Neighborhood-Level Socioeconomic Disparities in Radon Testing in North Carolina from 2010 to 2020

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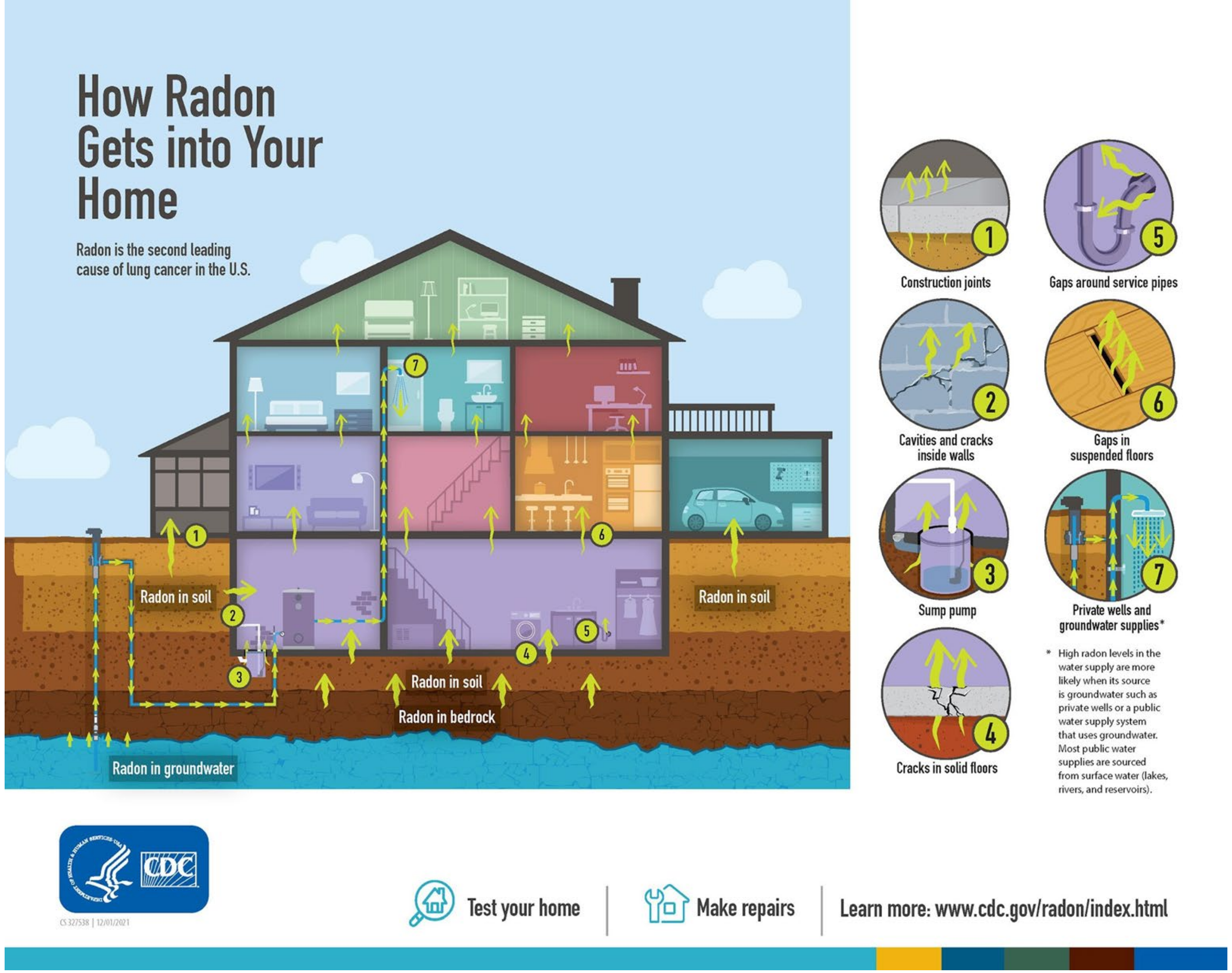
1950
1960
1970
1980
1990
2000
2010
2020
2030
Health Impacts and Studies
Radon's link to lung cancer
1960
Radon as a public health concern
1984
A human carcinogen by the WHO
1987
World Health Organization
Radon testing during COVID-19
2020
Regulations and Guidelines
Establishment of EPA
DEC 2, 1970
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Radon testing guidelines
1986
Radon Reduction Demonstration Act
1988
Radon-resistant construction techniques
1993
Radon in drinking water regulation
2000
Radon testing in schools
2010
Radon-resistant construction codes
2015
Awareness and Advocacy
Radon-induced lung cancer awareness
1988
National Radon Action Plan
2009
Radon Awareness Week
OCT 20, 2013 - OCT 26, 2013
National Radon Action Month
JANUARY 2020
1950
1960
1970
1980
1990
2000
2010
2020
2030



Radon is an odorless, invisible, radioactive gas naturally released from rocks, soil, and water.

Radon can get into homes and buildings through small cracks or holes and build up in the air.

Over time, breathing in high levels of radon can cause lung cancer.

https://www.cdc.gov/nceh/features/protect-homeradon/index.html#:~:text=Radon%20is%20an%20odorless%2C%20invisible,radon%20can%20cause%20lung%20cancer.

Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies

S Darby, D Hill, A Auvinen, J M Barros-Dios, H Baysson, F Bochicchio, H Deo, R Falk, F Forastiere, M Hakama, I Heid, L Kreienbrock, M Kreuzer, F Lagarde, I Mäkeläinen, C Muirhead, W Oberaigner, G Pershagen, A Ruano-Ravina, E Ruosteenoja, A Schaffrath Rosario, M Tirmarche, L Tomášek, E Whitley, H E Wichmann, R Doll

Abstract

Objective To determine the risk of lung cancer associated with exposure at home to the radioactive disintegration products of naturally occurring radon gas

Design Collaborative analysis of individual data from 13 case-control studies of residential radon and lung cancer.

Setting Nine European countries.

Subjects 7148 cases of lung cancer and 14 208 controls.

Main outcome measures Relative risks of lung cancer and radon gas concentrations in homes inhabited during the previous 5-34 years measured in becquerels (radon disintegrations per second) per cubic metre (Bq/m^3) of household air.

Results The mean measured radon concentration in homes of people in the control group was 97 Bq/m^3, with 11% measuring >200 and 4% measuring >400 Bq/m^3. For cases of lung cancer the mean concentration was 104 Bq/m^3. The risk of lung cancer increased by 8.4% (95% confidence interval 3.0% to 15.8%) per 100 Bq/m^3 increase in measured radon ($P = 0.0007$). This corresponds to an increase of 16% (5% to 31%) per 100 Bq/m^3 increase in usual radon—that is, after correction for the dilution caused by random uncertainties in measuring radon concentrations. The dose-response relation seemed to be linear with no threshold and remained significant ($P = 0.04$) in analyses limited to individuals from homes with measured radon <200 Bq/m^3. The proportionate excess risk did not differ significantly with study, age, sex, or smoking. In the absence of other causes of death, the absolute risks of lung cancer by age 75 years at usual radon concentrations of 0, 100, and 400 Bq/m^3 would be about 0.4%, 0.5%, and 0.7%, respectively, for lifelong non-smokers, and about 25 times greater (10%, 12%, and 16%) for cigarette smokers.

Conclusions Collectively, though not separately, these studies show appreciable hazards from residential radon, particularly for smokers and recent ex-smokers, and indicate that it is responsible for about 2% of all deaths from cancer in Europe.

into a series of short lived radioactive progeny. Two of these, polonium-218 and polonium-214, also decay by emitting α particles. If inhaled, radon itself is mostly exhaled immediately. Its short lived progeny, however, which are solid, tend to be deposited on the bronchial epithelium, thus exposing cells to α irradiation.

Air pollution by radon is ubiquitous. Concentrations are low outdoors but can build up indoors, especially in homes, where most exposure of the general population occurs. The highest concentrations to which workers have been routinely exposed occur underground, particularly in uranium mines. Studies of exposed miners have consistently found associations between radon and lung cancer.[2 3] Extrapolation from these studies suggests that in many countries residential radon, which involves lower exposure in much larger numbers of people, could cause a substantial minority of all lung cancers. This is of practical relevance because radon concentrations in existing buildings can usually be reduced at moderate cost—for example, by increasing underfloor ventilation—while low concentrations can usually be ensured at reasonable or low cost in new buildings—for example, by installing a radon proof barrier at ground level. These extrapolations, however, depend on uncertain assumptions because the levels of exposure in miners that produced evident risk were usually much higher, lasted only a few years, and took place under different particulate air and other conditions.[1-3] Moreover, history on smoking is often lacking, or limited, in the studies of miners and some miners were also exposed to other lung carcinogens such as arsenic.

Studies to estimate directly the risk of lung cancer associated with residential radon exposure over several decades have been conducted in many European countries. Individually these studies have not been large enough to assess moderate risks reliably. Greater statistical power can be achieved by combining information from several studies, but this cannot be done satisfactorily from published information. Urban areas tend to have

https://pubmed.ncbi.nlm.nih.gov/15613366/

- Overall, radon is the second leading cause of lung cancer.

- Radon is responsible for about 21,000 **lung cancer** deaths every year.

- About 2,900 of these deaths occur among people who have never smoked.

https://www.epa.gov/radon/health-risk-radon

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Climate Change, Radon Exposure and Lung Cancer

The Duke Climate Commitment is a **university-wide**, **impact-oriented initiative** to address the climate crisis by creating **sustainable** and **equitable** solutions that place society on the path toward a **resilient, flourishing, carbon-neutral world**. Through **education, research, external engagement** and **campus operations**, the Duke Climate Commitment seeks to imagine, design and implement a sustainable future for all.

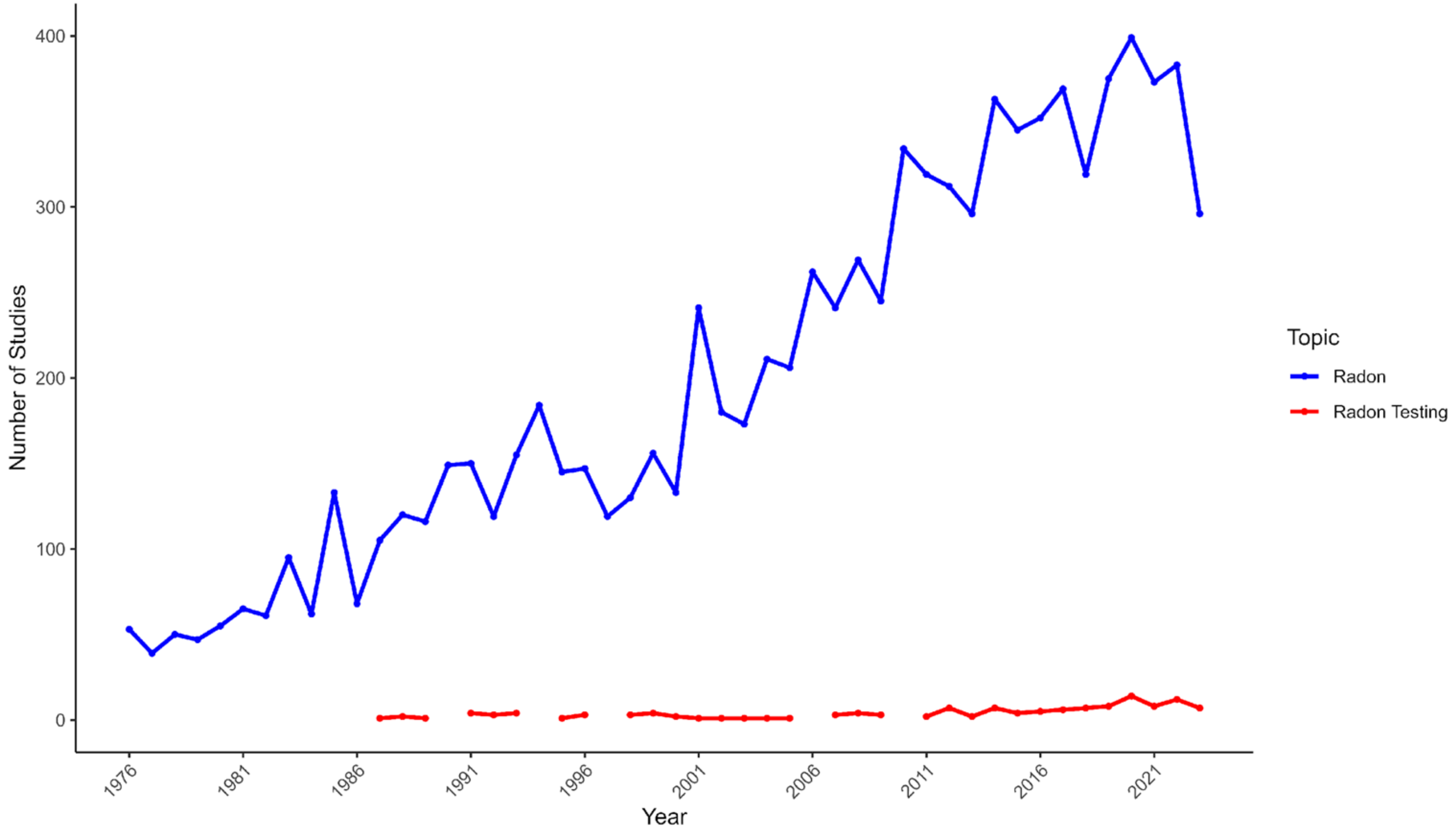
Aims

1. Explore the distribution of **radon testing** and identify influential factors in North Carolina.

2. Investigate the potential trends in future radon exposure influenced by climate change.

Radon Testing

Identify research gaps: Known and Unknown.



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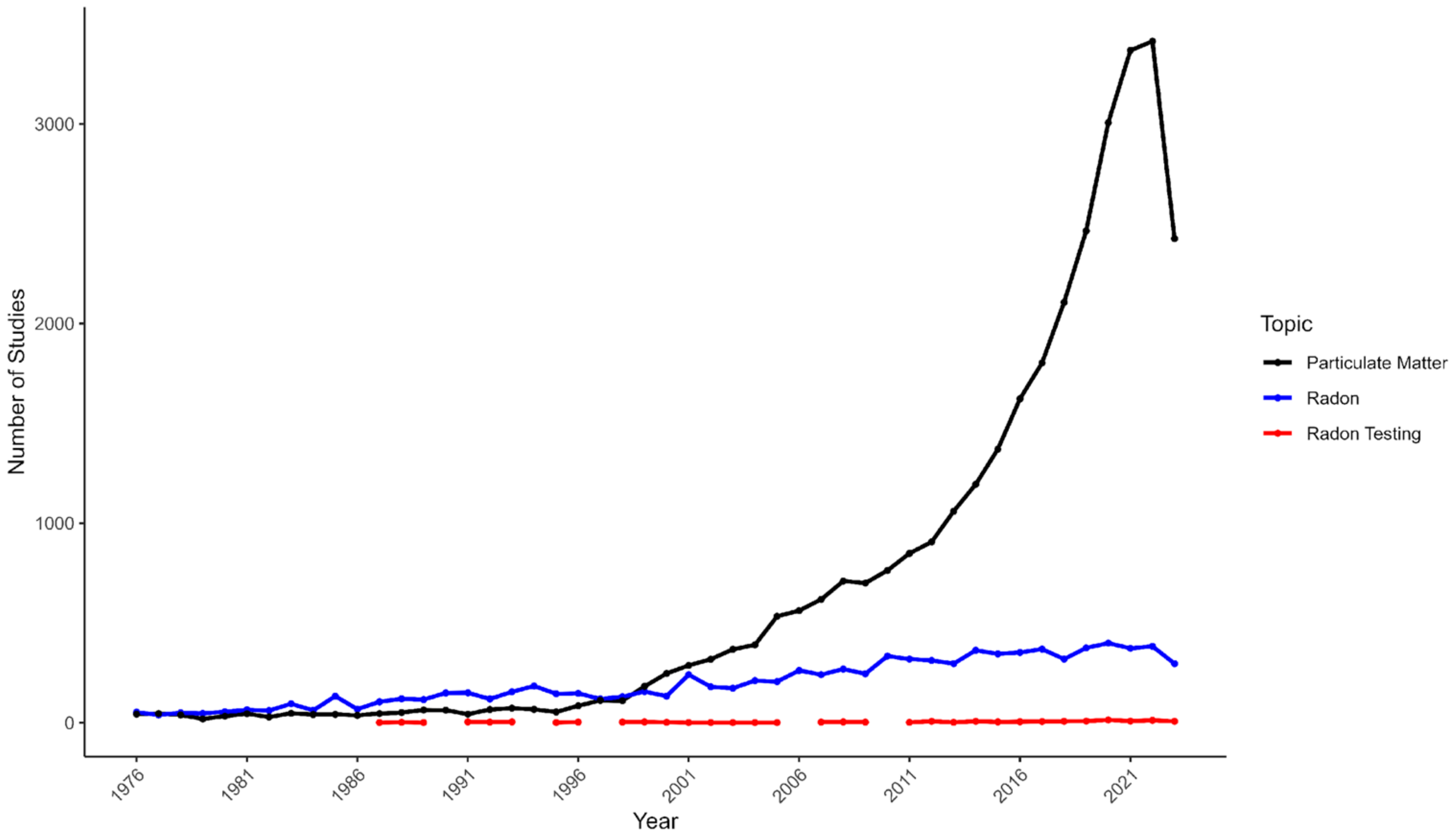
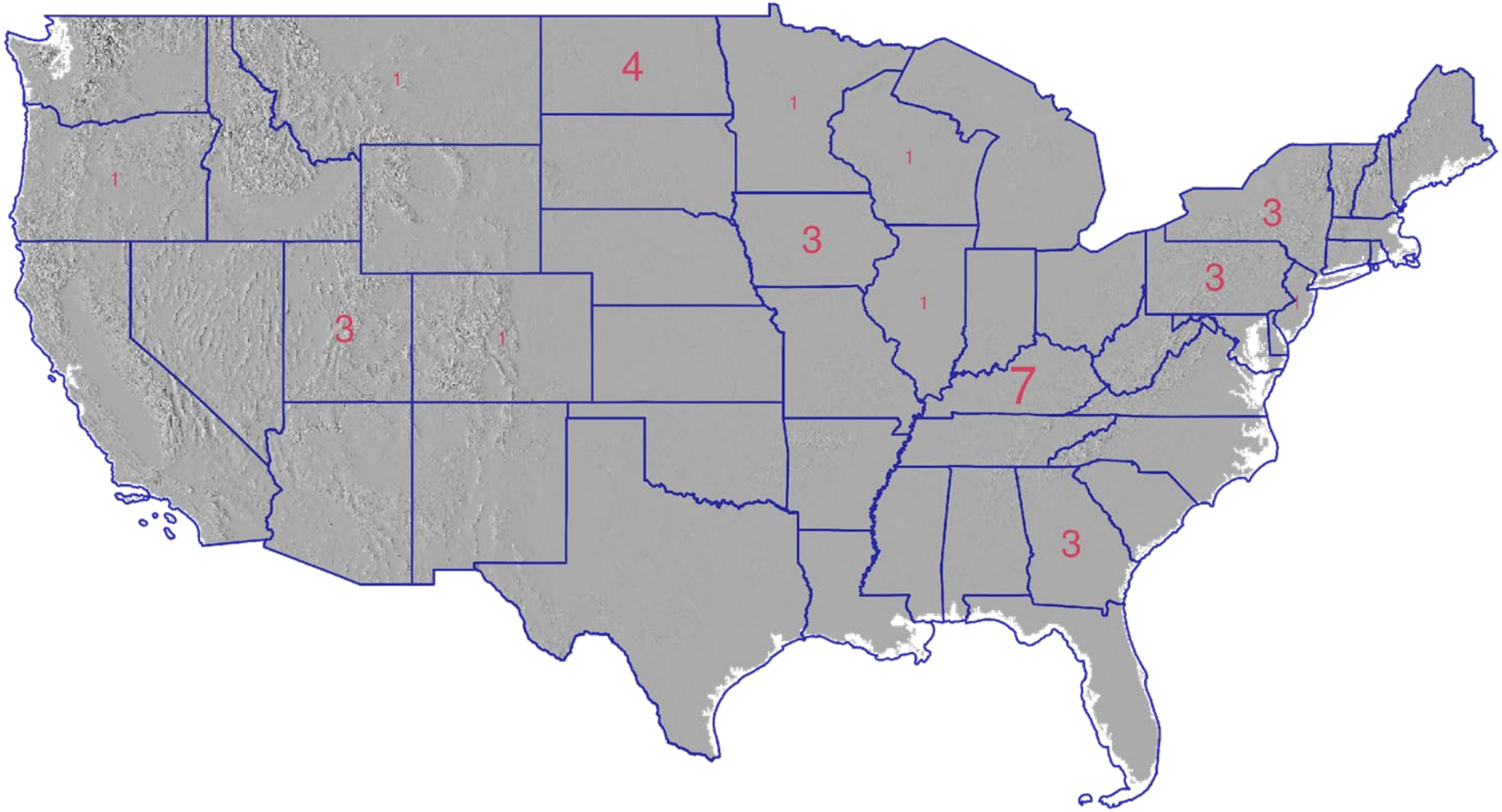
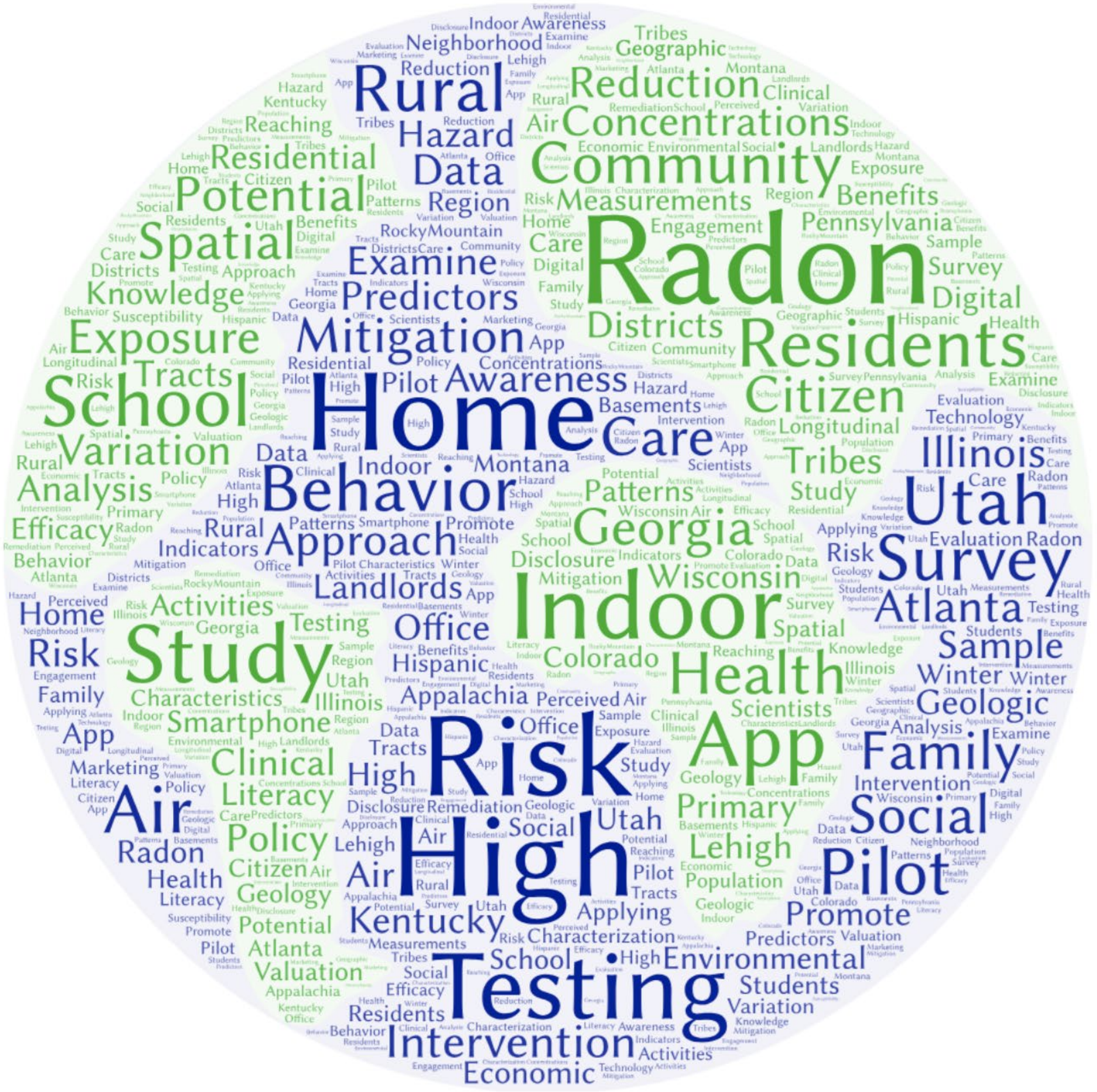


Source: PubMed

Number of Radon Testing Research Studies by State




Radon
Home
Risk
High
Testing
Indoor
Rural
Community
Residents
School
Study
App
Mitigation
Behavior
Concentrations
Reduction
Utah
Survey
Pilot
Georgia
Health
Approach
Spatial
Potential
Exposure
Residential
Hazard
Data
Examine
Predictors
Citizen
Care
Illinois
Atlanta
Family
Social
Air
Intervention
Kentucky
Tribes
Districts
Measurements
Tracts
Variation
Analysis
Efficacy
Knowledge
Awareness
Landlords
Office
Clinical
Literacy
Policy
Geology
Radon
Colorado
Wisconsin
Sample
Geologic
Winter
Primary
Lehigh
Promote
Environmental
Characterization
Economic
Students
Appalachia
Smartphone
Characteristics
Hispanic
Disclosure
Remediation
Valuation
Montana
Pennsylvania
Neighborhood
Geographic
Longitudinal
Digital
Engagement
Benefits
Region
Patterns
Activities
Indicators
Scientists
Technology
Population
Applying
Perceived
Basements
Susceptibility
Marketing
Evaluation
Reaching
RockyMountain
Residents
Economic

- Radon Testing Methods
- **Public Awareness and Engagement**
- Policy and Interventions
- Technological Solutions
- **Social and Economic Aspects**

Science of the Total Environment 834 (2022) 155290

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Neighborhood characteristics of low radon testing activities: A longitudinal study in Atlanta, Georgia, United States

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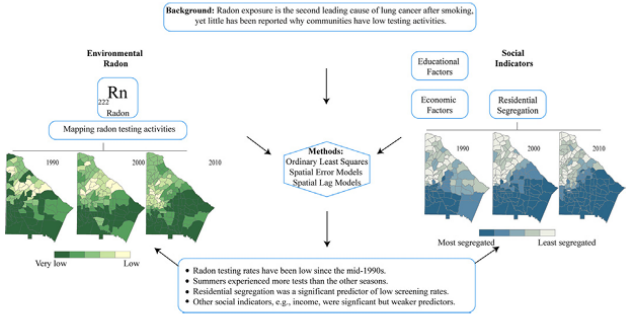
HIGHLIGHTS

- Use residential segregation and social indicators to predict indoor radon testing
- Spatial regression models to understand the factors behind testing patterns
- Testing activities have been low in 25 years.
- Residentially segregated communities had very low radon testing rates.
- Other social indicators, such as income and education, were weaker predictors.

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor: Paulo Pereira

Keywords:
Radon testing
Residential segregation
Environmental justice
Social indicators
GIS

ABSTRACT

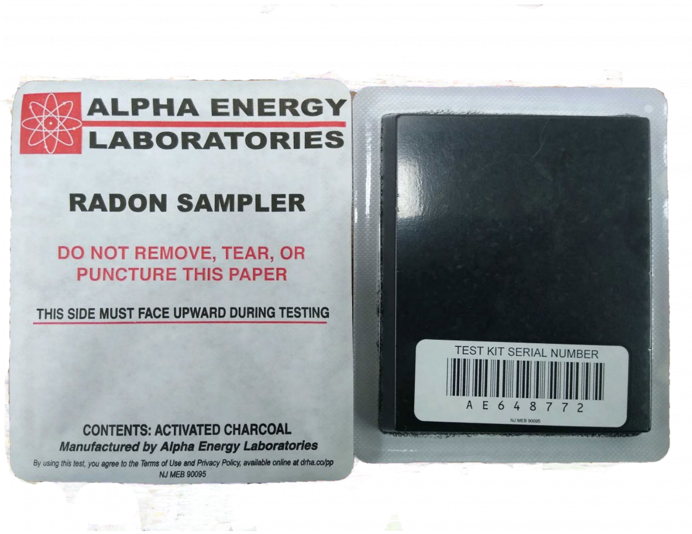
Radon testing remains low even nationwide although its exposure is the leading cause of lung cancer among non-smokers. Little has been done to examine the neighborhood characteristics with low testing prevalence. This study investigated the associations between indoor radon testing and neighborhood characteristics in an urban environment with the highest Radon potential. A total of 25 years (1990–2015) of radon tests ($n = 6355$) were pooled from public and private sources in DeKalb County, Georgia, United States. Neighborhoods were characterized using racial residential segregation for African Amercians in addition to other social indicators. The associations between neighborhood characteristics and radon testing rates were evaluated using Ordinary Least Squares and Spatial Regression Models, respectively. Results show that the testing rates were lower than 6.5% over the 25 years. Summers followed by early springs experienced more tests than the other seasons. Areas of low testing rates ($\leq$1.55%) spatially matches the mostly segregated neighborhoods. Residential segregation expanded in the 25 years and was significantly correlated (P value < 0.05) with low testing rates, even after other social indicators were controlled. Associations with the other social indicators, such as income or education, were weaker. Concertedly identifying the culturally relevant interventions in segregated communities is necessary to reduce and eliminate threats from environmental radon.

Radon Testing in North Carolina from 2010 to 2020

Aim 1: Explore the distribution of **radon testing** and identify influential factors in North Carolina.

https://www.cdc.gov/radon/radon-test.html

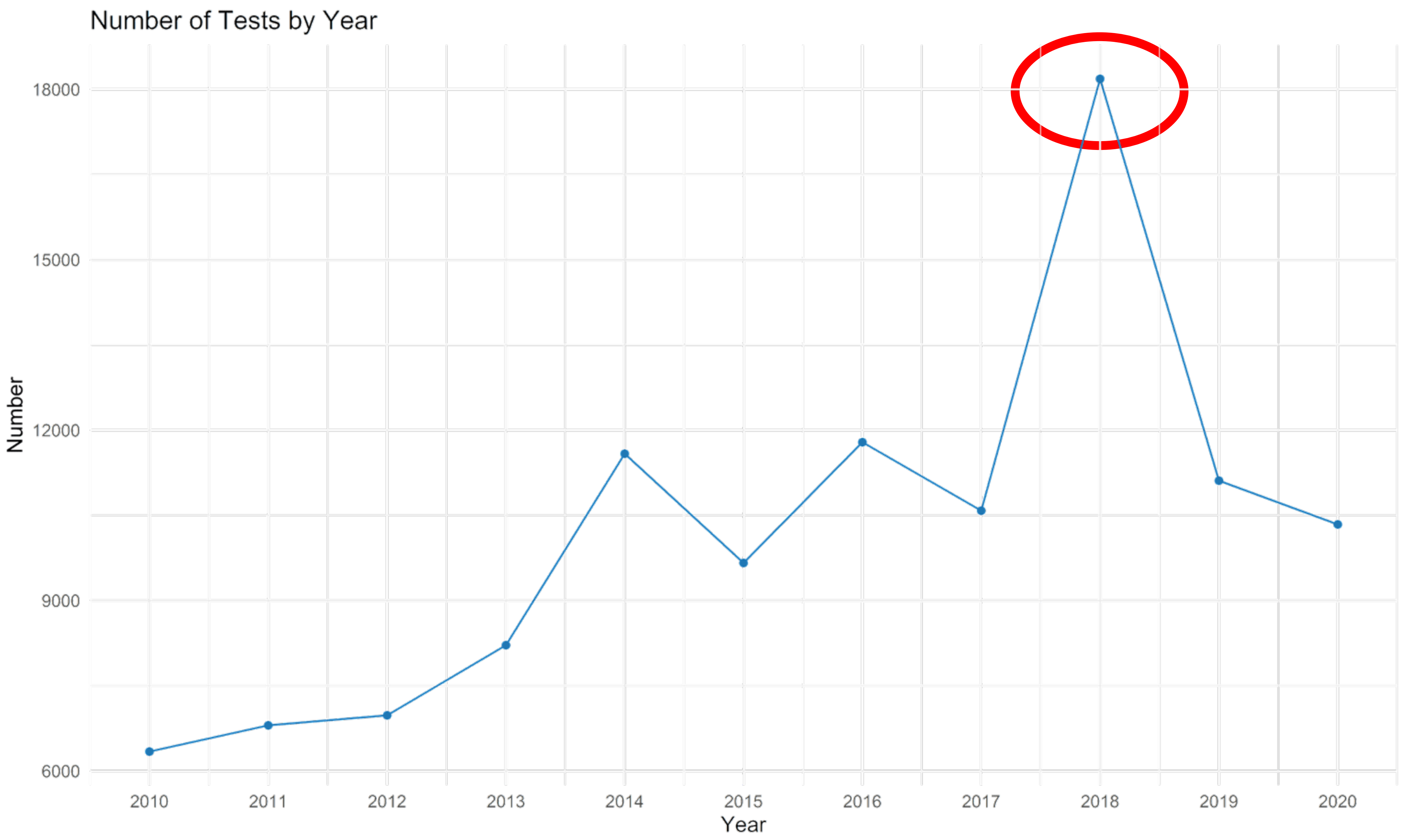
NCDHHS



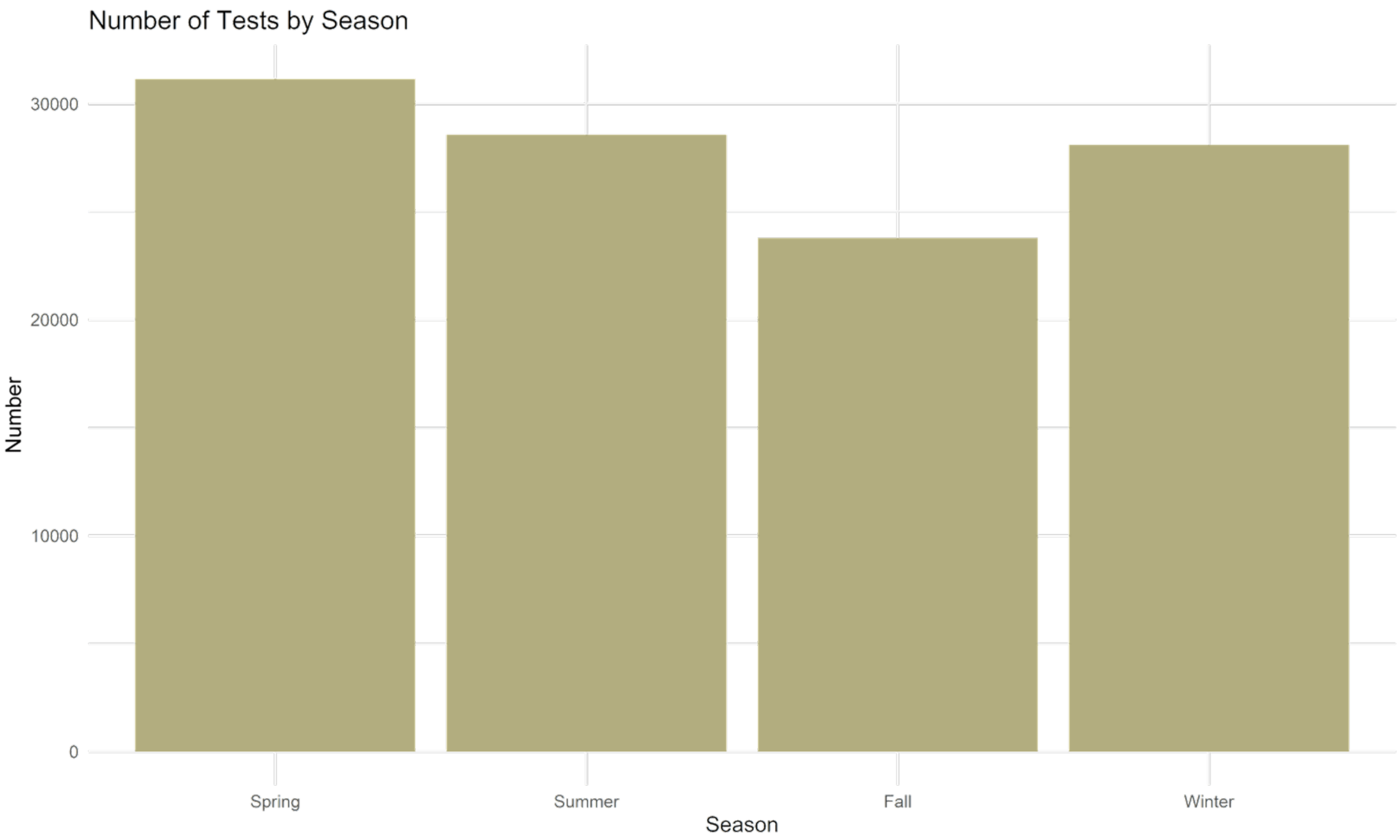
- Two commercial radon test kit companies: Alpha Energy and Airchek
- Short term test of 3-7 days
- Laboratory test
- State radon awareness month

Data

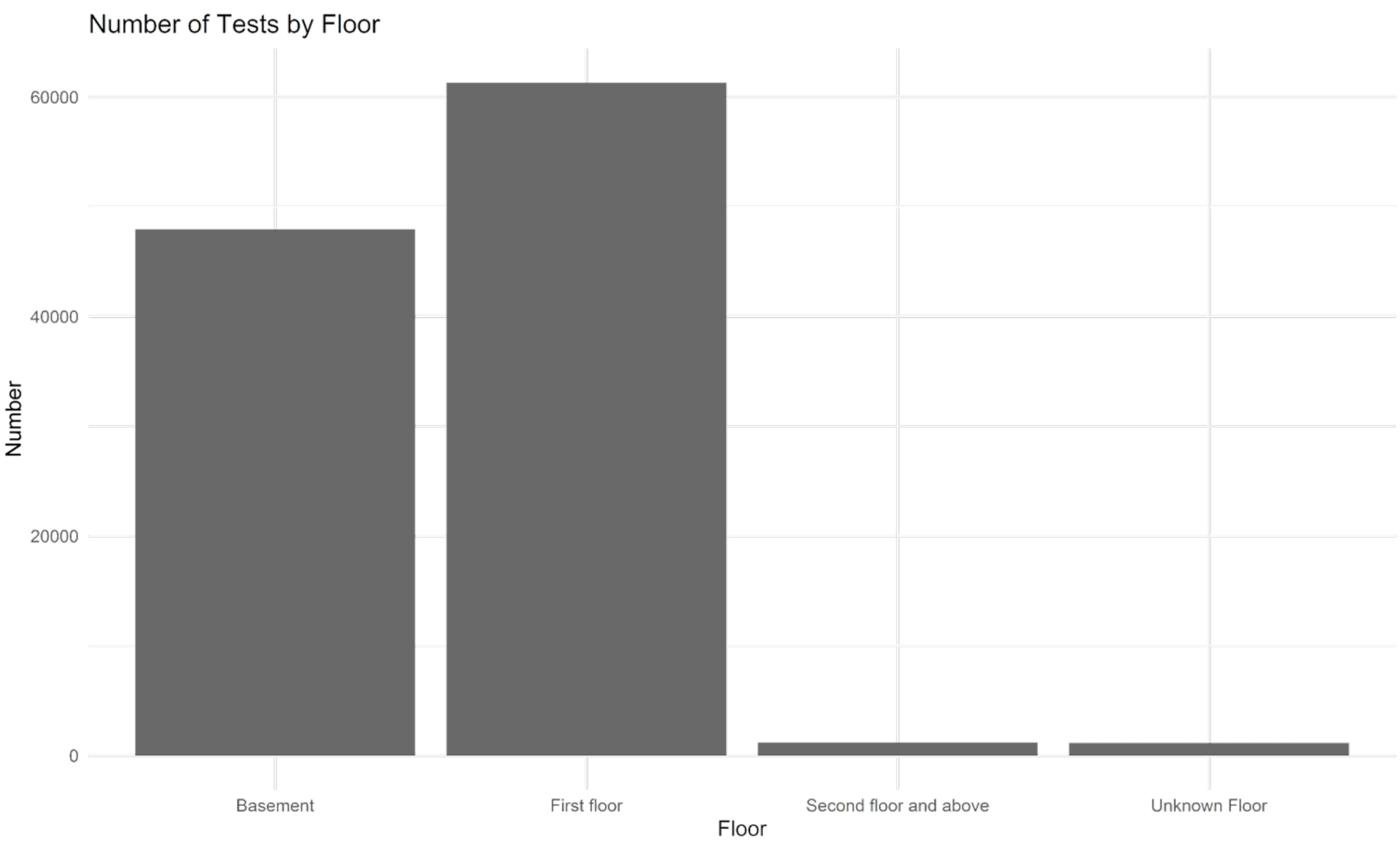
- Number of tests: 111,601
- Time: 2010-2020
- Area: 2195 census tracts
- Missing Area: 159 census tracts

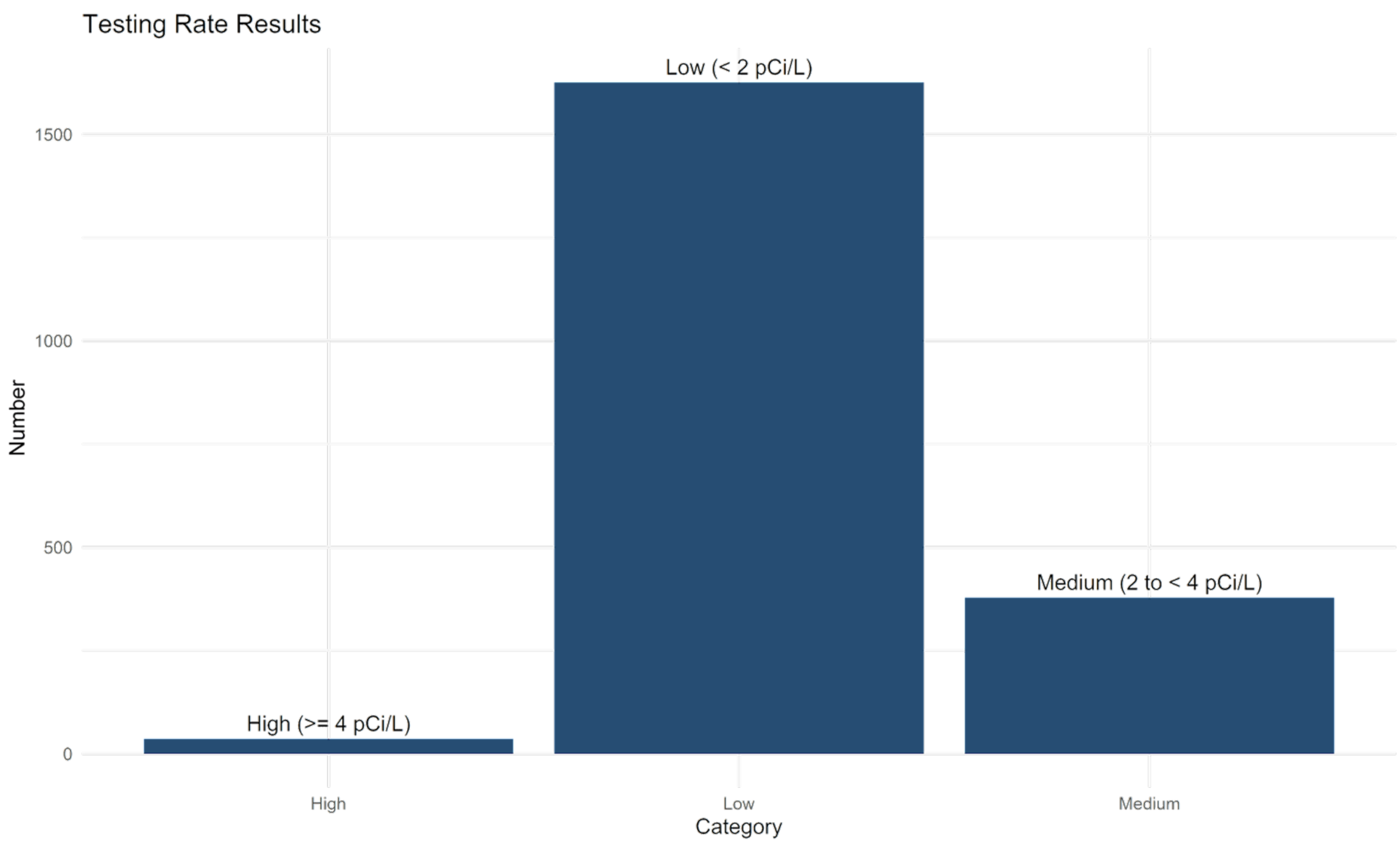


Number of Tests by Year
18000
15000
12000
9000
6000
Number
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Year

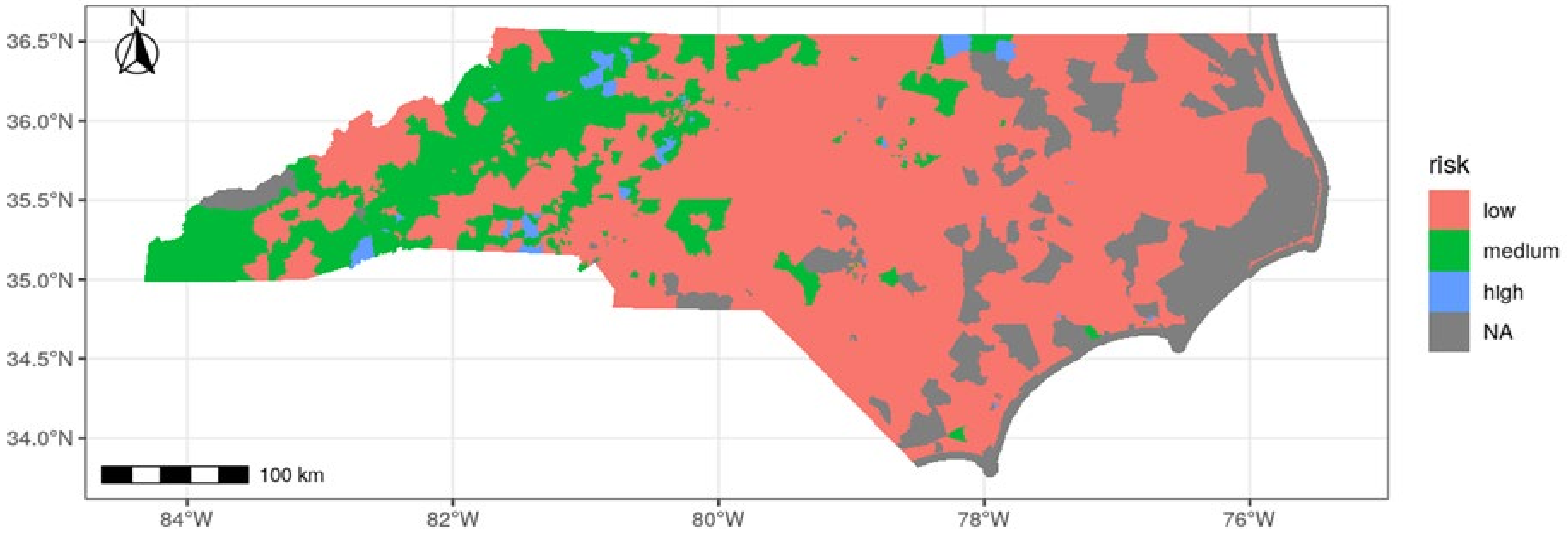


Number of Tests by Season
30000
20000
10000
0
Number
Spring
Summer
Fall
Winter
Season

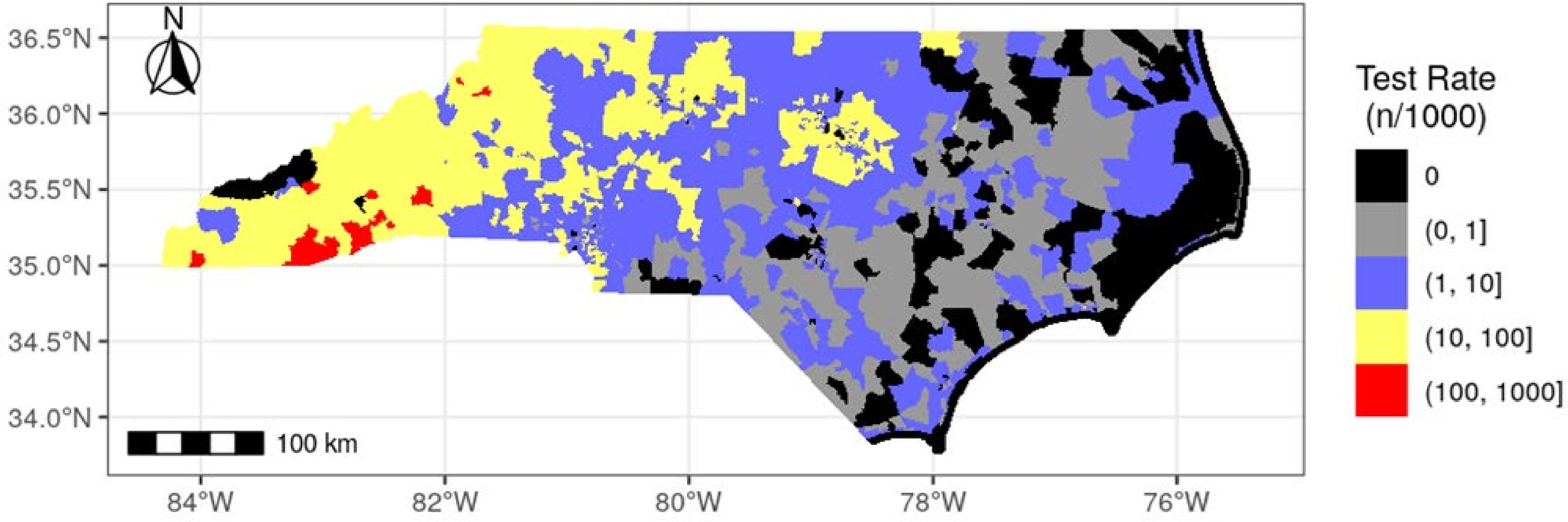

Number of Tests by Floor
60000
40000
20000
0
Number
Basement
First floor
Second floor and above
Unknown Floor
Floor



Testing Rate Results
Low (< 2 pCi/L)
Medium (2 to < 4 pCi/L)
High (>= 4 pCi/L)
1500
1000
500
0
Number
High
Low
Medium
Category



Distribution of radon risk levels across 2195 Census Tracts in North Carolina, USA. Low (< 2 pCi/L), Medium (≥ 2 pCi/L & <4 pCi/L) and High (≥4 pCi/L).



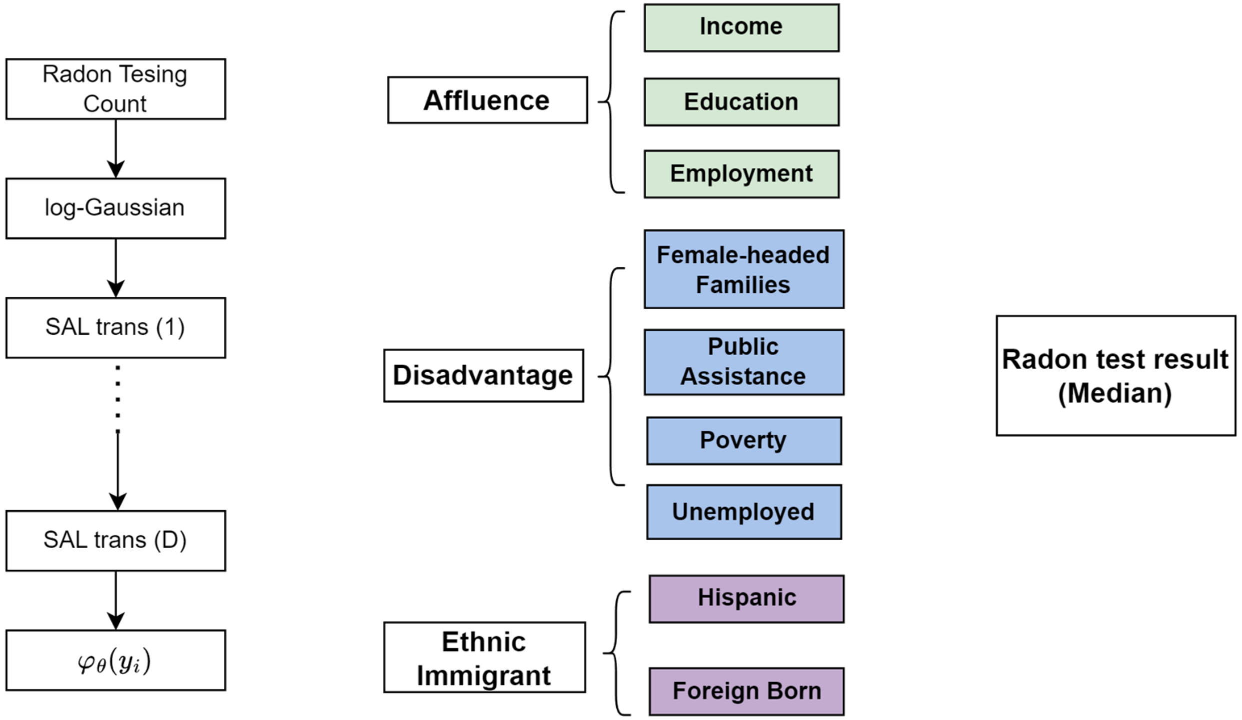
Distribution of radon test rates across 2195 Census Tracts in North Carolina, USA, Expressed as number tested per 1000 people.

National Neighborhood Data Archive

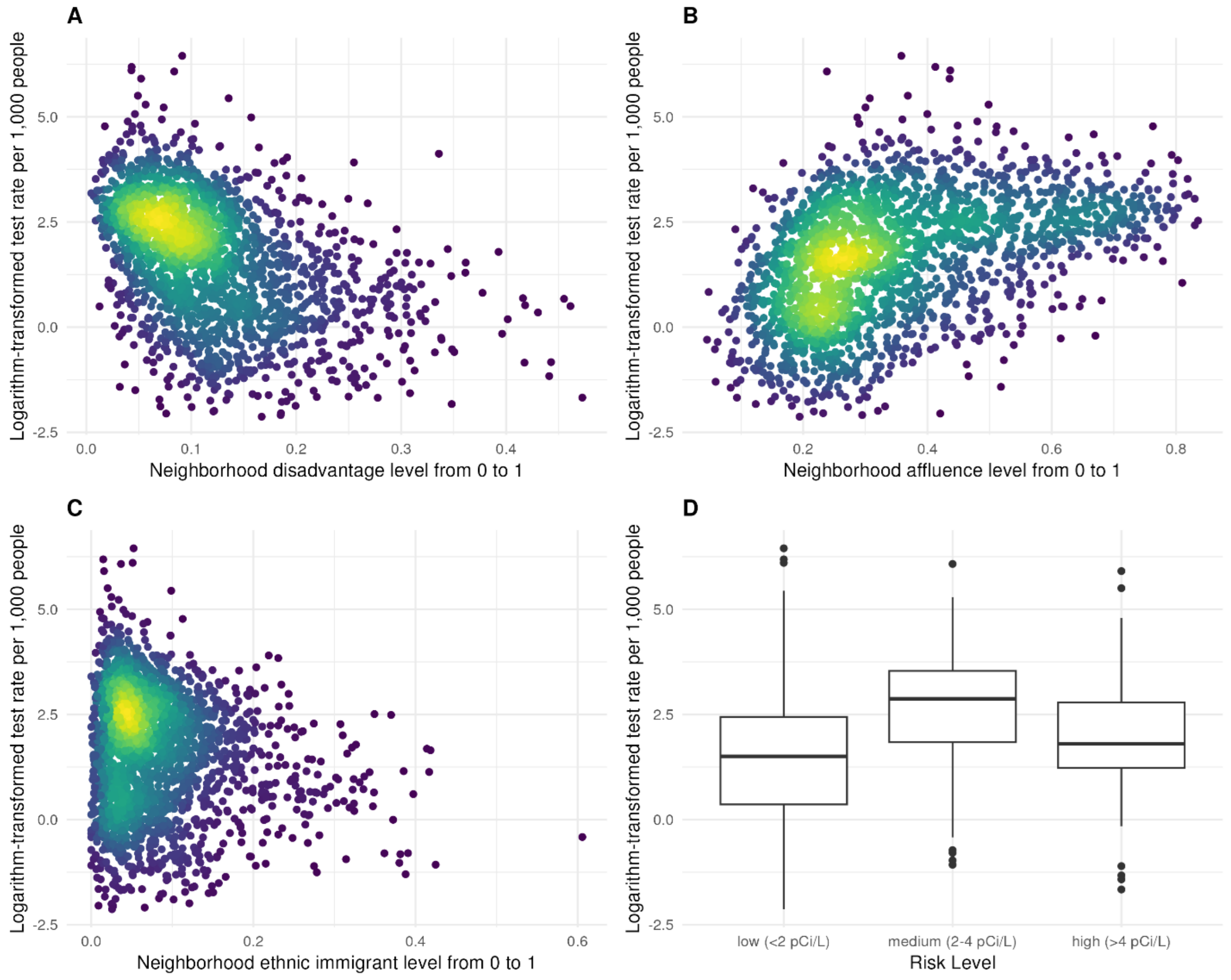
- Established in 2019, the National Neighborhood Data Archive is an open data repository. It was created to facilitate research on the relationship between neighborhoods and health, especially within the context of large federally funded surveys and cohort studies.

https://nanda.isr.umich.edu/

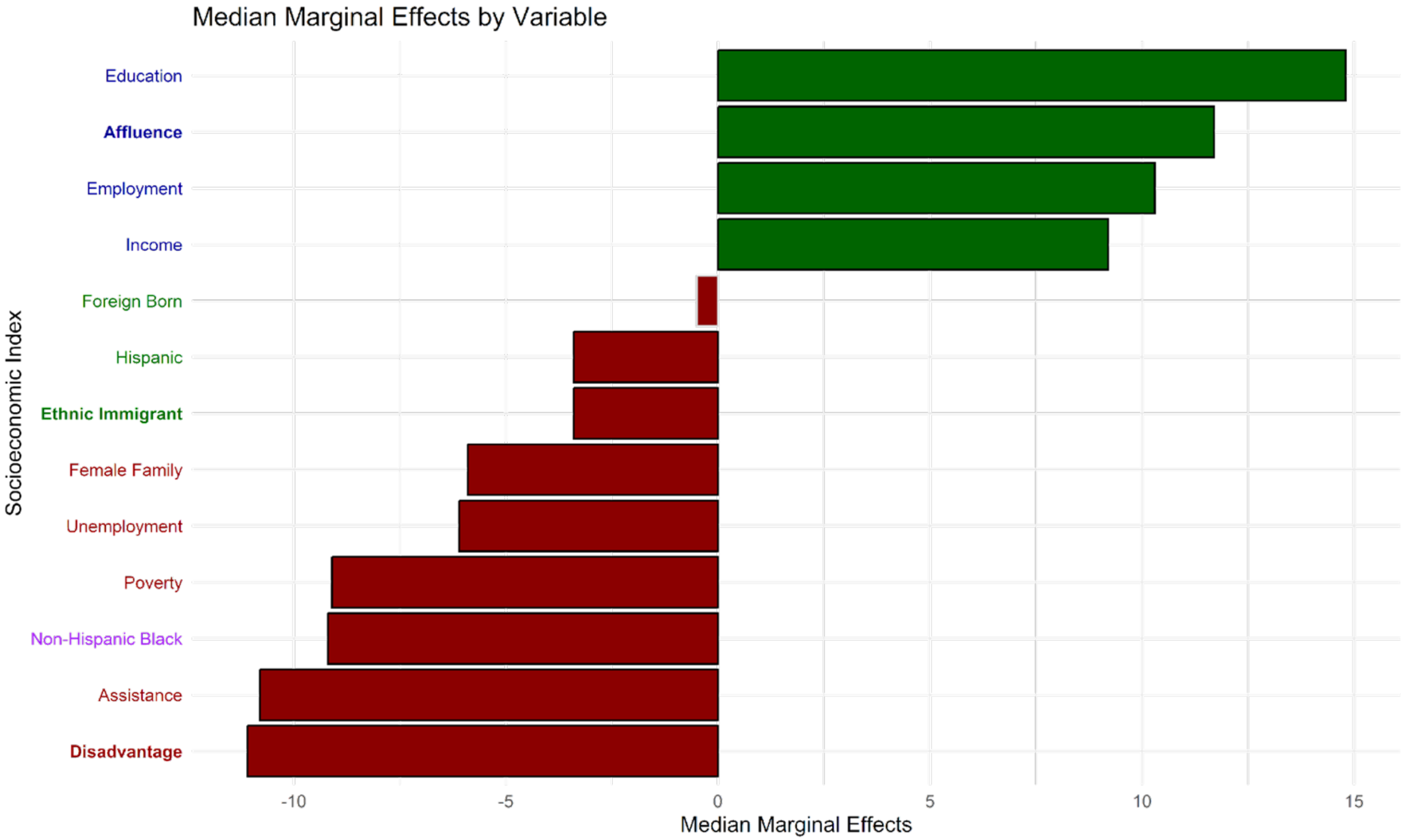
- Relationship between radon test rate and Socioeconomic status and demographics.



https://github.com/dmuraka/spmoran



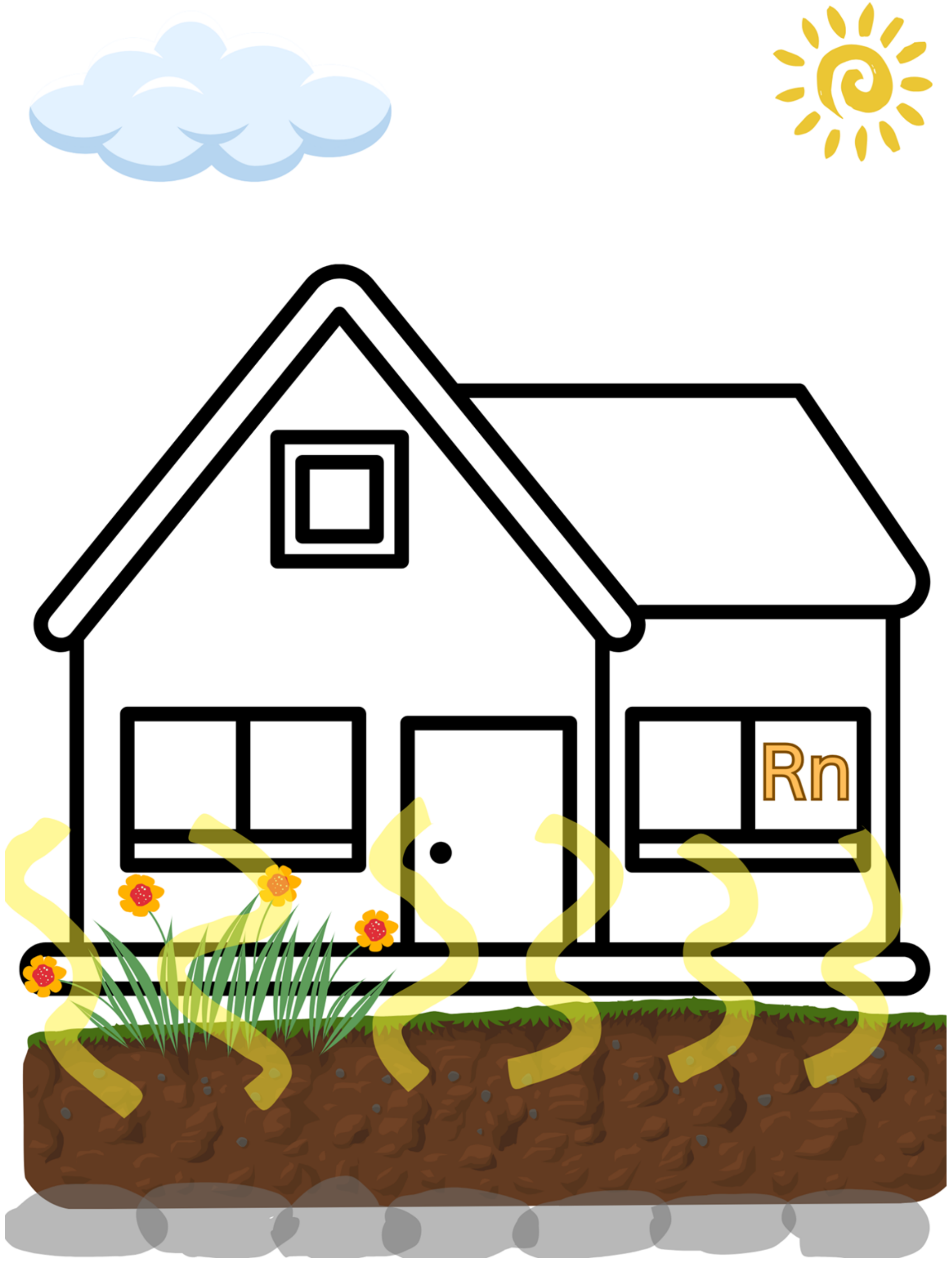
Radon test rates in relation to neighborhood attributes (A-C) and distribution of radon test rates by risk (radon concentration) categories (D) in the state of North Carolina, USA.



Median Marginal Effects by Variable
Socioeconomic Index
Education
Affluence
Employment
Income
Foreign Born
Hispanic
Ethnic Immigrant
Female Family
Unemployment
Poverty
Non-Hispanic Black
Assistance
Disadvantage
-10
-5
0
5
10
15
Median Marginal Effects

Conclusion

- Most neighborhood indicators, excluding "**Foreign Born**", significantly influence radon testing rates.
- "**Affluence**" variables, especially "**Education**", positively impact radon testing rates.
- "**Disadvantage**" variables tend to decrease radon testing likelihood.
- Moran.I values indicate strong spatial patterns in radon testing distribution.

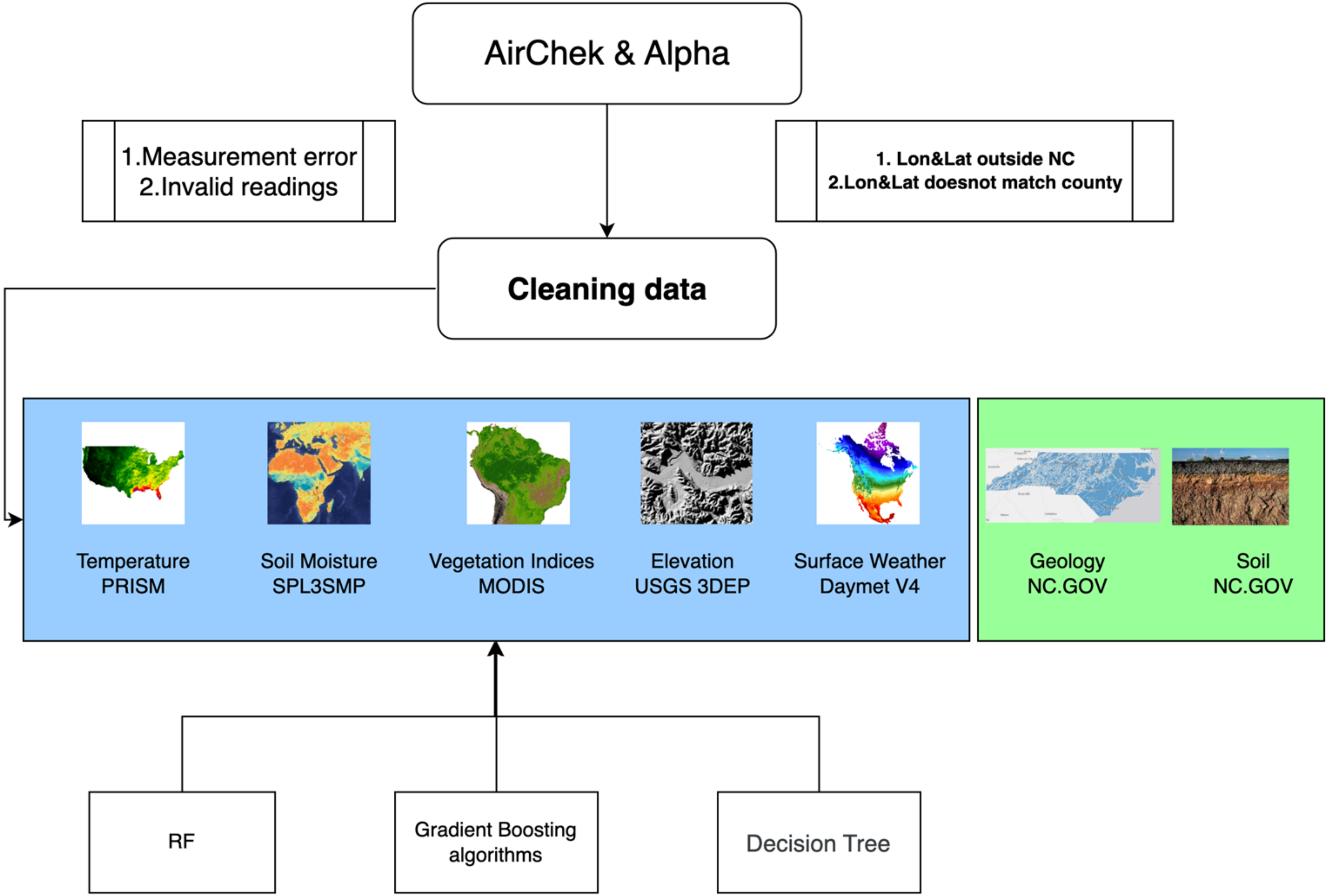


Two Messages

1. There's significant potential for expanding our knowledge in the realm of radon testing.

2. Radon testing highlights areas where we need to address disparities to ensure equitable solutions.

Future Aims



AirChek & Alpha
1.Measurement error
2.Invalid readings
1. Lon&Lat outside NC
2.Lon&Lat doesnot match county
Cleaning data
Temperature
PRISM
Soil Moisture
SPL3SMP
Vegetation Indices
MODIS
Elevation
USGS 3DEP
Surface Weather
Daymet V4
Geology
NC.GOV
Soil
NC.GOV
RF
Gradient Boosting
algorithms
Decision Tree

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Questions or Concerns?
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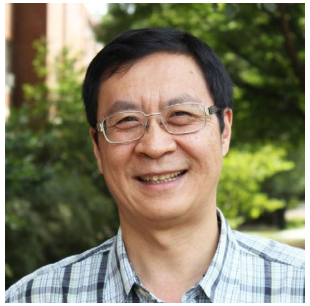

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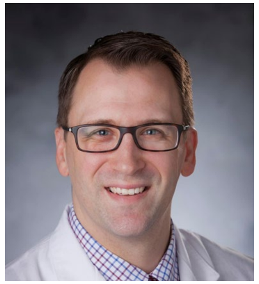

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Thank you!