



NC Department of Health and Human Services

Radon: Increased Toxicity Risk for Children and Smokers

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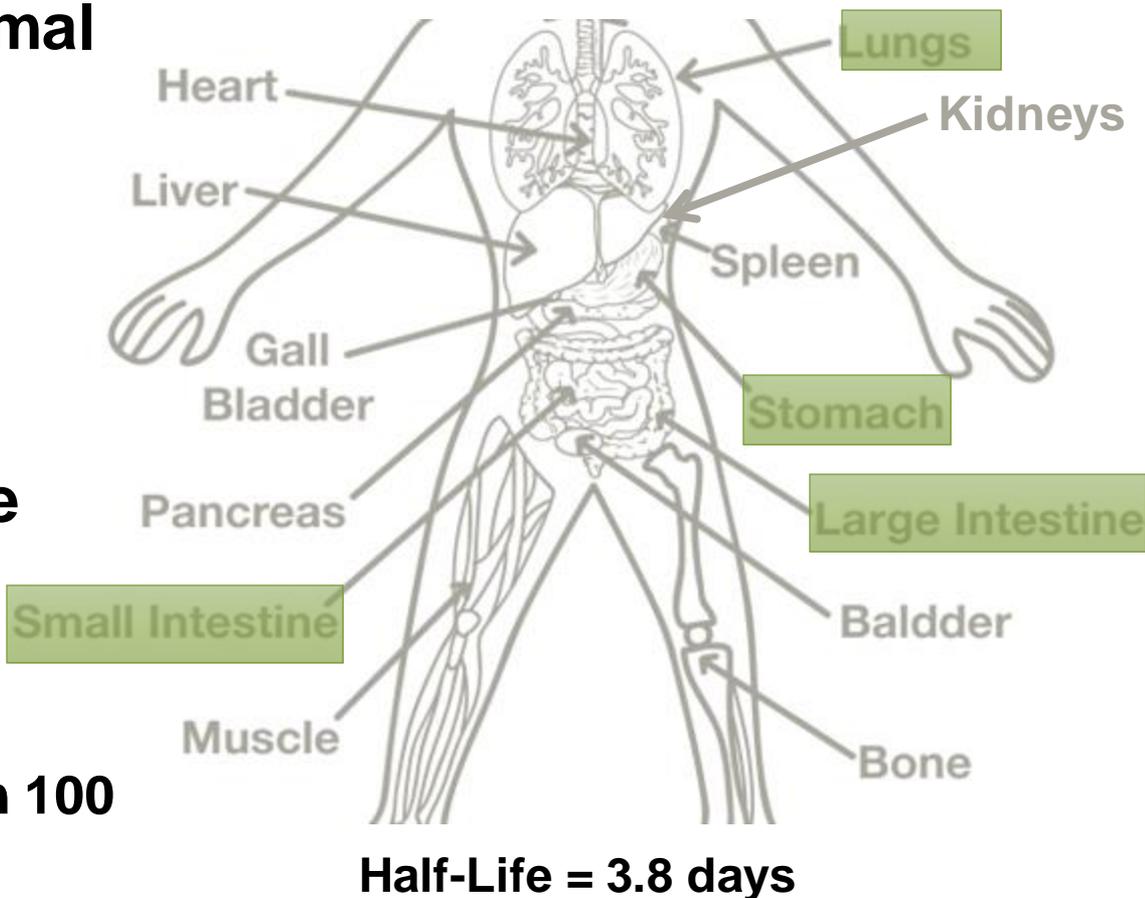
Radon Gas

- **Gasses out of water**
- **Inhalation**
- **Ingestion**



Radon – ADME – Ingestion/Inhalation

- **Absorption – Minimal**
- **Distribution**
 - Fat
- **Metabolism – None**
- **Excretion**
 - Exhaled Air (95% in 100 mins)



Source: ATSDR Toxicological Profile for Radon; Body (https://coloringtop.com/sites/default/files/17_1674.jpg)

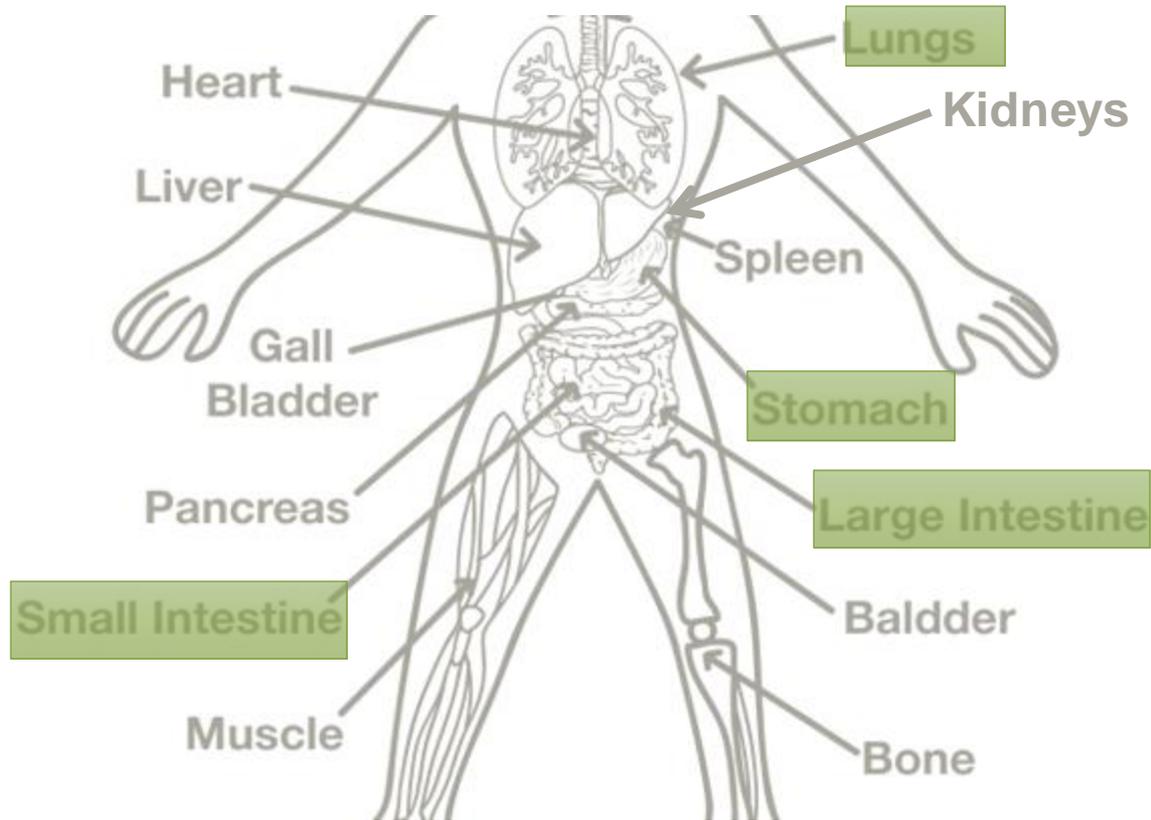
Radon - ADME

Inhalation

- Lung Cancer

Ingestion

- Stomach and Intestinal Cancers



Half-Life = 3.8 days

Source: ATSDR Toxicological Profile for Radon; Body (https://coloringtop.com/sites/default/files/17_1674.jpg)

Radon – Inhalation Guidance

- **US Surgeon General - Health Advisory of 4 pCi/L in Homes (2005)**

- **Leading cause of lung cancer, after smoking**
- **For carcinogenic risk assessment 1 in 10,000 is considered the highest, acceptable carcinogenic risk**

Carcinogenic Risk Associated with Radon Exposures via Inhalation		
Radon Level		Never Smoked
20 pCi/L		23 in 1,000
10 pCi/L		18 in 1,000
8 pCi/L		15 in 1,000
4 pCi/L		7 in 1,000
2 pCi/L		4 in 1,000
1.3 pCi/L		2 in 1,000
0.4 pCi/L		

Source: US EPA (<https://www.epa.gov/radon/health-risk-radon>)

Compounding Impacts of Radon - Smokers

- **Radon is the leading cause of lung cancer among nonsmokers.**
 - **Radon is responsible for approximately 450 deaths each years in North Carolina**
 - **The risk of lung cancer from radon exposure is estimated at between 10 to 20 times greater for persons who smoke cigarettes as compared with those who have never smoked.**

Radon – Inhalation Guidance Revisited

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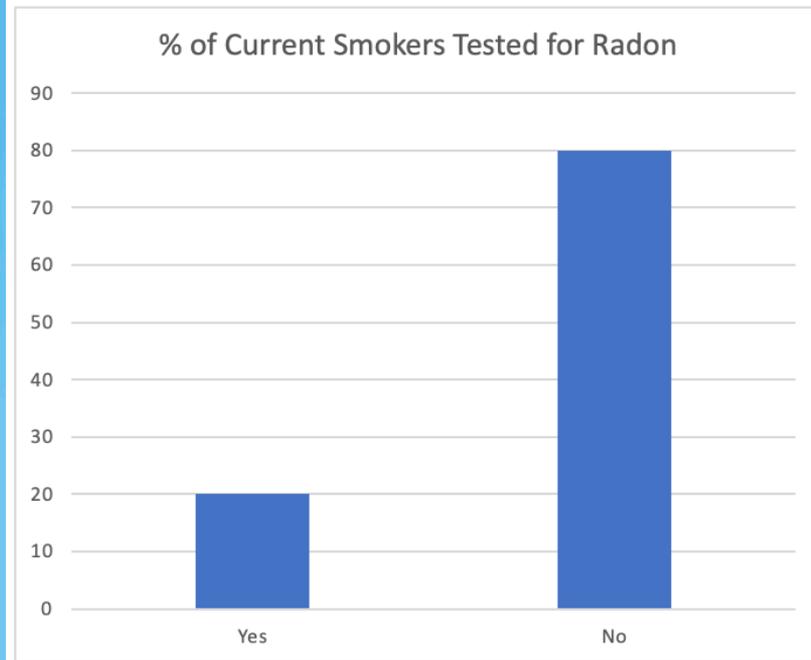
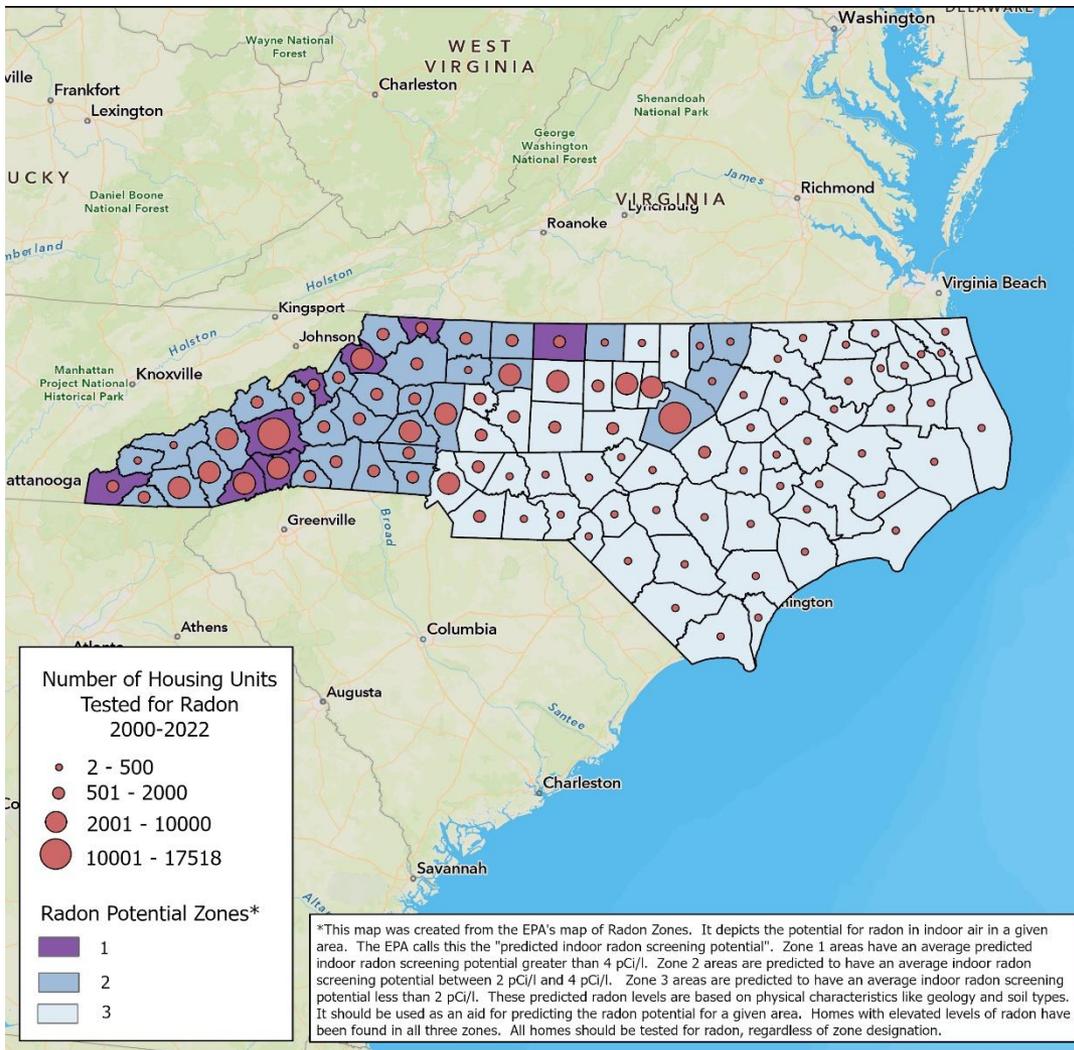
Radon Level	Smoked	Never Smoked
20 pCi/L	260 in 1,000	23 in 1,000
10 pCi/L	150 in 1,000	18 in 1,000
8 pCi/L	120 in 1,000	15 in 1,000
4 pCi/L	62 in 1,000	7 in 1,000
2 pCi/L	32 in 1,000	4 in 1,000
1.3 pCi/L	20 in 1,000	2 in 1,000
0.4 pCi/L	3 in 1,000	

Source: US EPA (<https://www.epa.gov/radon/health-risk-radon>)

Compounding Impacts of Radon - Children

- Risk of lung cancer in children resulting from exposure to radon may be almost **2x as high** as the risk to adults exposed to the same amount of radon.
 - If children are also exposed to tobacco smoke, the risk of lung cancer is at **least 20 times greater**.
- Chronic home radon exposure can lead to higher inflammatory biomarker concentrations in children and adolescents
 - Inflammation induced by radon exposure can cause cascading effects on immune health and increased risk of physical illness, such as asthma or chronic obstructive pulmonary disease

Radon Testing in North Carolina



Radon Testing in Schools

- **Currently, survey data has been compiled from 1,102 schools, with 23,448 classrooms tested in 94 counties (at least one school per county) out of 100 counties in North Carolina.**
- **The average radon level tested is: 1.79 pCi/l.**
- **Based on North Carolina Radiation Protection Program analysis, approximately 11% of these tested classrooms had radon concentrations greater than 4 pCi/l.**
- **Full dataset can be found here:**
 - <https://www.ncdhhs.gov/divisions/health-service-regulation/north-carolina-radon-program/nc-radon-data#RadonTestResultsinNCSchools-3449>

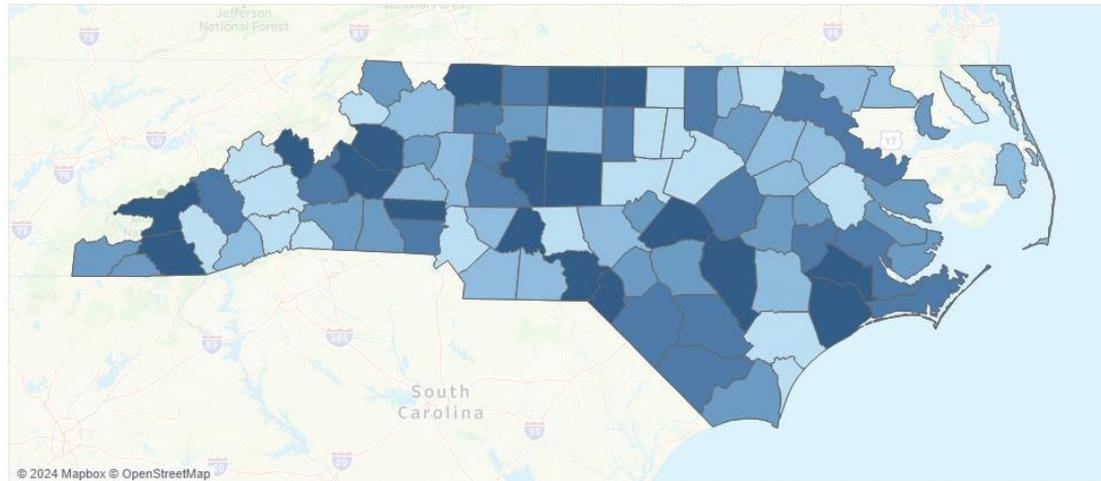
Age-Adjusted Lung Cancer Rates in NC

- EJ Maps
- County Maps
- Trends
- Comparisons
- Fact Sheets
- About

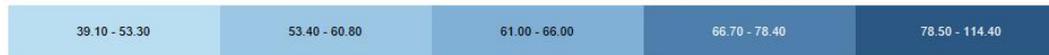
Click on a place on the map for the option to view it more closely on the Trends Over Time dashboard.

Select Content Area: Long-term Health Effects
 Select Group: Cancer
 Select Indicator: Lung and Bronchus Cancer
 Select Measure: Age-adjusted Rate of Lung and Bronchus Can...
 Select Year: 2019

Showing Age-adjusted Rate of Lung and Bronchus Cancer in 2019



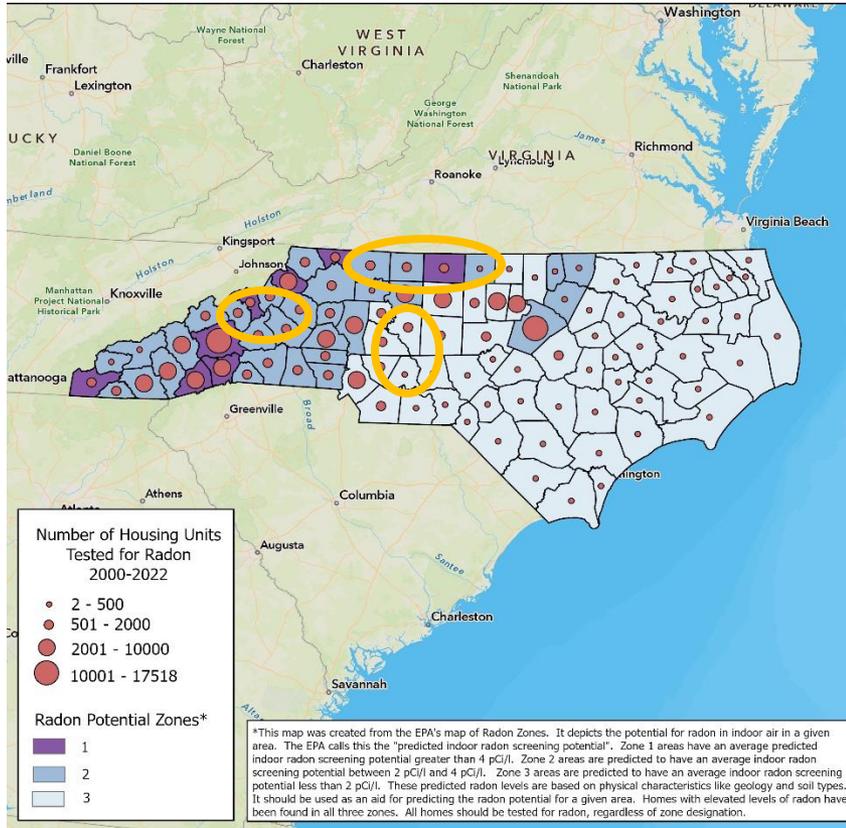
Units: cases per 100,000 - Scale adjusts for range of the data for each year



About the Age-adjusted Rate of Lung and Bronchus Cancer:

Age-adjusted Rate of Lung and Bronchus Cancer per 100,000 population. Lung cancer is a type of cancer that starts in the lungs. Symptoms of lung cancer include a cough that does not go away, coughing up blood or rust colored spit/ phlegm, chest pain, hoarseness, unexpected weight loss, shortness of breath, new wheezing, loss of appetite, or feeling weak or tired unexpectedly. You can reduce your risk of lung cancer by avoiding or quitting smoking, testing your home for radon, and reducing high indoor radon levels. For more information about Lung Cancer prevention and screening, go to: <https://www.dph.ncdhs.gov/chronicdiseaseandinjury/cancerpreventionandcontrol/docs/LungCancer-Web.pdf>. Methods: Age-adjusting ensures that differences in rates between two populations are not a result of differences in age distributions of those populations. An Age-adjusted Rate is a weighted average of the age-specific rates expressed as a rate per 100,000 persons, using a standard population to calculate the weights based on the proportion of the population in specific age groups. The Central Cancer Registry (CCR) uses the 2000 United States Census population as the standard population. Rates are calculated using the bridged-race population estimates obtained from the National Center for Health Statistics available online at <https://www.cdc.gov>.

2019 Age-Adjusted Lung Cancer Rates in NC

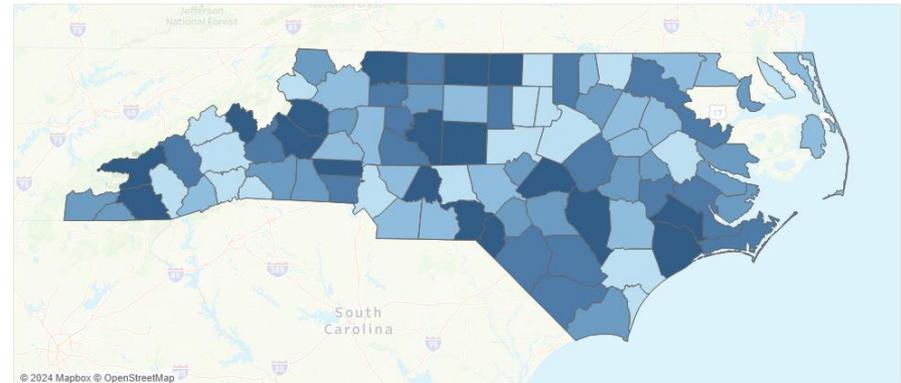


EJ Maps	County Maps	Trends	Comparisons	Fact Sheets	About
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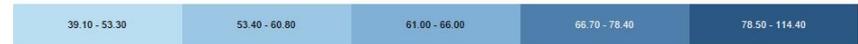
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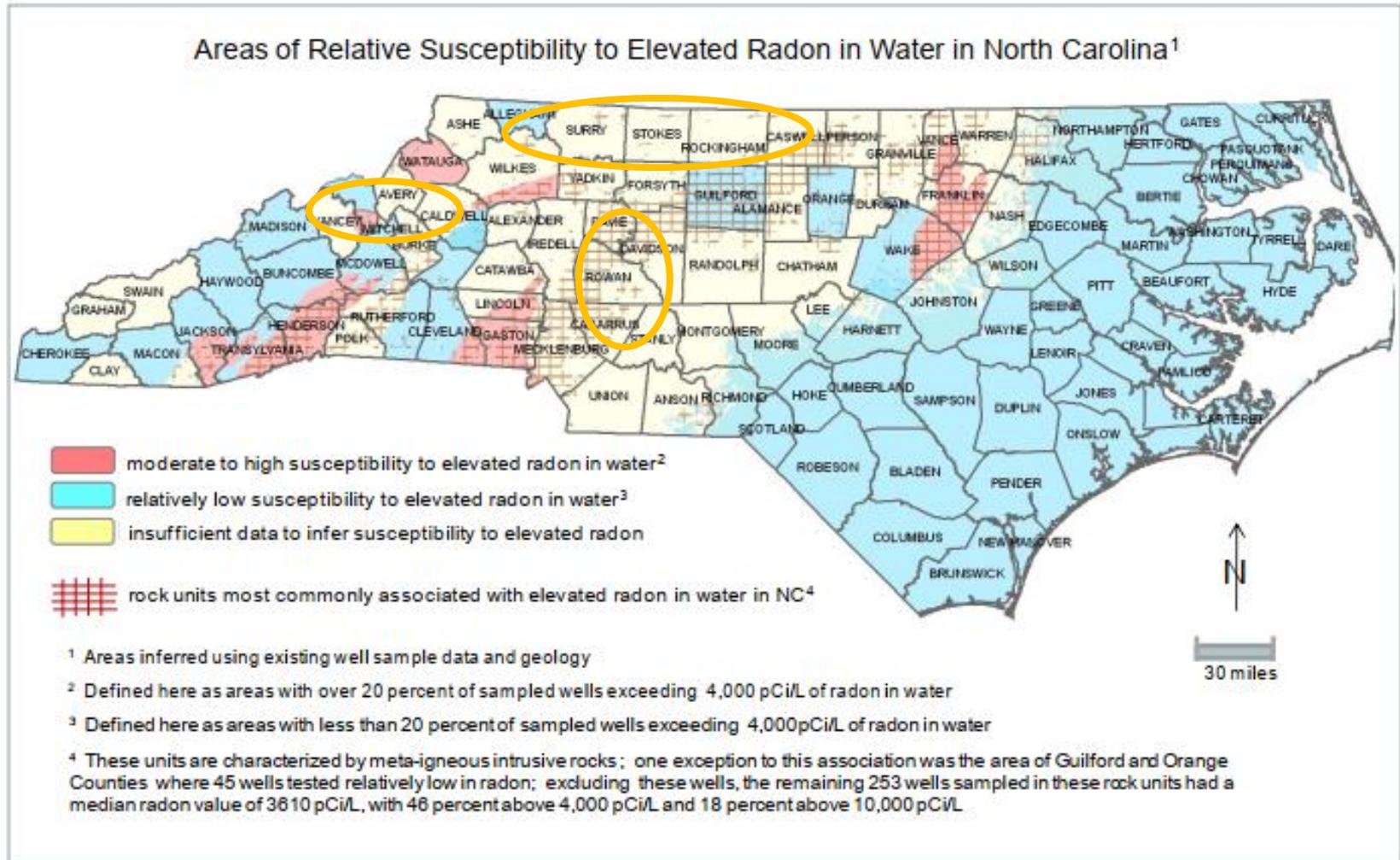
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Susceptibility to Radon in Water



Radon – Water Guidance

US Environmental Protection Agency (2012)

Maximum Contaminant Level Goal (non-enforceable)	Proposed Maximum Contaminant Level (non-enforceable)
0 pCi/L	300 pCi/L or 4,000 pCi/L

- With the assumption that 10,000 pCi/L of Radon in water contributes to 1 pCi/L in air

NC Radon-in-Water Advisory Committee Report (2011)

- 4,000-10,000 pCi/L treatment is optional
- >10,000 pCi/L treatment should be considered in conjunction with air radon testing and remediation

Source: US EPA (<https://archive.epa.gov/water/archive/web/pdf/epa815r12002.pdf>); NC Radon-in-Water Advisory Committee Report (http://ncradon.org/Publications_files/Final%20Report%20of%20the%20NC%20Radon%20in%20Water%20Advisory%20Committee%20030911.pdf)

Cancer Risk for Smokers from Radon Exposures

Table 7. Current Federal drinking water standards or enforceable standards for public water supplies and associated estimated increased lifetime cancer incidence risks.

EPA-Regulated Compound	MCL, in ug/L	Basis for MCL	Increased Lifetime Cancer Risk Estimate
Arsenic	10	Cost; EPA believes, given present technology and resources, this is the lowest level to which water systems can reasonably be required to treat	1E-2 (1 in 100)
Benzene	5	Analytical feasibility	5E-6 (5 in 1,000,000)
Ethylene dibromide (EDB)	0.05	Analytical feasibility	1E-4 (1 in 10,000)
Heptachlor epoxide	0.2	Analytical feasibility	5E-5 (5 in 100,000)
Pentachlorophenol	1	Analytical feasibility	3E-6 (3 in 1,000,000)
Tetrachlorodibenzodioxins	0.00003	Analytical feasibility	1E-4 (1 in 10,000)
Tetrachloroethylene	5	Analytical feasibility	1E-5 (1 in 100,000)
Trichloroethylene	5	Analytical feasibility	5.9E-5 (6 in 100,000)
Vinyl chloride	2	Analytical feasibility	8E-5 (8 in 100,000)

MCL, maximum contaminant level; ug/L, micrograms per liter

- Median indoor air level for NC ~ 2.6 pCi/L
 - ~ 1 in 50 cancer mortality risk
- Median radon in water level between 3000 to 6000 pCi/L
 - ~ 1 in 250 cancer mortality risk

Table 4. Estimated increased lifetime lung cancer mortality risks from inhalation of radon and decay products in indoor air and off gassed from radon in water for ever smokers and never smokers, from National Research Council, Risk Assessment of Radon in Drinking Water, National Academy Press, p. 16, Table ES-1.

Concentration of radon in air, pCi/L	Estimated increased lifetime cancer mortality risk for ever smokers ^a	Estimated increased lifetime cancer mortality risk for never smokers ^a
1	9.6E-3 (96 per 10,000)	1.9E-3 (19 per 10,000)
2	1.9E-2 (190 per 10,000)	3.7E-3 (37 per 10,000)
4	3.8E-2 (380 per 10,000)	7.4E-3 (74 per 10,000)
8	7.7E-2 (770 per 10,000)	1.5E-2 (150 per 10,000)
10	9.6E-2 (960 per 10,000)	1.9E-2 (190 per 10,000)

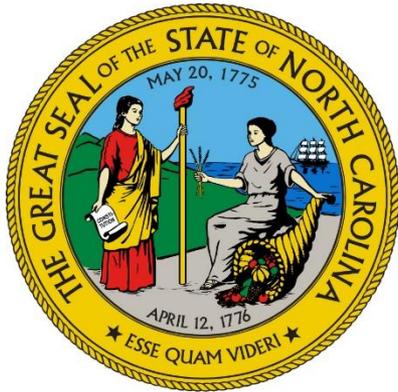
Concentration of radon in water, pCi/L	Estimated increased lifetime cancer mortality risk for ever smokers ^a	Estimated increased lifetime cancer mortality risk for never smokers ^a
300	2.9E-4 (3 per 10,000)	5.6E-5 (less than 1 per 10,000)
1,000	9.6E-4 (10 per 10,000)	1.9E-4 (2 per 10,000)
2,000	1.9E-3 (19 per 10,000)	3.8E-4 (4 per 10,000)
4,000	3.8E-3 (38 per 10,000)	7.6E-4 (8 per 10,000)
10,000	9.6E-3 (96 per 10,000)	1.9E-3 (19 per 10,000)
15,000	1.4E-2 (140 per 10,000)	2.9E-3 (29 per 10,000)
20,000	1.9E-2 (190 per 10,000)	3.8E-3 (38 per 10,000)
40,000	3.8E-2 (380 per 10,000)	7.6E-3 (76 per 10,000)

^a From National Research Council (NRC), Risk Assessment of Radon in Drinking Water, National Academy Press, p. 16, Table ES-1, as derived from NRC's 1999 report titled Biological Effects of Ionizing Radiation VI: The Health Effects of Exposure to Indoor Radon.

Remember: If children are also exposed to tobacco smoke, the risk of lung cancer is at **least 20 times greater**.

Key Takeaways

- **Radon is a potent carcinogen with increased adverse health impacts on smokers and children.**
 - **Can also increase risk of non-cancer, respiratory illness.**
- **Radon exposures via drinking water can be a significant route of exposure.**
- **Need increased testing and awareness to fully understand the impacts of radon exposures in North Carolina.**



Questions?

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