



A Radon Testing Disparity Metric, State Reports, and Radon Risk Reduction in Rental Housing

EPA Region 3
Radon Stakeholder Meeting
Hershey, PA
September 26, 2023

Kevin M. Stewart
Director, Environmental Health

Acknowledgments

- Project funding by US EPA under an assistance agreement.
- Data provided by CDC (from states & labs) and Census Bureau.
- Concept development by American Lung Association.
- Calculations, consultation and report narrative provided by analysts at College of Public Health, University of Iowa.

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Disclaimer: Summaries and text not endorsed by EPA, CDC, or Census Bureau.

Acknowledgments

- Specifically, the following coauthors:
 - **Grant D. Brown, PhD** and
 - **Jacob Seedorff, MS**
both of Department of Biostatistics, College of Public Health, University of Iowa
 - **R. William Field, PhD** of College of Public Health, University of Iowa and Vagelos College of Physicians and Surgeons, Columbia University
- My work on behalf of the Lung Association was overseen by **Katherine Pruitt**, National Senior Director for Policy.

Three Starting Points

1) *Paramount Context*

- ***EVERYONE** deserves clean air.*
- *The **ONLY WAY** to know one's radon exposure is to test.*
- *Therefore, **ALL** indoor environments should be tested, and fixed as needed.*

2) The Problem of Resources

- *Competing Demands.*
- *Staffing.*
- *Funding.*

Many Ways to Use the Data

- One set of approaches has been to look for areas with
 - highest radon results,
 - highest averages,
 - highest fraction of results at least 4 pCi/L.

Many Ways to Use the Data

- Another way has been to pay attention to areas with
 - poor testing counts
 - lower rates of testing
 - by population
 - by housing.

Observations

- Limitations to looking at these data sets separately:
 - Focusing on radon-level statistics risks ignoring areas with poor testing rates.
 - Focusing on testing rates risks missing areas with worse radon.

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- Limitations to looking at these data sets separately:
 - Focusing on radon-level statistics risks ignoring areas with poor testing rates.
 - Focusing on testing rates risks missing areas with worse radon.
- Apparent that there are disparities in testing rates vs. expected average radon levels.

Suggesting an Additional Tool

Proposing a Solution

- Taking both radon levels and radon testing rates into account *with a single measure.*
- *Add* a tool to the toolbox.
- CDC system architecture very helpful.

Basis for Alternatives

- In each county:
 - R = mean pre-mitigation radon level
 - H = number of housing units
 - N = number of radon tests (using CDC's 10-year period)

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- With these numbers,
 - N/H is a measure of the testing rate
 - H/N is its reciprocal
- We'll set
 - D = Radon Testing Disparity Metric

The Alternative Selected

- New metric:
$$D = R * \log_{10}\left(\frac{H}{N}\right)$$

In each county:

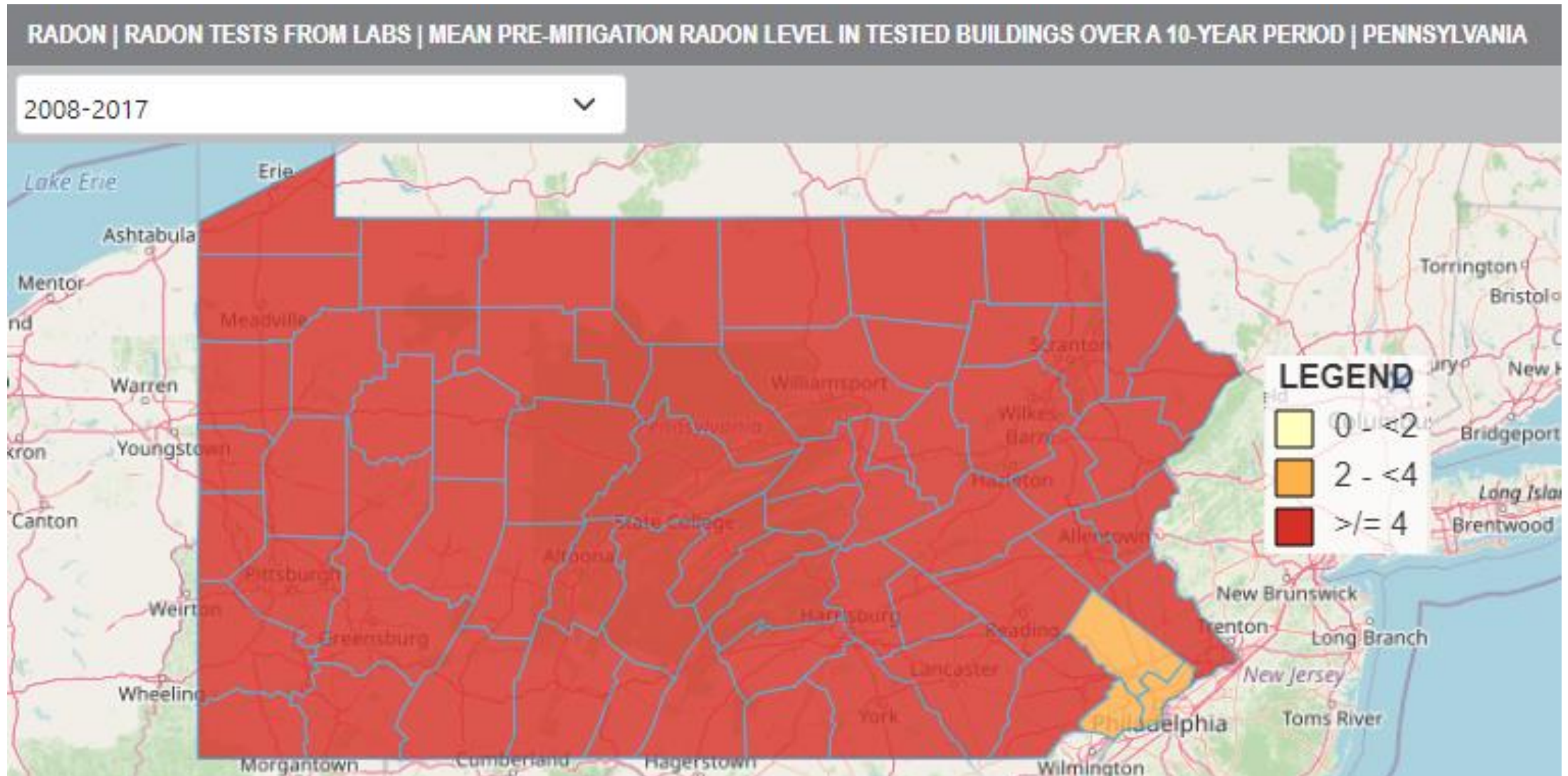
- D = Radon Testing Disparity Metric
- R = mean pre-mitigation radon level
- H = number of housing units
- N = number of radon tests (using CDC's 10-year period)

Important Caveats

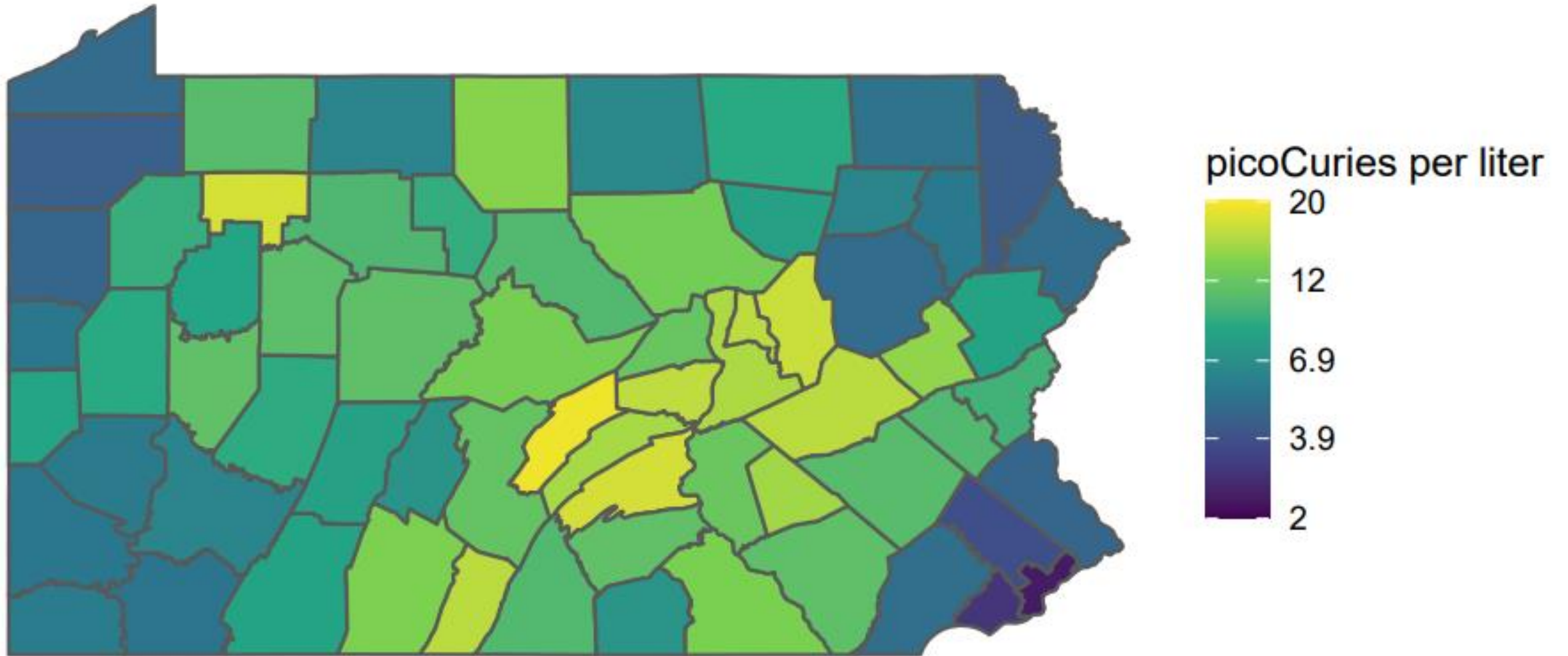
- The purpose here is to show how such a metric might provide guidance or inspiration for public outreach efforts, especially when facing difficult decisions presented by limited resources.
- It is NOT intended for general public use, but by those who already understand existing radon metrics and can use this as *another* tool.
- It is NOT intended as the last word. There are any opportunities for improvement. Consider this as Testing Disparity Metric Version 1.0.
- It is NOT to disparage or criticize any state's work to address radon, often under very difficult circumstances.

Cases for EPA Region 3

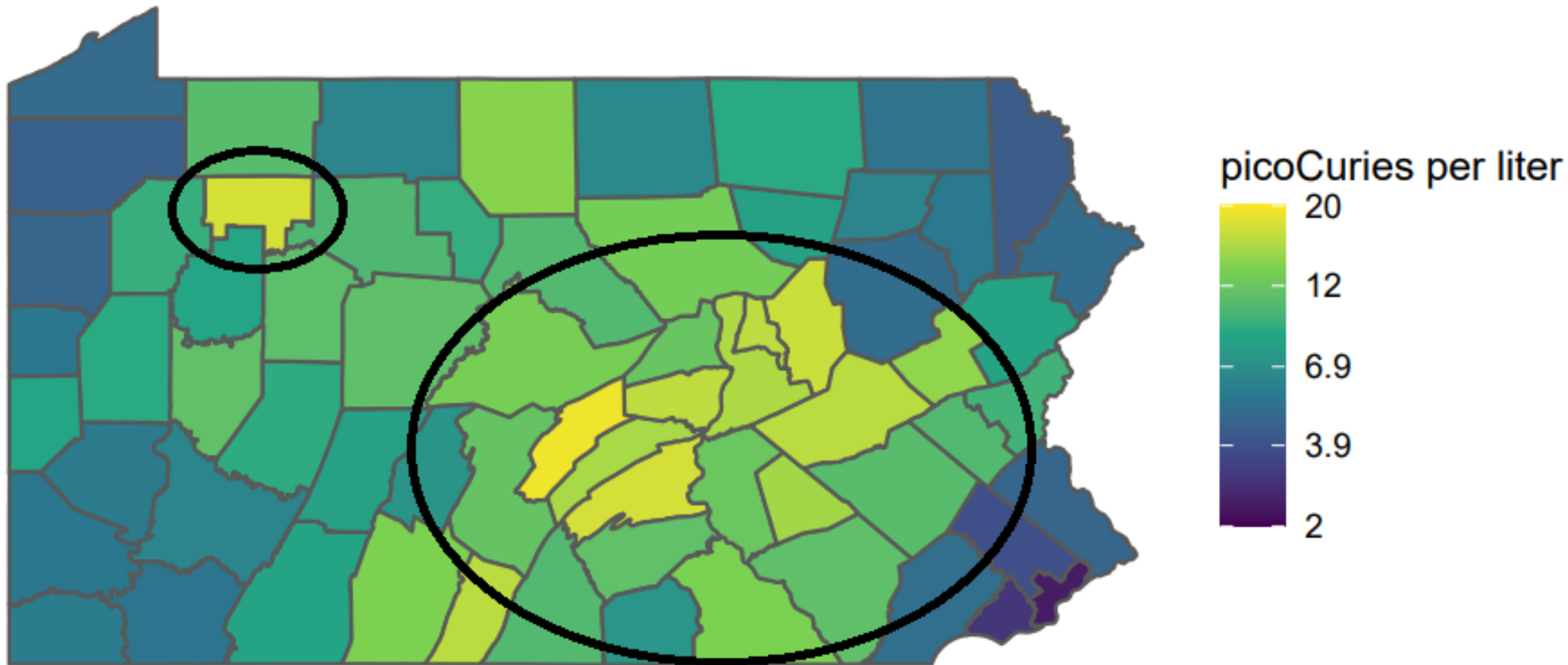
CDC NEPHT Data (PA County Radon Averages)



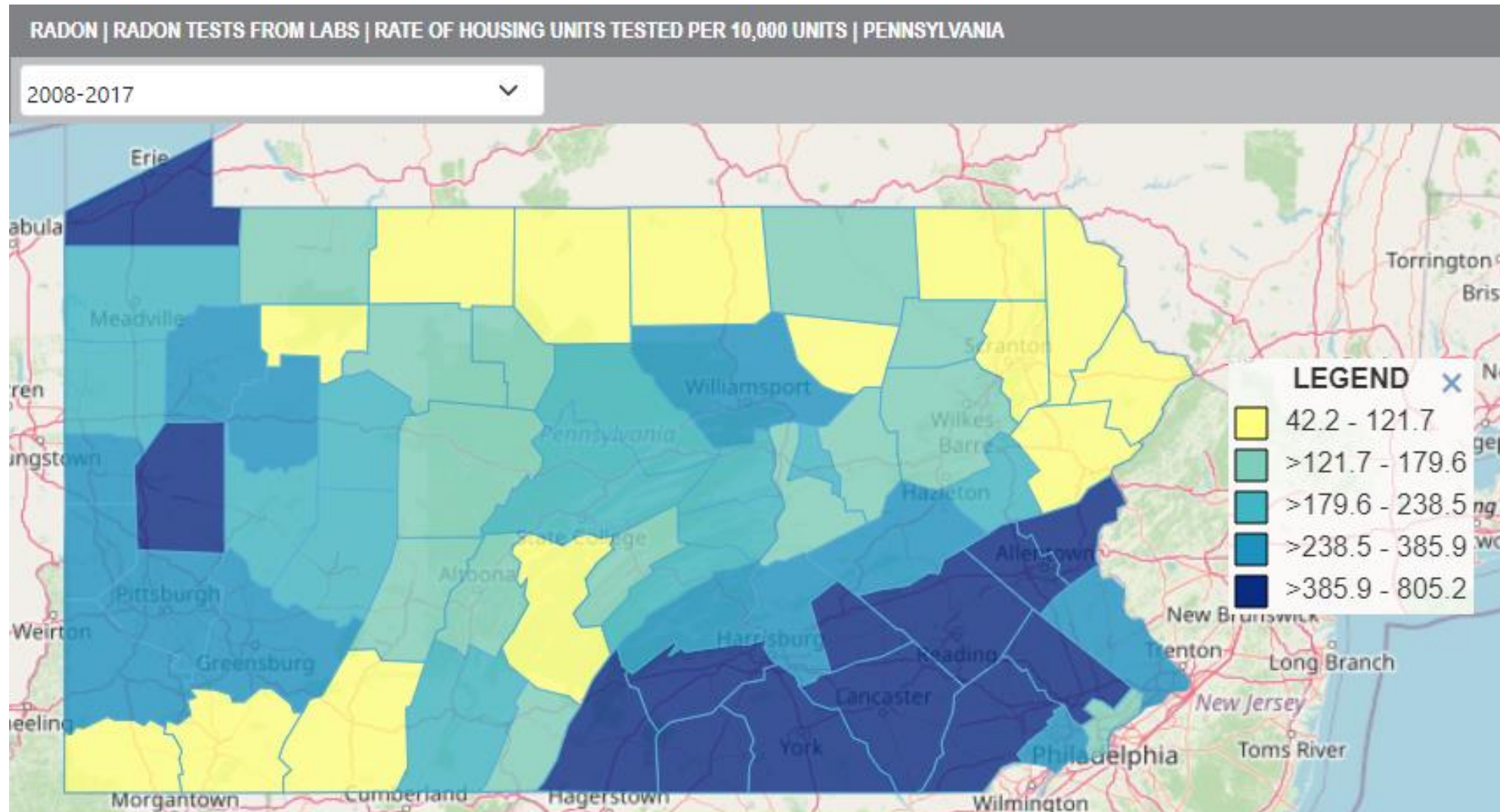
Same CDC Data (PA County Radon Averages)



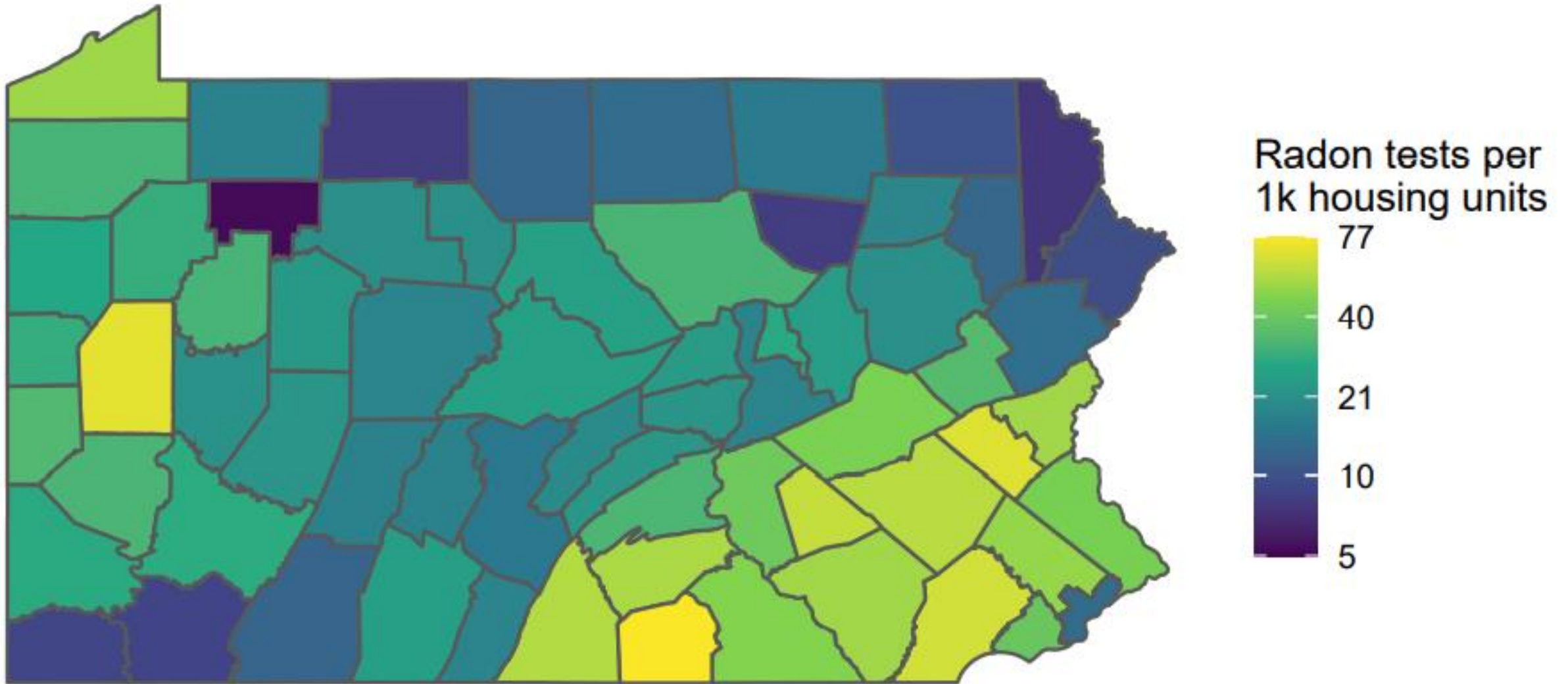
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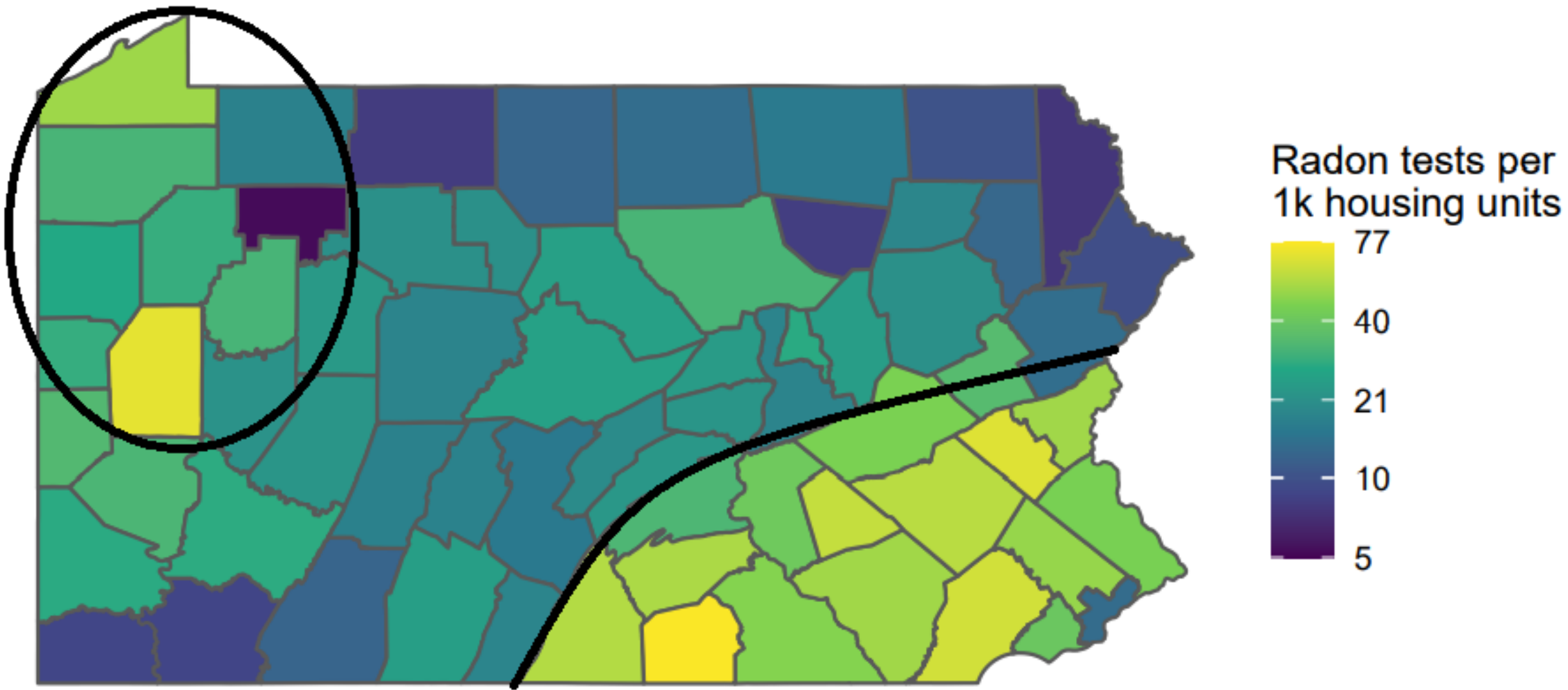
CDC NEPHT Data (PA Radon Testing Rates)



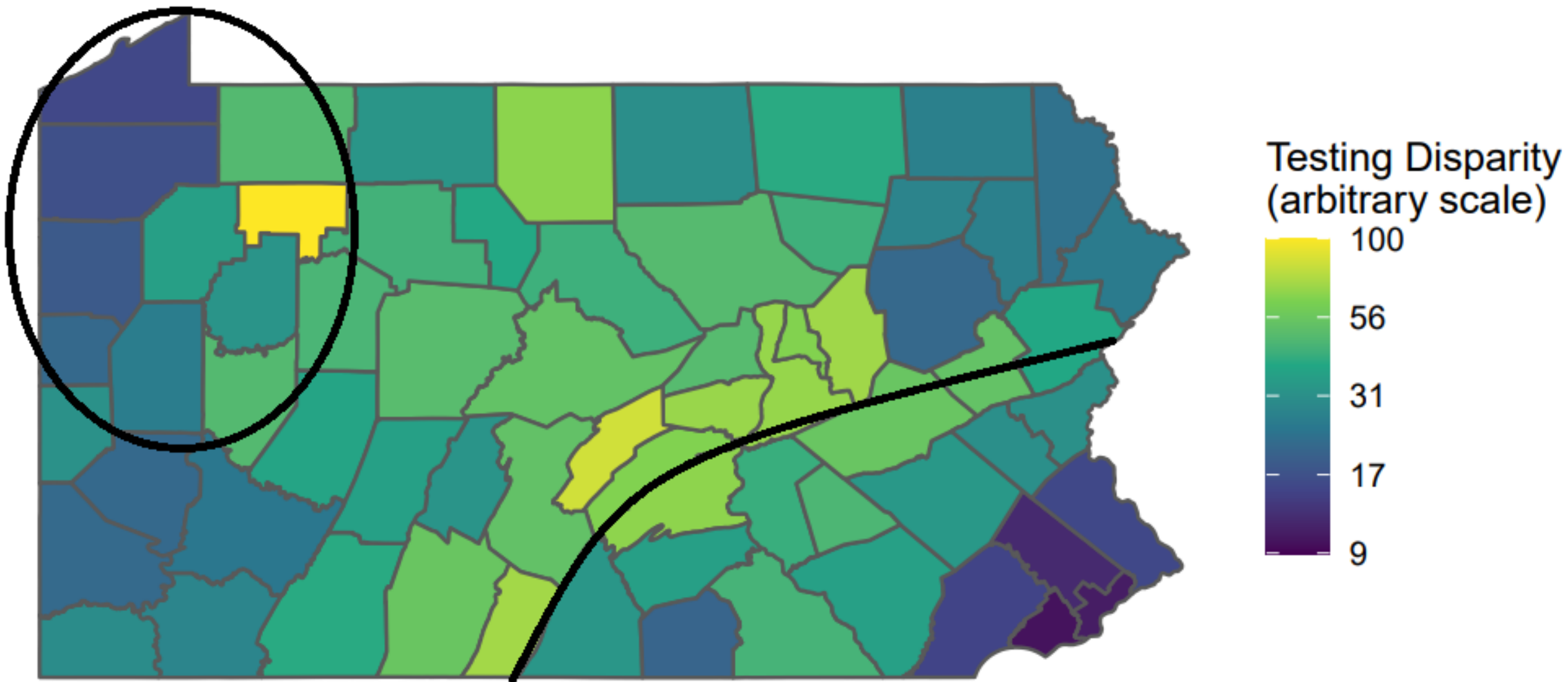
Same CDC Data (PA Radon Testing Rates)



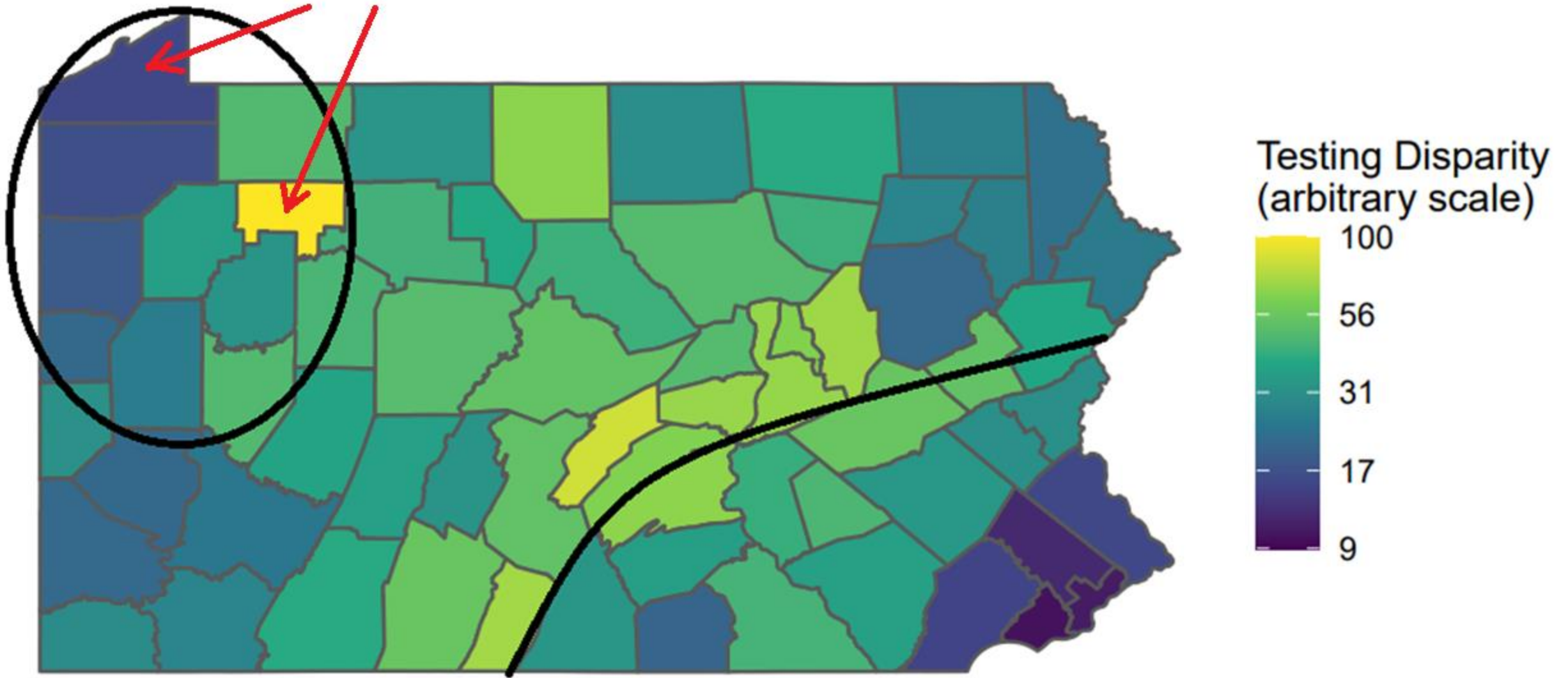
Same CDC Data (PA Radon Testing Rates)



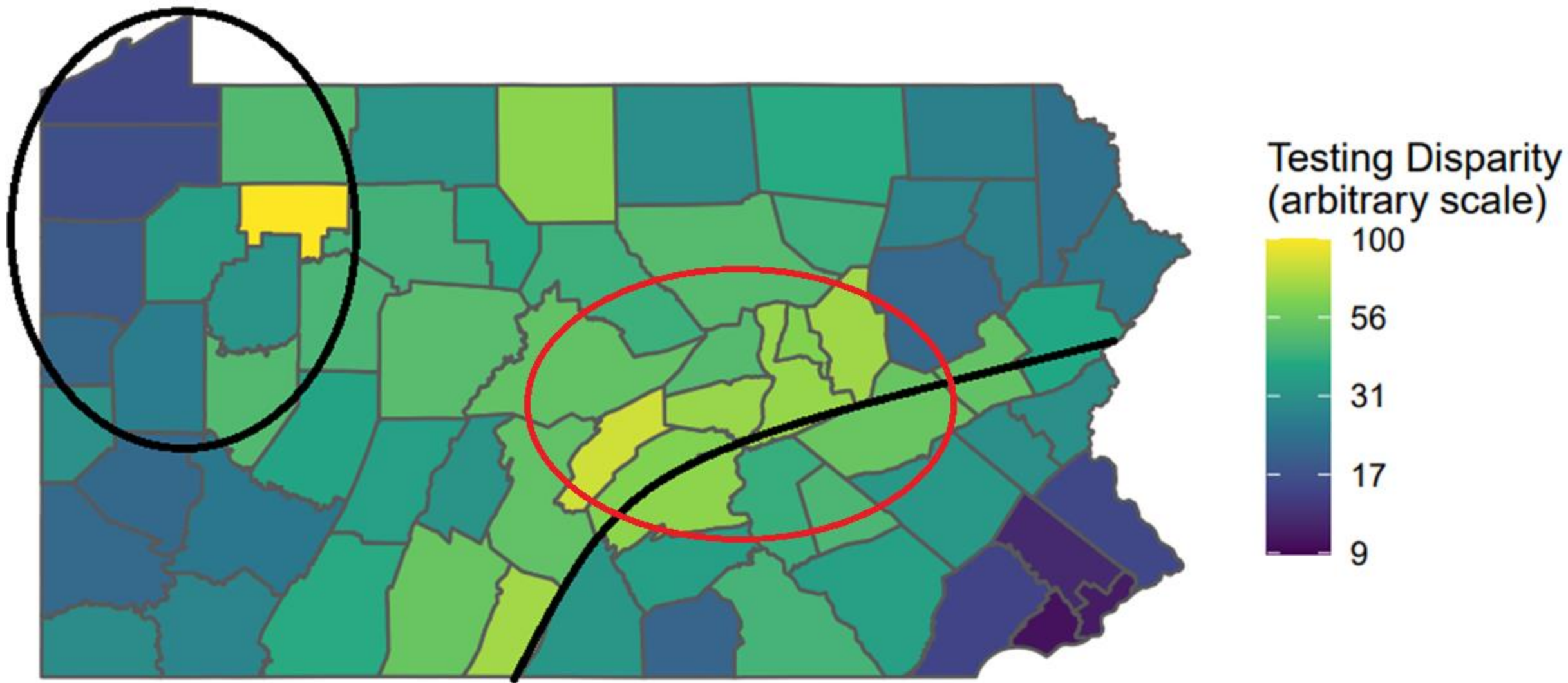
Combined Metric (PA Radon Testing Disparity)



Combined Metric (PA Radon Testing Disparity)



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State Reports on Radon Testing Disparity

Radon Testing Disparities: Pennsylvania

Radon and Radon Testing in the State of Pennsylvania

Report Generated: 2022-08-14



Introduction

The Environmental Protection Agency (EPA) estimates that radon exposure is the leading cause of lung cancer among individuals who do not smoke, and the second leading cause of lung cancer overall in the United States. The EPA also recommends homeowners consider radon testing for homes measuring between 2 pCi/L and 4 pCi/L.

Some counties exhibit radon concentrations that are substantially higher than the national average. The Pennsylvania Department of Environmental Protection (PA's Radon Action Plan) reports that radon concentrations are reported in homes in many of these counties.

Radon concentration is affected by many factors, including radon source strength and soil permeability within a geographic area. Some of the secondary causes of geographic radon concentration variation include differences in house type, and occupant behavior (e.g., opening windows).

Radon testing also varies widely within and between U.S. counties. This report is one of a set of state-by-state reports that attempts to provide a summary of U.S. publicly available radon testing data, provided by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Health and Human Services (HHS).

The purpose of this report is to provide a summary of radon testing data for Pennsylvania. The report includes a map of Pennsylvania showing radon testing rates by county, and a table of radon testing rates by county. The report also includes a list of radon testing rates by county, and a list of radon testing rates by county.

2 Using This Document

This document is primarily intended for use by individuals interested in radon testing in Pennsylvania. Those interested in radon testing in Pennsylvania should refer to this document for more information.

Radon in Pennsylvania

Radon is a naturally occurring radioactive gas that is colorless, odorless, and tasteless. It is produced by the natural decay of uranium and thorium in the earth's crust. Radon is a leading cause of lung cancer among individuals who do not smoke, and the second leading cause of lung cancer overall in the United States.

Radon testing is the process of measuring radon levels in a home. Radon testing can be done using a radon detector or a radon test kit. Radon testing is recommended for homes with radon levels between 2 pCi/L and 4 pCi/L.

Radon testing rates vary widely by county in Pennsylvania. The highest testing rates are in Allegheny County, and the lowest testing rates are in Berks County.

Radon testing rates are generally higher in counties with higher radon concentrations. This is because radon testing is more likely to be performed in areas where radon levels are higher.

Radon testing rates are also higher in counties with higher population densities. This is because radon testing is more likely to be performed in areas where there are more people.

Radon testing rates are also higher in counties with higher median household incomes. This is because radon testing is more likely to be performed in areas where people have more money.

Radon testing rates are also higher in counties with higher median ages. This is because radon testing is more likely to be performed in areas where people are older.

Radon testing rates are also higher in counties with higher median years of education. This is because radon testing is more likely to be performed in areas where people are more educated.

Radon testing rates are also higher in counties with higher median household sizes. This is because radon testing is more likely to be performed in areas where there are more people in a household.

Radon testing rates are also higher in counties with higher median household net worth. This is because radon testing is more likely to be performed in areas where people have more money.

Radon testing rates are also higher in counties with higher median household income per capita. This is because radon testing is more likely to be performed in areas where people have more money.

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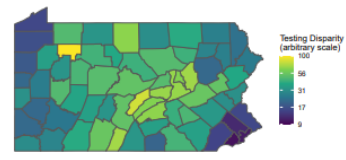
6 State Rankings

Table 1: State-level summary data. Note: Hawaii and Mississippi are excluded due to lack of data.

State	Mean Radon (pCi/L)	Radon Testing Rate (%)	Testing Disparity (arbitrary scale)
AK	1.1	100	100
AL	1.2	100	100
AR	1.3	100	100
AZ	1.4	100	100
CA	1.5	100	100
CO	1.6	100	100
CT	1.7	100	100
DC	1.8	100	100
DE	1.9	100	100
FL	2.0	100	100
GA	2.1	100	100
IA	2.2	100	100
ID	2.3	100	100
IL	2.4	100	100
IN	2.5	100	100
KS	2.6	100	100
KY	2.7	100	100
LA	2.8	100	100
MA	2.9	100	100
MD	3.0	100	100
ME	3.1	100	100
MI	3.2	100	100
MN	3.3	100	100
MO	3.4	100	100
MS	3.5	100	100
MT	3.6	100	100
NC	3.7	100	100
ND	3.8	100	100
NH	3.9	100	100
NJ	4.0	100	100
NM	4.1	100	100
NV	4.2	100	100
OH	4.3	100	100
OK	4.4	100	100
OR	4.5	100	100
PA	4.6	100	100
RI	4.7	100	100
SC	4.8	100	100
SD	4.9	100	100
TN	5.0	100	100
TX	5.1	100	100
UT	5.2	100	100
VA	5.3	100	100
VT	5.4	100	100
WA	5.5	100	100
WI	5.6	100	100
WV	5.7	100	100
WY	5.8	100	100

The tidyverse package for R version 4.1.2 [6, 7]. Full code used to generate this report is available at GitHub. Data were collected from 2008-2017 for the measures: Mean radon level in tested buildings and Number of pre-mitigation radon tests per 10 years. Data was accessed on 2022-07-29. Data used were those as reported by testing laboratories reporting in the CDC's radon data collection and mapping effort. Data were unavailable, data as reported by states to CDC analysis. Smoothing was applied to Figures 1, 2, and 3, so these figures show regional variation in testing rates and radon levels. The smoothing is a Bayesian Intrinsic Conditional Autoregressive model, implemented with `inla` [8]. The Testing Disparity metric is $R = \ln(\frac{R}{N})$ where R is the mean number of housing units, and N is the number of Radon tests per 10 years. The values shown in Figure 3 are the lowest value of the Testing Disparity metric in the U.S. is 0, and the highest value of the Testing Disparity metric is 100, with values above 25% of the national maximum prevent outliers from dominating the scale. This approach allows for areas which may benefit more from attention to testing than areas with high radon concentrations, and policy should not be based on radon testing rates alone. In addition to the presence of unaccounted-for small variations in testing rates, comparisons between states may be affected by population density, or prioritize high or low population areas. Direct comparisons within each respective state.

Figure 3: Smoothed Testing Disparity metric by county.



All homes and buildings should be tested for radon. The counties shown on the high end of the Testing Disparity scale call for increased attention, but radon testing in all counties remains an ongoing need. Higher radon levels vary widely, and elevated concentrations have been reported in many counties with low radon averages.

Finally, Figure 3 shows a combined measure - a more nuanced view than considering mean radon level and radon testing rates separately - that attempts to capture which counties might be likelier to benefit from increased attention to radon testing. This Testing Disparity metric is designed to show higher values for areas with high radon concentration, as well as low testing rates. The highest values are observed in areas with both, indicating that more tests are especially needed. It is also important to consider the radon concentrations and testing rates separately, but the Testing Disparity metric offers a quick visual way to highlight the areas where more attention to testing might be the most beneficial.

5 Technical Notes

Data on radon tests and mean concentrations was obtained from the CDC National Public Health Environmental Tracking Network via the Tracking API [4, 5]. Census data for housing-unit adjusted comparisons were obtained from

8 Disclaimer

This document was prepared on behalf of the American Lung Association by researchers at the University of Iowa. This project has been funded wholly or in part by the U.S. Environmental Protection Agency under assistance provided to the American Lung Association. The data presented in this document do not necessarily reflect the views of the U.S. Environmental Protection Agency or the American Lung Association.

Appendix: Supplemental Figures

Figure 4: Raw number of radon tests by county.



Figure 5: Raw number of radon tests by county.



Figure 6: Mean radon level by county.



Figure 7: Raw number of radon tests per 1,000 housing units by county.



Figure 8: Smoothed number of Radon tests by county.



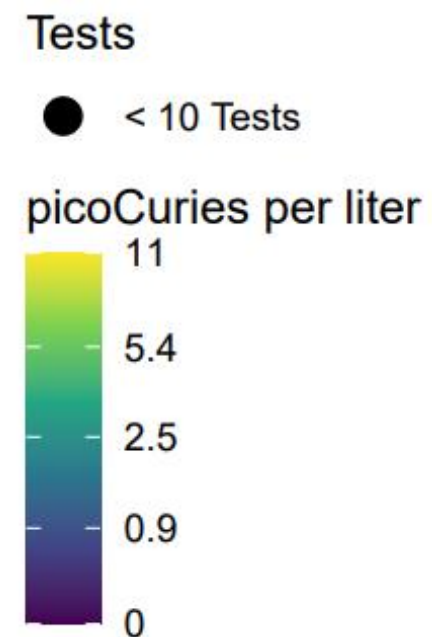
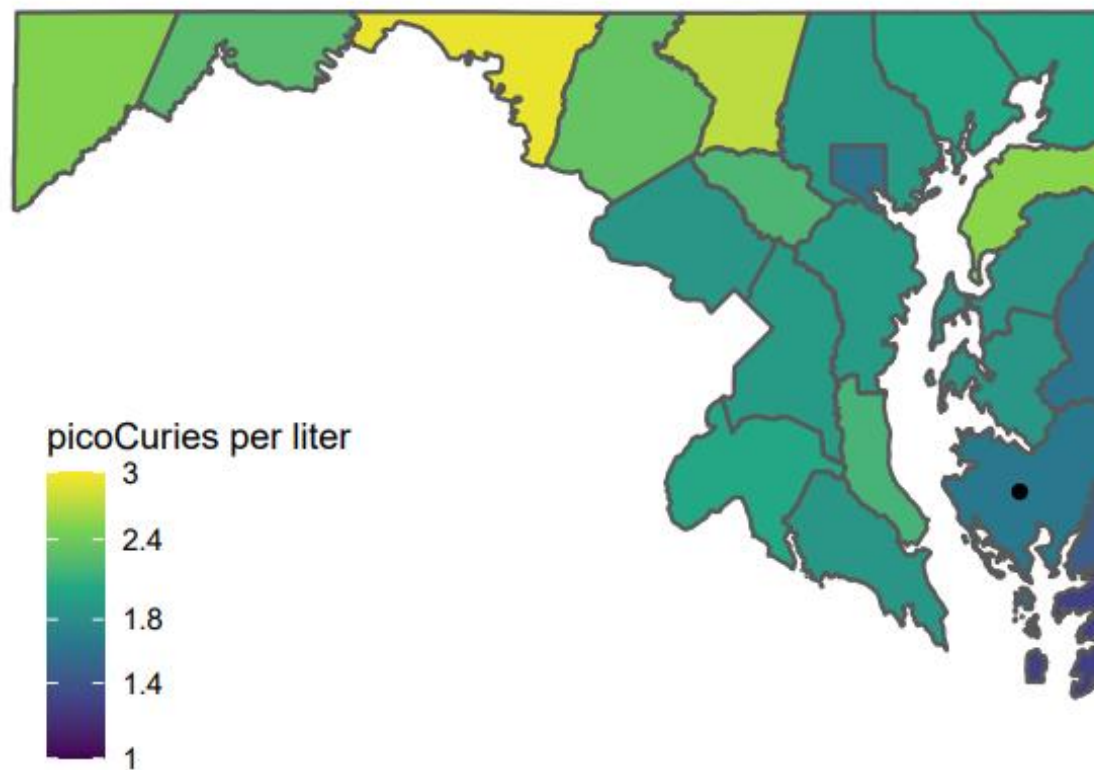
Available Now

- Available via www.Lung.org/radon

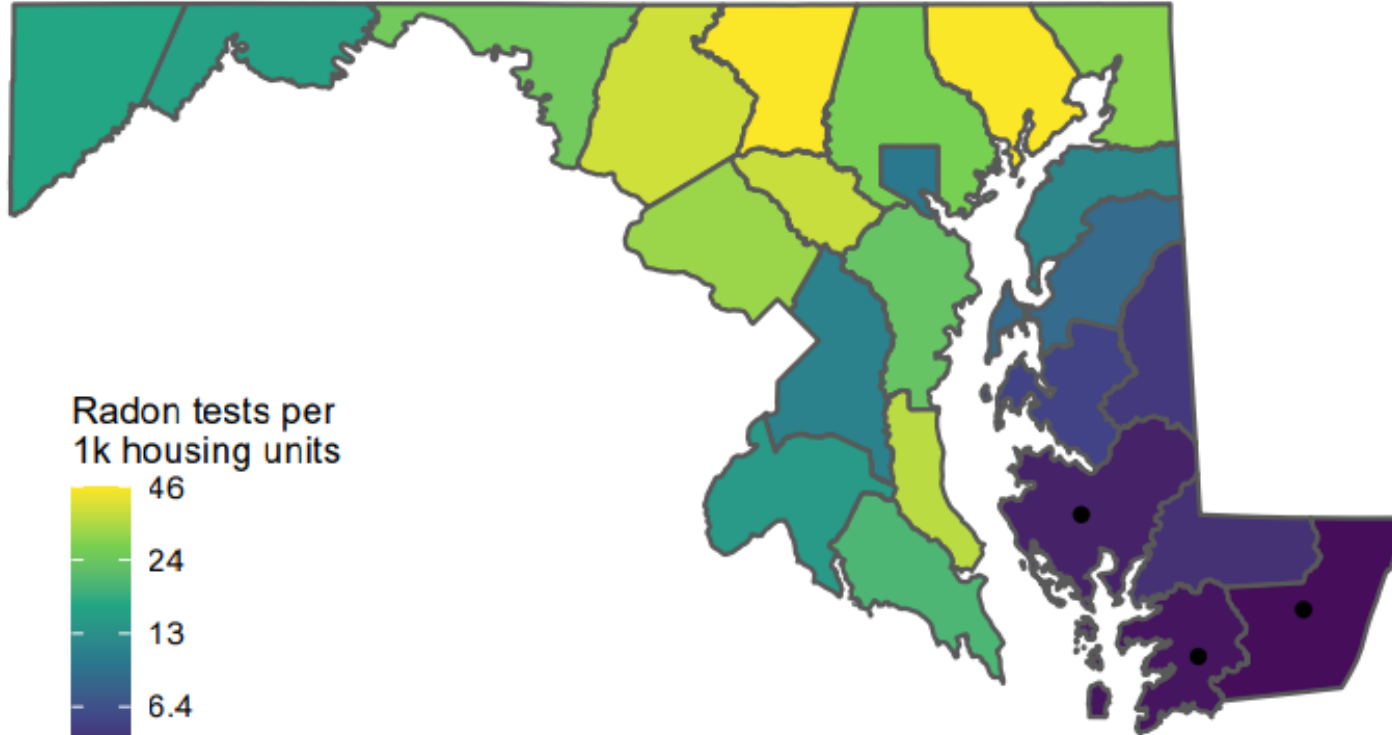
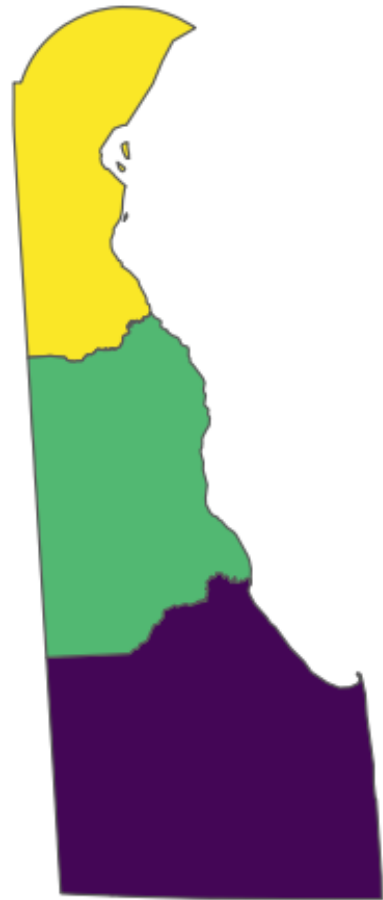
Go to Radon Resources for Professionals,
then under For State and Local Policy Makers.

- 49 individual reports (DC & all states except HI and MS)

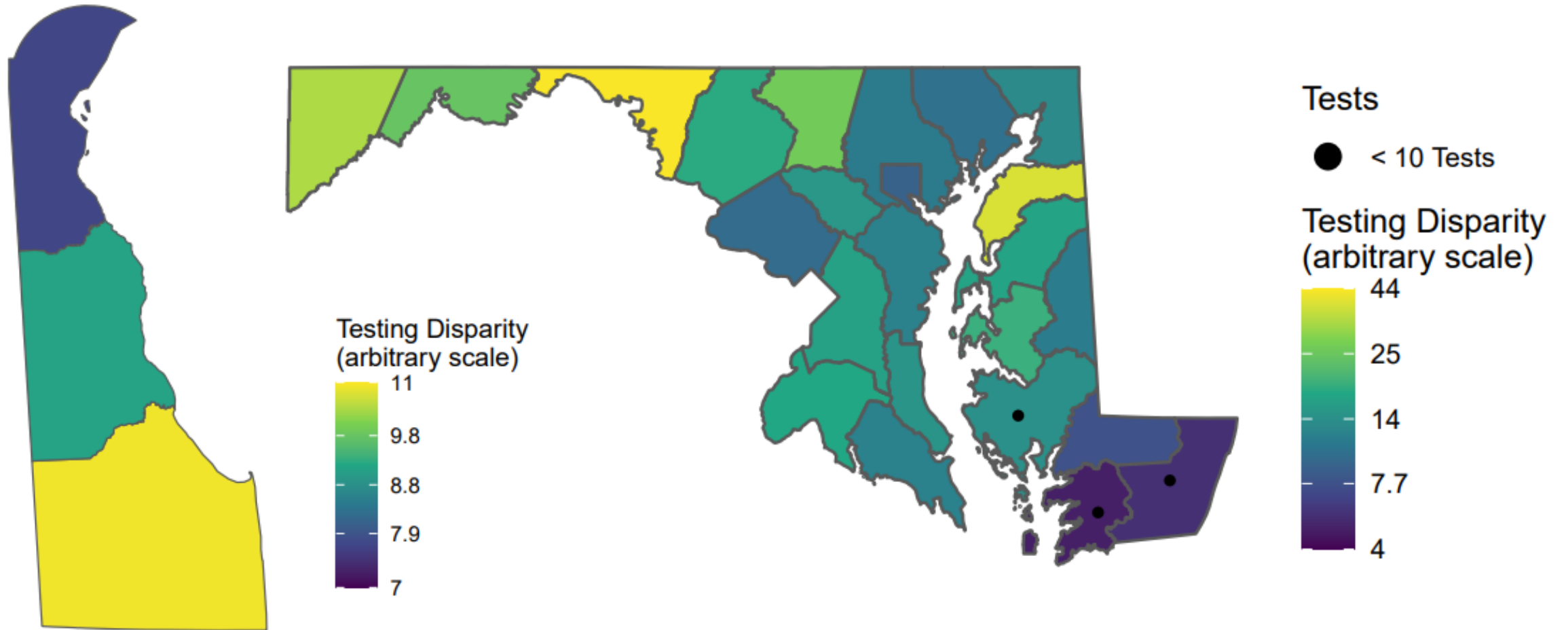
• CDC Data (County Averages) + Smoothing



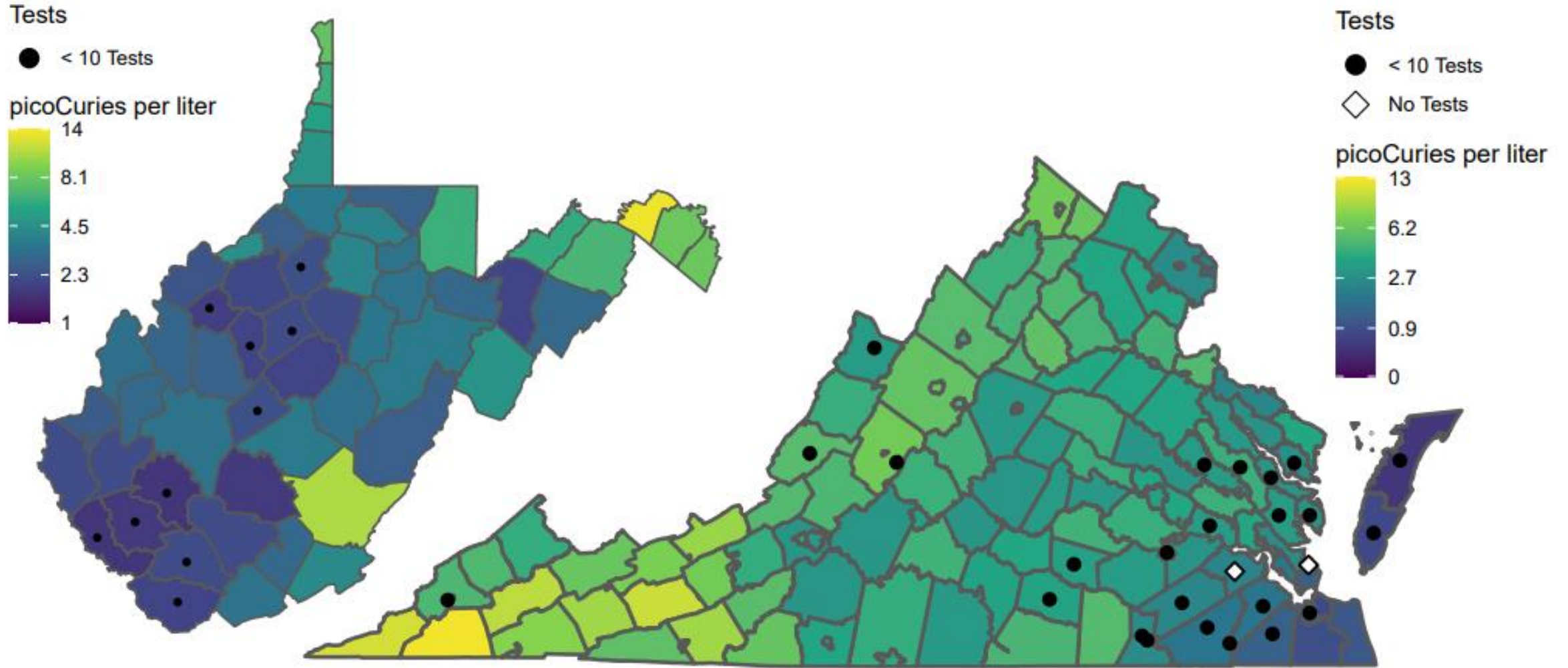
• CDC Data (Testing Rates) + Smoothing



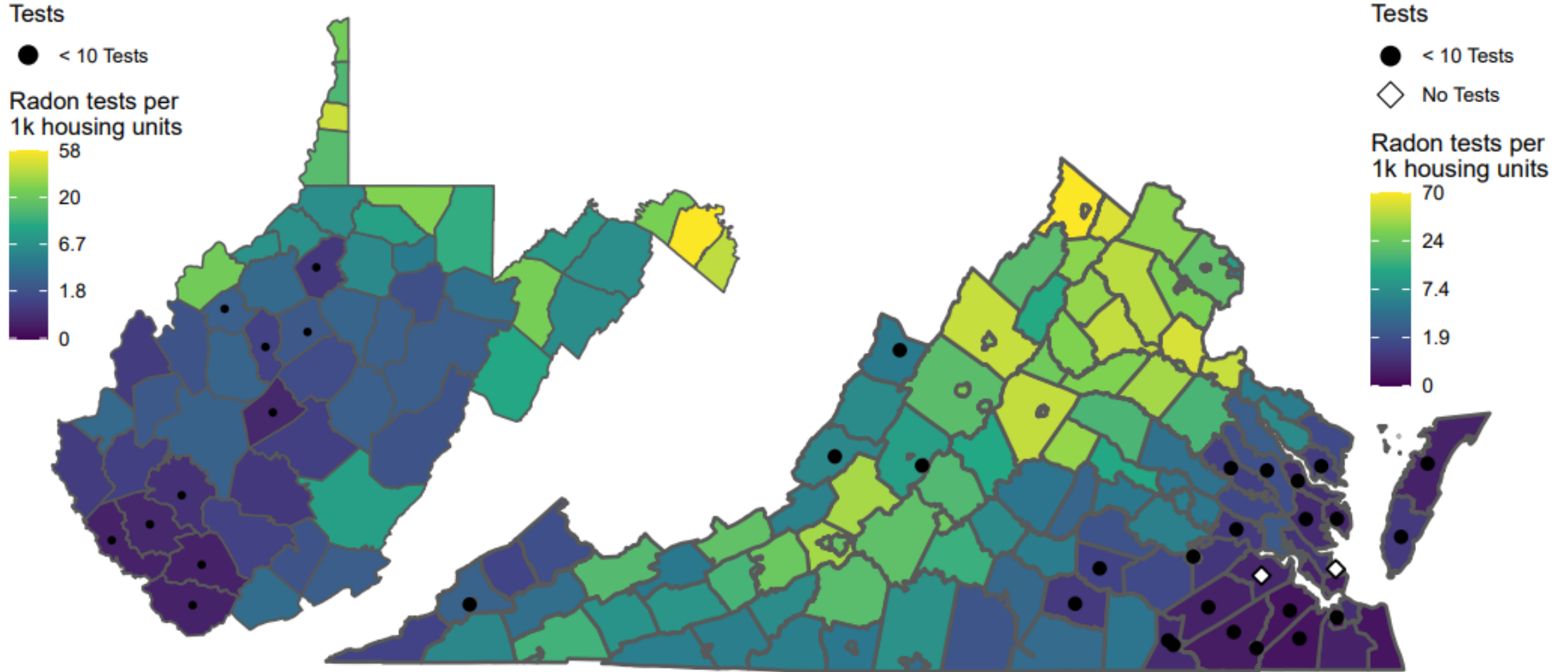
• Combined (Radon Testing Disparity Metric)



• CDC Data (County Averages) + Smoothing



• CDC Data (Testing Rates) + Smoothing

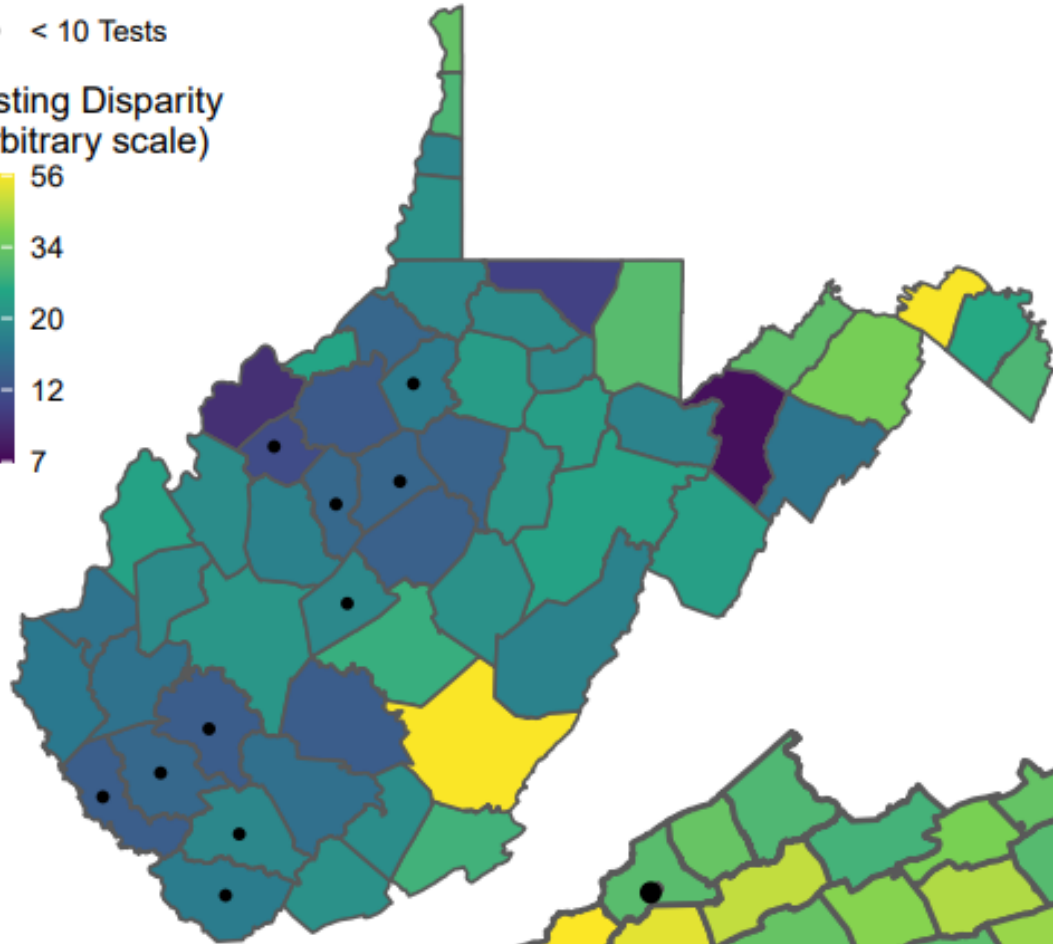
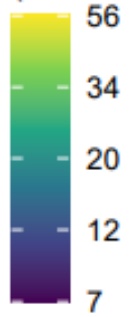


• Combined (Radon Testing Disparity Metric)

Tests

● < 10 Tests

Testing Disparity
(arbitrary scale)

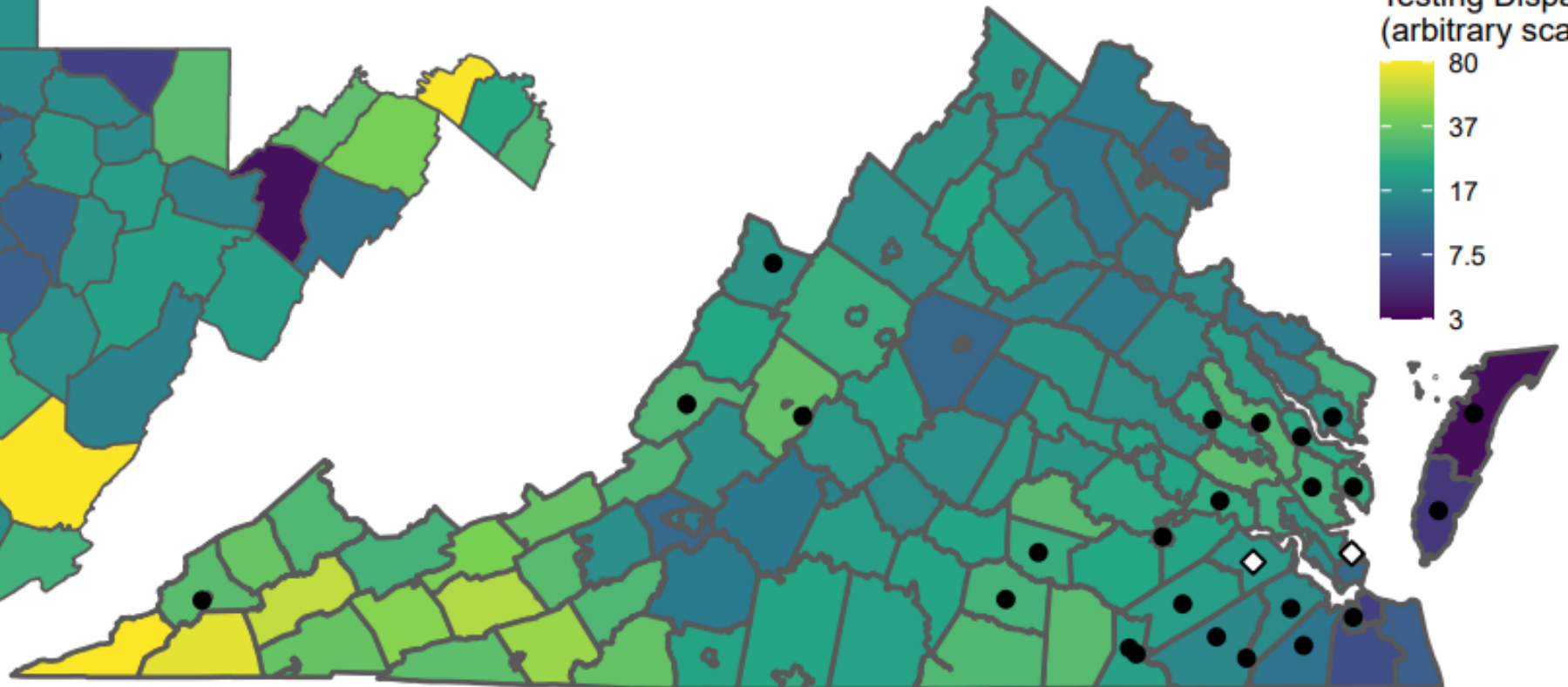
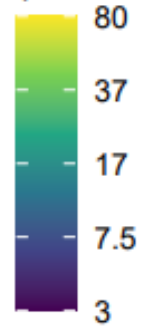


Tests

● < 10 Tests

◇ No Tests

Testing Disparity
(arbitrary scale)



District of Columbia

State	Rank	Weighted Average Smoothed Testing Disparity	Estimated Mean Radon Level	Housing Units	Radon Tests (10 years)	Radon Tests per 1,000 Housing Units
Maryland	35	13.8	3.2	2,470,316	47,941	19.4
Florida	36	13.5	2.1	9,673,682	53,794	5.6
Oregon	37	13.4	2.8	1,808,465	23,951	13.2
Vermont	38	13.1	3.4	339,439	10,600	31.2
Michigan	39	12.1	3.1	4,629,611	114,407	24.7
Nevada	40	11.0	2.1	1,285,684	10,930	8.5
District of Columbia	41	9.8	1.9	322,793	2,126	6.6
North Carolina	42	9.7	2.2	4,747,943	73,139	15.4
Delaware	43	9.0	2.2	443,781	12,214	27.5

Radon Risk Reduction in Rental Housing

New Report



National Center for
HEALTHY HOUSING

Radon Risk Reduction Strategies in Rental Housing:
Opportunities to Strengthen State and Local Policies

Radon / Rental Housing Report


Foundation of need—Prevalence of home *rental*:

- More than half of Black and Hispanic adults.
- A third of White adults.
- About 60% of people with the lowest incomes
(compared to 10% of people with the highest incomes).

Radon / Rental Housing Report

- Available via both:
 - Lung.org/radon-in-rental-housing
 - Bit.ly/NCHHpubsRadonRRS

Radon Remediation Report



American Lung Association.

National Center for HEALTHY HOUSING

Radon Risk Reduction Strategies in Rental Housing: Opportunities to Strengthen State and Local Policies

Introduction

Exposure to radon leads to an estimated 21,000 lung cancer deaths annually in the United States and increases health disparities because the benefits of radon mitigation are not equally shared. Most radon policies apply to owner-occupied units; fewer policies apply to rental units, which are disproportionately occupied by people with lower incomes and people of color.¹ These disparities are further compounded by the fact that people of color are less likely than White individuals to have lung cancer diagnosed early.

Although new federal requirements will expand the number of rental homes tested and mitigated when federal assistance is involved, additional action is needed. State and local requirements can help fill gaps in federal policy and protect people from radon risks, especially those who rent homes. The benefits of fixing radon radon to prevent lung cancers are enormous. It is estimated that every dollar spent on radon testing and repairs in multifamily housing returns \$11 to \$20 in avoided healthcare costs.²

Radon Basics

Why Radon Is a Concern

Radon is a colorless, odorless gas that forms from the natural breakdown of uranium in rocks and soils. It becomes a health risk when it seeps from the ground into our homes. Radon and its decay products are

How Radon Is Addressed in Homes

Testing radon levels in homes is simple and there are proven solutions for preventing radon from entering homes. EPA's website provides information about how and how-to test kits, fixing testing and mitigation professionals, and some different radon reduction options.

The most reliable option for any building with concrete between the ground and building is called "sub-slab depressurization"—also referred to as "active radon mitigation." It involves inserting a suction pipe through the floor to the ground underneath and using a fan to draw the radon up and out of the home.

For homes with crawl spaces, mitigation typically involves covering the dirt floor with thick plastic sheeting and using a pipe and fan to draw the radon from under the sheet to the outdoors.

In apartment buildings, pipes and fans can be installed exterior during construction as part of a retrofit. In such buildings, it can be more efficient and effective to address radon through a building-wide solution, rather than in isolated units.

National standards of practice for radon testing and mitigation have been developed by the American Association of Radon Scientists and Technologists (AARST) under standards-development protocols of the American National Standards Institute (ANSI). According to industry estimates,³ professional testing costs range from \$100 to \$275 per unit for single-family housing and \$50 to \$95 per unit for multifamily housing. Mitigation costs range from \$1,500 to \$3,000 and \$2,500 to \$4,000 for single- and multifamily housing, respectively. Costs may vary greatly if a regulator—Fannie Mae and Freddie Mac, for instance⁴—has those processes built into (and possibly even outside) these ranges, by region and urbanicity and by local availability of labor. Before buying the mortgage of a multifamily property, either a lender or investor should consider the placement and review of the tests—a task that can be performed by a professional, such as the environmental professional's role responsible for analyzing the results. The process must also adhere to any state radon requirements.

Federal Radon Policy and Regulations

Federal action to address radon has increased in recent years, including changes that will affect rental units. For example, HUD's Federal Housing Administration (FHA) expanded its testing requirements for multifamily properties receiving FHA mortgage insurance, and multifamily projects required under the Federal Housing Finance Administration (FHFA) will also have new testing requirements. However, these changes only reach a fraction of estimated 48 million rental units nationwide. FHA insures approximately 160,000 units per year, the entities that FHFA regulates finance about 10 times that number,⁵ and HUD's Rental Assistance Demonstration (RAD) program to convert public housing to privately owned properties reaches about 100,000 units each year. However, because these federal requirements are relatively new, data are lacking on the number of units that have been tested and mitigated as a result. Still, these recent efforts are a positive step toward implementing the current National Radon Action Plan (NRAP), which was developed by the American Lung Association, industry members, advocates, and state and federal agency officials with funding support from EPA. The first goal of that plan explicitly recommends radon requirements for rental units during real estate transactions. Additional details about the requirements follow.

The Federal Housing Finance Administration (FHFA) adopted, on January 19, 2023, more robust radon testing requirements for multifamily properties with loan applications received after October 1, 2023, for two entities that it regulates—Fannie Mae and Freddie Mac (collectively "Fannie Mae and Freddie Mac").⁶ These mortgage buyers, before buying the mortgage of a multifamily property, either a lender or investor should consider the placement and review of the tests—a task that can be performed by a professional, such as the environmental professional's role responsible for analyzing the results. The process must also adhere to any state radon requirements.

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Explicitly consider health equity and environmental justice. States and localities can use their testing data to effectively target radon testing to the communities at greatest risk. For example, the Minnesota Department of Health created a mapping tool to show radon testing rates in communities across the state alongside demographic information. Additional information can ensure that those that have a stake in radon policies, such as tenants with lower incomes, have a role in shaping the requirements. Addressing radon in rental housing also will help address historical inequities that have left such housing without the same protections as owner-occupied units.

Leverage zoning and housing code updates. Boulder County, Colorado, widely used a grant from the state department of health to develop radon-resistant new construction requirements for the unincorporated areas of Boulder County. When the City of Boulder's land use department was writing zoning requirements for the growing vacation rental market, they invited the county environment to help craft radon requirements. The hope is to expand these requirements to all rental housing. Similarly, a local government incorporated radon testing and mitigation into the housing and zoning code. A local government incorporated to establish the rental market in what is predominantly a university town. The City of Denver building and housing department invited the public health department to comment on revisions to the city's housing code, but they were unable to add radon testing requirements because the changes were limited to issues covered in the existing code.

Strengths and Limitations of Existing Policies

Many radon laws and policies reflect compromises that emphasize feasibility and cost over public health.

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mitigation expenses. In 2023, Rhode Island's general assembly proposed a testing requirement and use of a certified radon professional to confirm a tenant's test. For additional information on state radon laws, see the Environmental Law Institute (ELI) summary of state radon laws, which is updated annually. According to ELI, housing codes and landlord-tenant laws are two ways to address environmental health issues, such as radon, in housing. Housing codes set minimum standards for conditions in rental housing and are sometimes referred to as property maintenance codes or sanitation codes. Typically applied by localities, housing codes can also be adopted at the state level. Landlord-tenant laws lay out the rights and responsibilities of landlords and tenants and provide a tenant with legal recourse if a landlord fails to remedy substandard housing conditions. The reliability of test results, whether they are sufficient professionals to carry out testing and mitigation, and the appropriate testing protocols for apartments, they may question whether action was warranted in rental units because of potentially short-term exposures.

Those involved with successful local efforts offer the following recommendations:

- Use local data to make the case for stronger radon policies. Boulder County, Colorado, noted that half of area homes exceeded EPA's action level. This provided a powerful rationale for action. Montgomery County, Maryland, conducted a public information campaign to help build support for radon action.
- Proactively build relationships with real estate agents, landlords, homeowners, and other stakeholders.
- Adopt established testing and mitigation protocols.
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Radon / Rental Housing Report

- Radon Basics
- Federal Radon Policy and Regulations
 - FHFA, HUD, Depts. of Defense and Agriculture
- State and Local Radon Policies
 - Notification, Disclosure, Testing, Building Codes, Landlord-Tenant Laws, Some Specific Cases

Radon / Rental Housing Report

- Recommendations for State and Local Policy Action
 - Use local data, build relationships, adopt established protocols, explicitly consider health equity & EJ, leverage zoning and building code updates.
 - Study strengths and limitations of existing policies.
 - Require specific components: Notification/disclosure, require testing, qualified professional, mitigation, RRNC, penalty and enforcement, review & response

A circular graphic with a blue background. The interior of the circle is filled with a dense field of 3D question marks. The question marks are rendered in a light blue color with a subtle wood-grain texture, giving them a three-dimensional appearance. They are scattered across the circle, with some in the foreground appearing larger and more detailed, while others in the background are smaller and more blurred. The overall effect is a sense of depth and abundance of questions.

Questions?

For more information

- www.Lung.org/Radon
- 1-800-LUNG-USA

- Kevin.Stewart@Lung.org

Some Proposed Alternatives

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 - R = mean pre-mitigation radon level
 - N/H is a measure of the testing rate
- Experimented with some forms:
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 $D = R * (H - N) / H = R * (1 - N/H) \rightarrow$ Since N/H is almost always very small, **the value simply strongly reflected R .**

Essential Perspectives

- Not intended as last word. Consider this as Testing Disparity

Metric Version 1.0.

- Users can access the background information at [GitHub](#) links in the reports.

State TEXAS	County Name	Housing Units	Raw Testing Disparity	Smoothed Testing Disparity	Raw Mean Radon Level	Smoothed Mean Radon Level	Raw Test Count	Smoothed Test Count
	Blanco County	5866	0.69346241	18.7342725	0.2	2.183099403	2	1.965531733
	Borden County	394	NA	27.13505697	NA	3.186041841	NA	0.163037647
	Bosque County	9805	NA	9.057347201	NA	1.055026417	NA	2.177463085
	Bowie County	40202	NA	13.8963929	NA	1.466141899	NA	5.021883693
	Brazoria County	142608	3.28409452	7.50761877	0.9	0.900492388	32	32.85137984
	Brazos County	94330	1.98153119	4.194048446	0.6	0.603830883	47	45.62980332
	Brewster County	5575	10.6902286	23.24416655	3.4	3.025676836	4	4.468507242
	Briscoe County	957	NA	42.0332954	NA	5.207812394	NA	0.627873043
	Brooks County	3237	NA	4.676589319	NA	0.54556996	NA	0.299721591
	Brown County	19355	3.98576318	9.484602616	1	1.068648344	2	3.328863636
	Burleson County	9315	NA	6.575574766	NA	0.868941726	NA	3.933742998
	Burnet County	23943	132.881428	235.5797226	37.6	25.7020152	7	6.775578078
	Caldwell County	15671	4.28347339	10.08468156	1.1	1.163663086	2	3.396400392
	Calhoun County	12151	NA	9.098825494	NA	1.040868572	NA	2.225487062
	Callahan County	6792	NA	10.18688947	NA	1.222420637	NA	1.82903386
	Cameron County	154019	3.00496843	6.821538842	0.8	0.798712098	27	25.86094322

Opportunities for Refinement

- The architecture of this report has been designed to be readily used
 - As is;
 - With updated data;
 - With modified calculation methodology.
- The Lung Association is open to learn of suggestions, recommendations for improvements.

Implications for Decision-makers

- Primary intended users: State and Tribal radon officials, public health officials, academics.
- Primary purpose: Assistance in addressing needs when facing difficult decisions presented by limited resources.
- Radon service providers as well as local interested parties can also learn where they might pay additional attention.

Calls to Action

- Radon program decision-makers: Review and assess how it might help you in directing resources.
 - State, Tribal, Local radon officials
 - Public health agencies
- Provide feedback on the documents and methodology, suggestions for improvements.
- States and laboratories: ***Provide better data, more of it and more recent, to CDC. (Tools ensure confidentiality.)***