Explore radon associations with other cancer sites.
- Disparities by demographics and risk factors.
- Account for healthcare access.
- Investigate potential mechanism for observed effect.

Limitations:

- Exposure misclassification (tract average ≠ individual).
- Lacked individual-level risk factors.
- Missing radon data.
- Radon risk reflects long-term exposure.
- Residence at diagnosis may not represent true exposure.

Reference

[1] Health Risk of Radon, United States Environmental Protection Agency. https://www.epa.gov/radon/health-risk-radon

[2] 2025 Kentucky Cancer Needs Assessment Update. Lexington, KY (2025).

[2] Radon Potential, https://kygs.uky.edu/geology/radon. (Access in 2025).

[4] Stanley FK, et.al. Comprehensive survey of household radon gas levels and risk factors in southern Alberta. CMAJ Open. 2017 Mar 28;5(1):E255-E264. doi: 10.9778/cmajo.20160142. PMID: 28401142; PMCID: PMC5378506.