The Association Between Indoor Radon Levels and Lung Cancer Mortality in the Penn State Cancer Institute Catchment Area

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Indoor Environments ™ 2024 - Radon and Vapor Intrusion Symposium

Presentation Outline

- Introduction and Lung Cancer Epidemiology
- What we Know: Radon and Lung Cancer
- Penn State Cancer Institute: Goals and Catchment Area
- Research Aims, Results, Conclusions
- Implementation Science: Frameworks for Solutions
- Study Limitations & Next Steps

Epidemiology: United States Lung Cancer (LC)

- Annual new cases :
  - 117,190 males,
  - 118,830 females

2 among all cancers

- Annual deaths:
  - 68, 820 males
  - 61, 360 females

1 among all cancers

Based on data from SEER 17 (2012–2018), https://seer.cancer.gov/canques/survival.html
American Cancer Society, Cancer Statistics 2022,
https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2022.html

Lung Cancer Incidence in Pennsylvania

Site	New Cases*	5 Year Survival (%)
Pennsylvania	62	26.8
National	56.7	25

* Age-adjusted incidence rate/100,000
Source https://www.lung.org/research/state-of-lung-cancer

Lung Cancer Mortality in Pennsylvania

Site	Mortality Cases*
Pennsylvania	34.3
National	32.4

* Age-adjusted mortality rate/100,000
Source: https://statecancerprofiles.cancer.gov/quick-profiles/index.php?statename=pennsylvania#t=3

Common Lung Cancer Risk Factors

South Carolina Department of Health and Environmental Control

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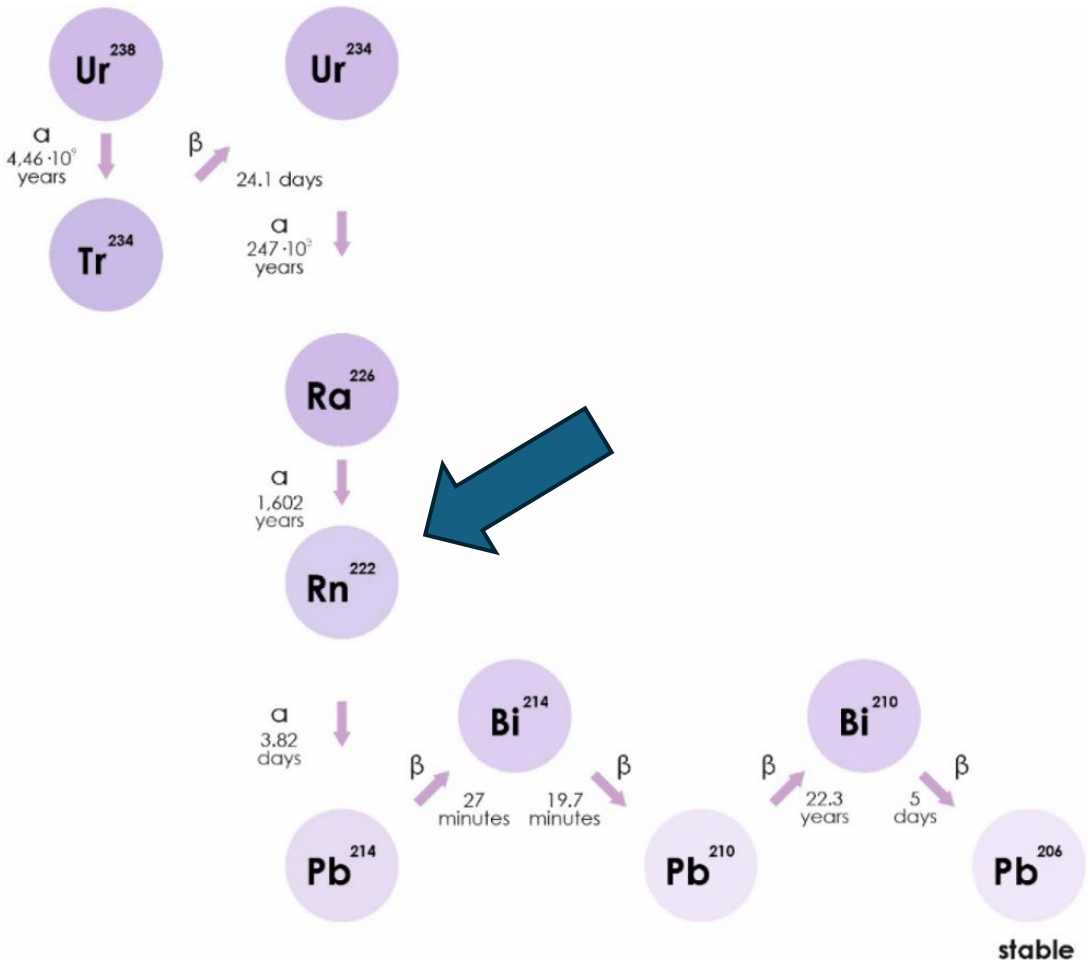
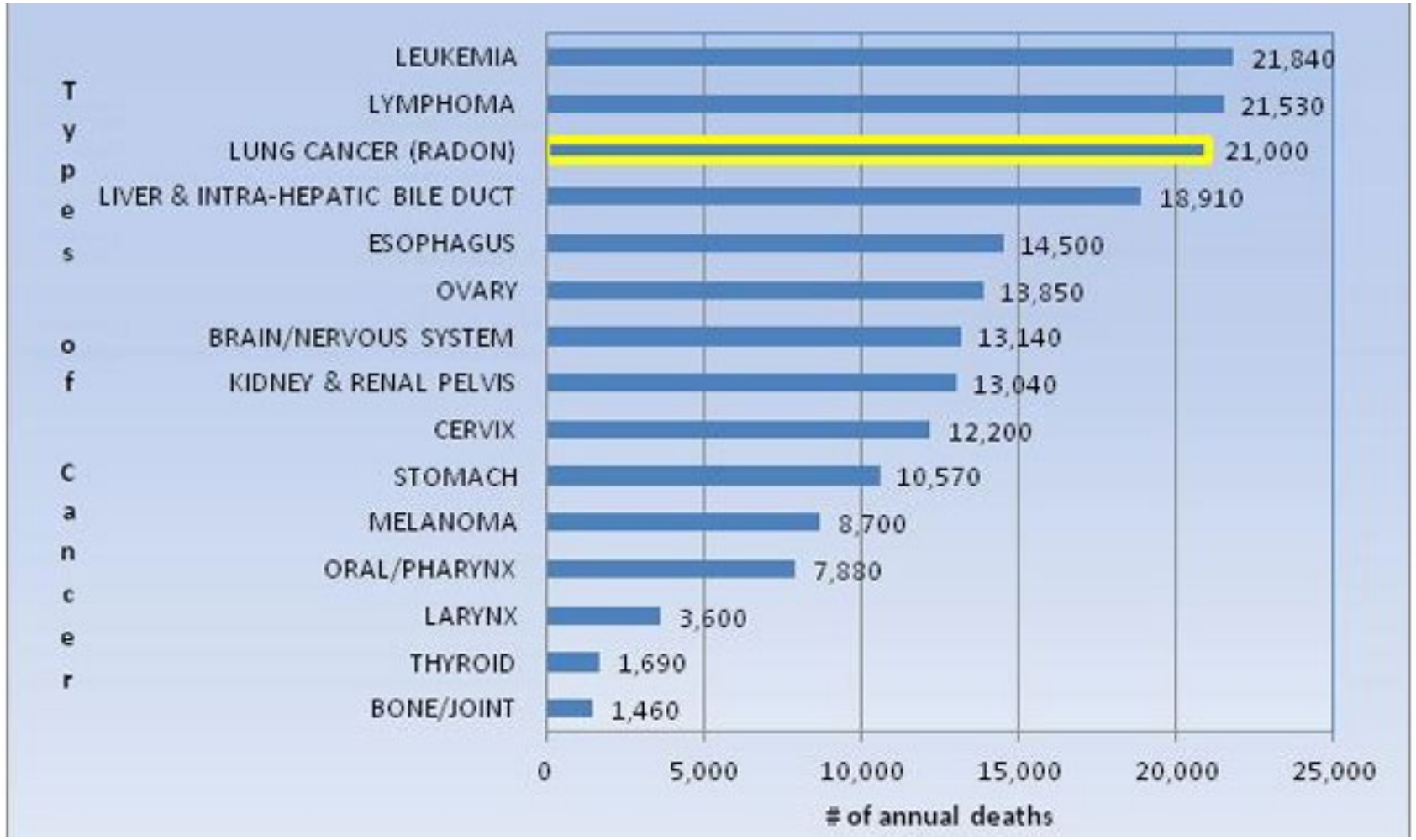
Radon and Lung Cancer

- Byproduct of uranium decay
- 2nd leading cause of LC
- 1st leading cause of LC in nonsmokers
- Accounts for 3%-14% of lung cancer diagnoses



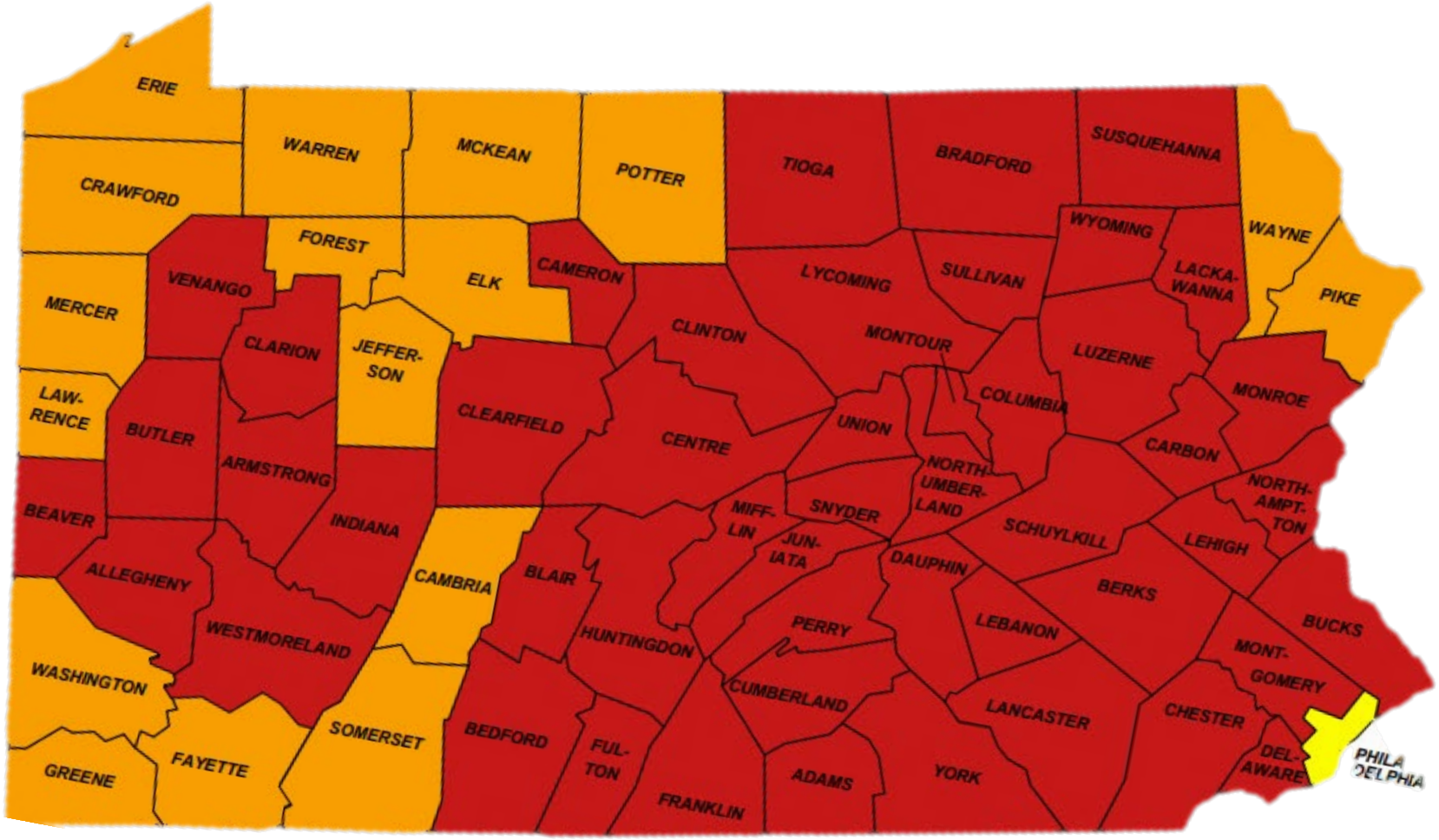
Bersimbaev, R.;. Radon Biomonitoring and microRNA in Lung Cancer. Int. J. Mol. Sci. 2020, 21, 2154.

Radon-induced Lung Cancer deaths



https://www.epa.gov/sites/default/files/2016-12/documents/2016_a_citizens_guide_to_radon.pdf

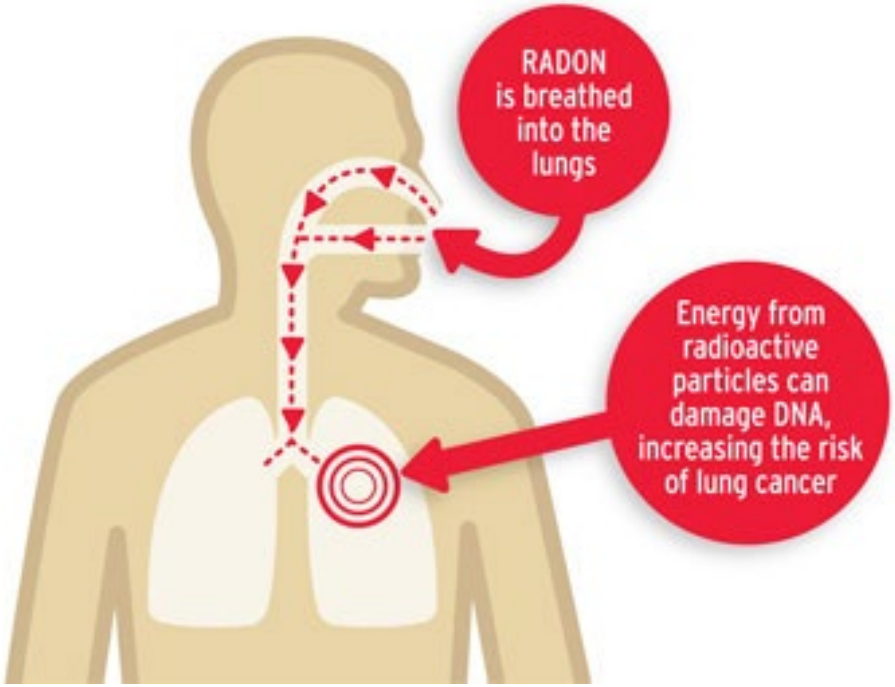
Radon Potential in Pennsylvania



https://www.epa.gov/radon/epa-map-radon-zones

How does radon cause lung cancer?

- radon gets trapped in lungs → radon decays → alpha particles are emitted → oxidative stress increases → cellular + DNA damage



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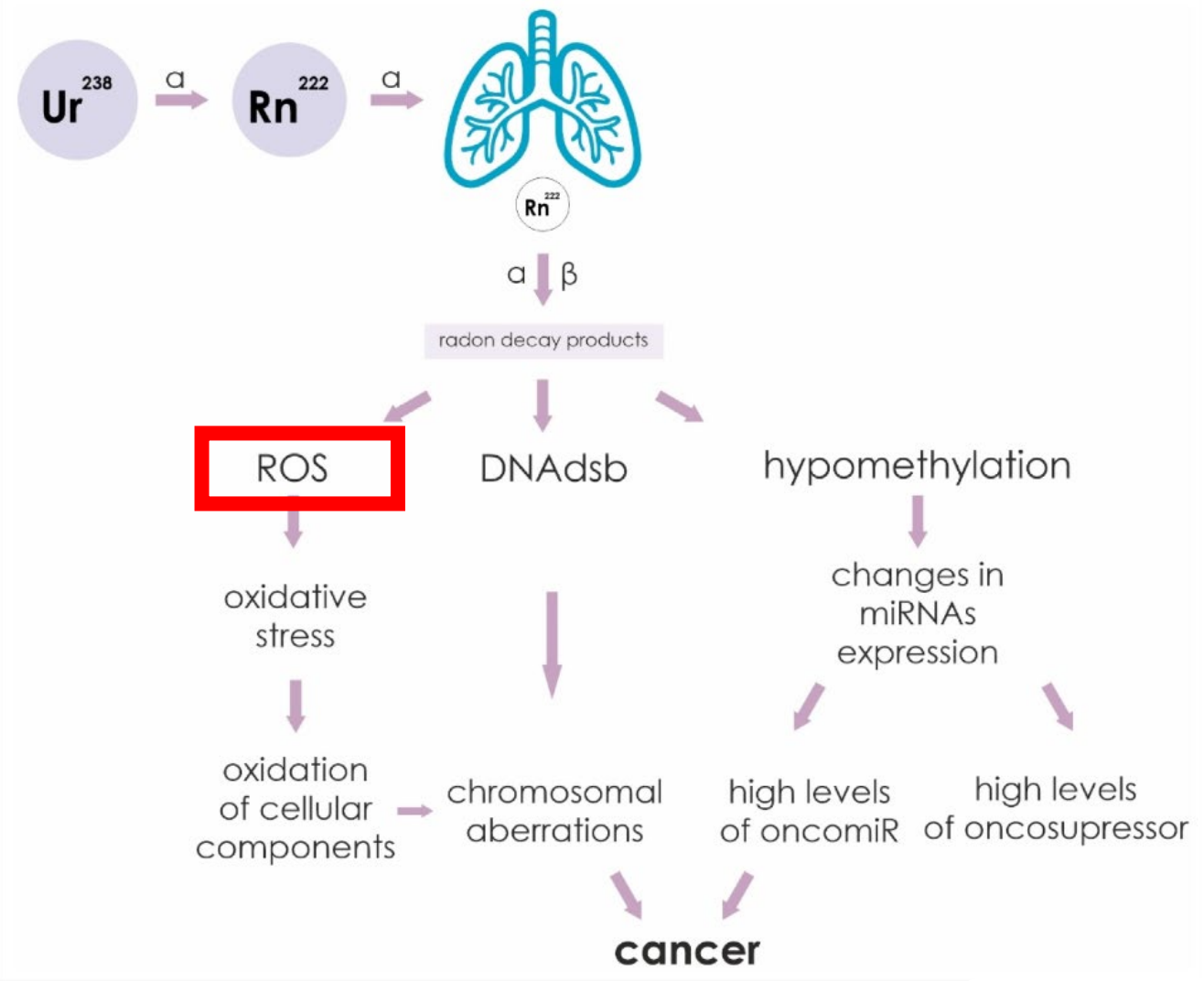

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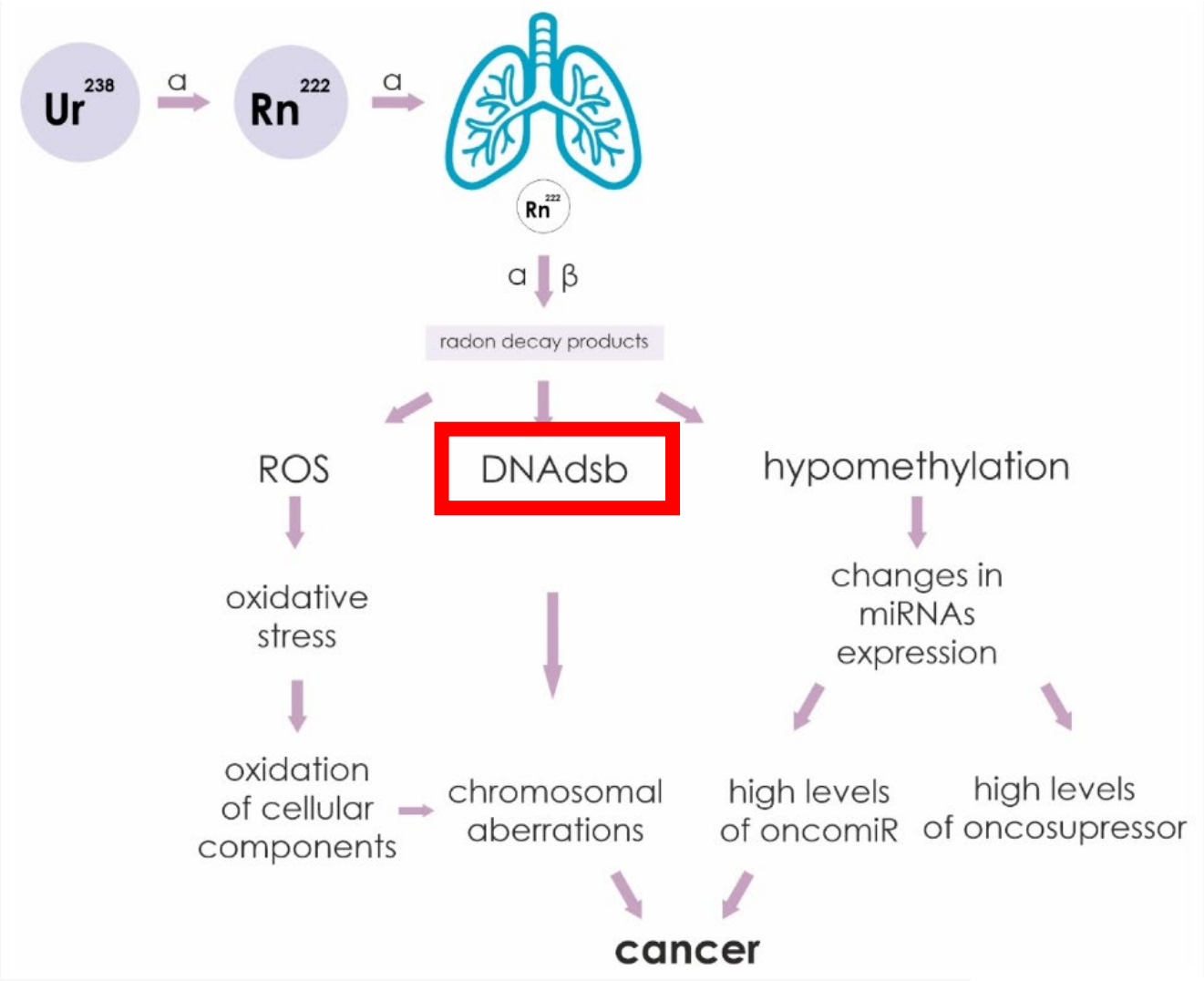

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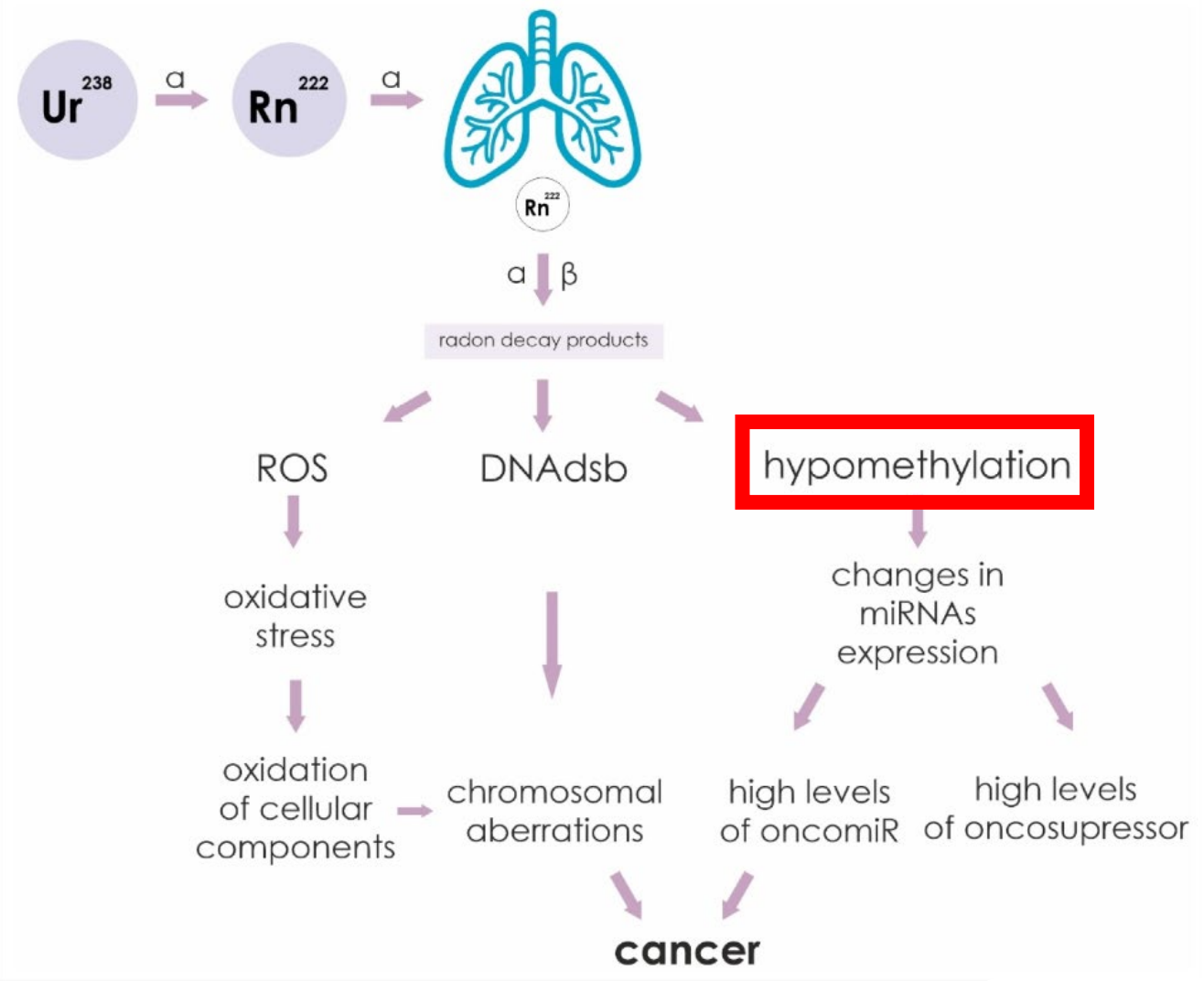

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Synergistic risks: Tobacco Smoke

Table 1: Radon Exposure in Smokers vs. Nonsmokers

If 1,000 people were exposed to this level over a lifetime*		
Radon Level	**Smokers**	**Non-smokers**
20 pCi/L	About 260 people could get lung cancer	About 36 people could get lung cancer
8 pCi/L	About 20 people could get lung cancer	About 15 people could get lung cancer
4 pCi/L	About 62 people could get lung cancer	About 7 people could get lung cancer

*Lifetime exposure= 70 years and 18 hours per day

https://www.epa.gov/sites/default/files/2016-12/documents/2016_a_citizens_guide_to_radon.pdf

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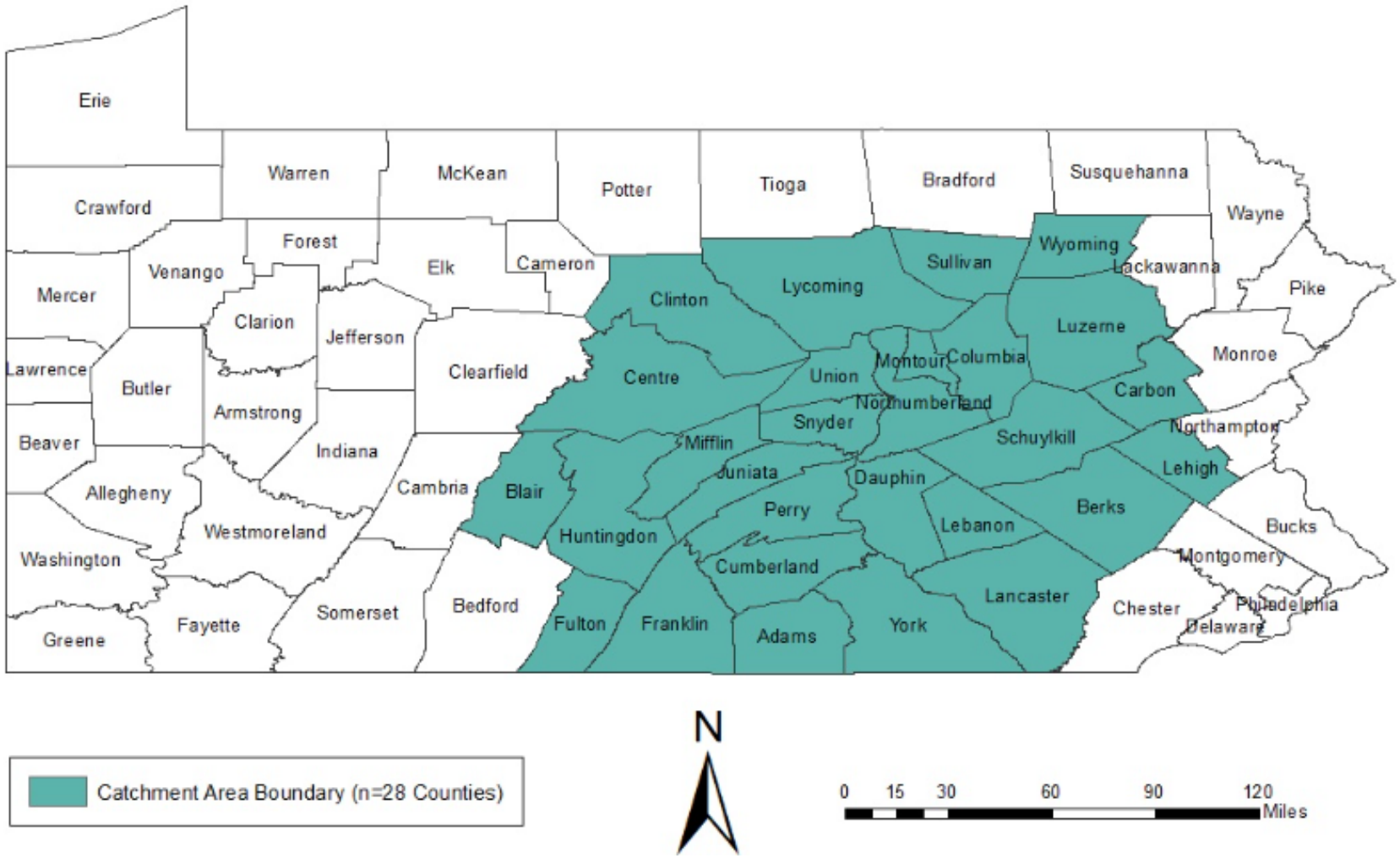
Penn State Cancer Institute Goals

- Improve cancer prevention, treatment and early detection
- Reducing health disparities
- Ensuring equitable access to care
- Reduce cancer burden

The Importance of Catchment Areas

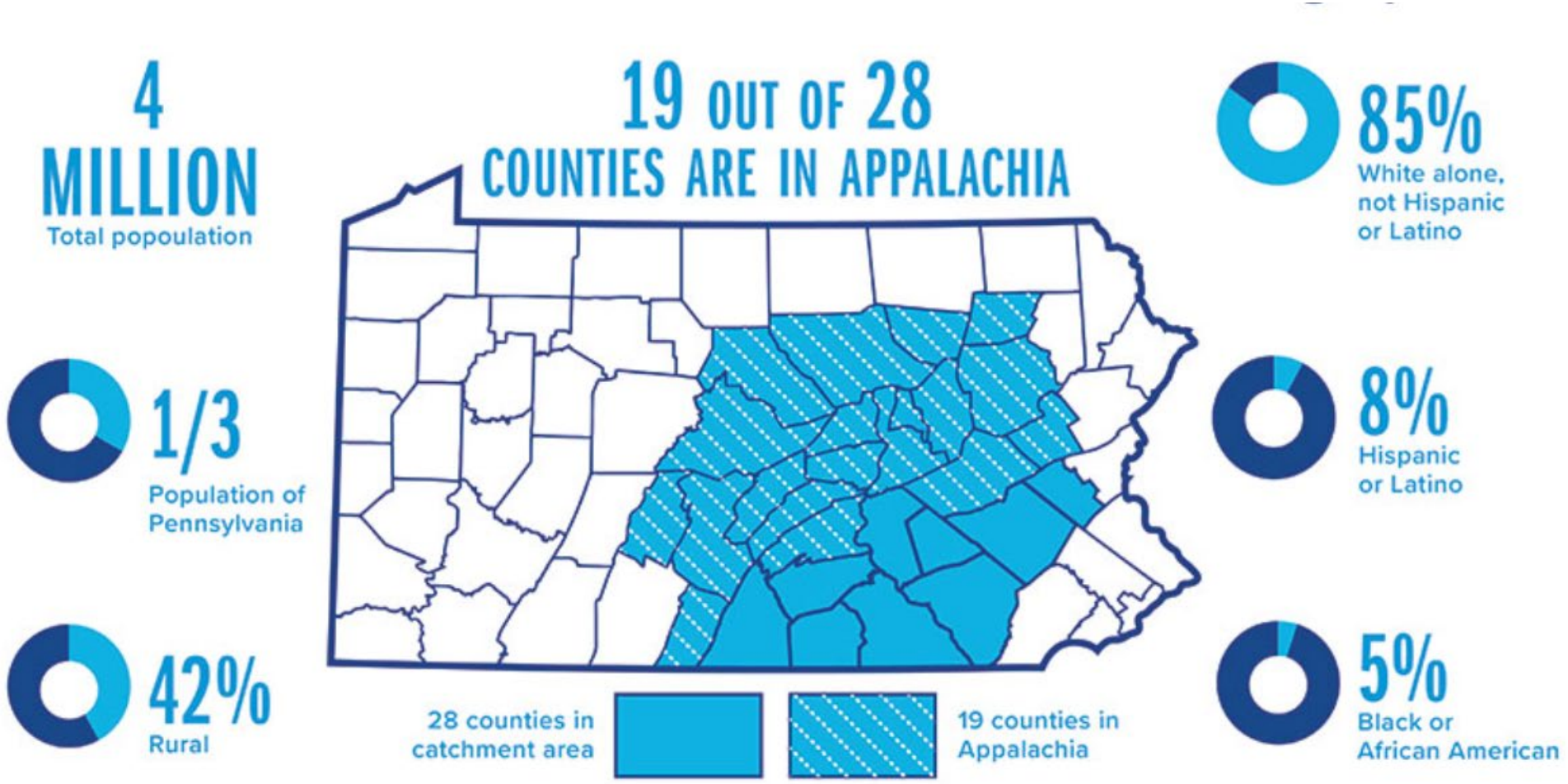
- Define a hospital's primary population
- Planning & Strategy
- Resource Allocation
- Access to Services
- Equity and Inclusion

The Penn State Cancer Institute Catchment Area



https://cancer.psu.edu/community/outreach

Catchment Area Demographics



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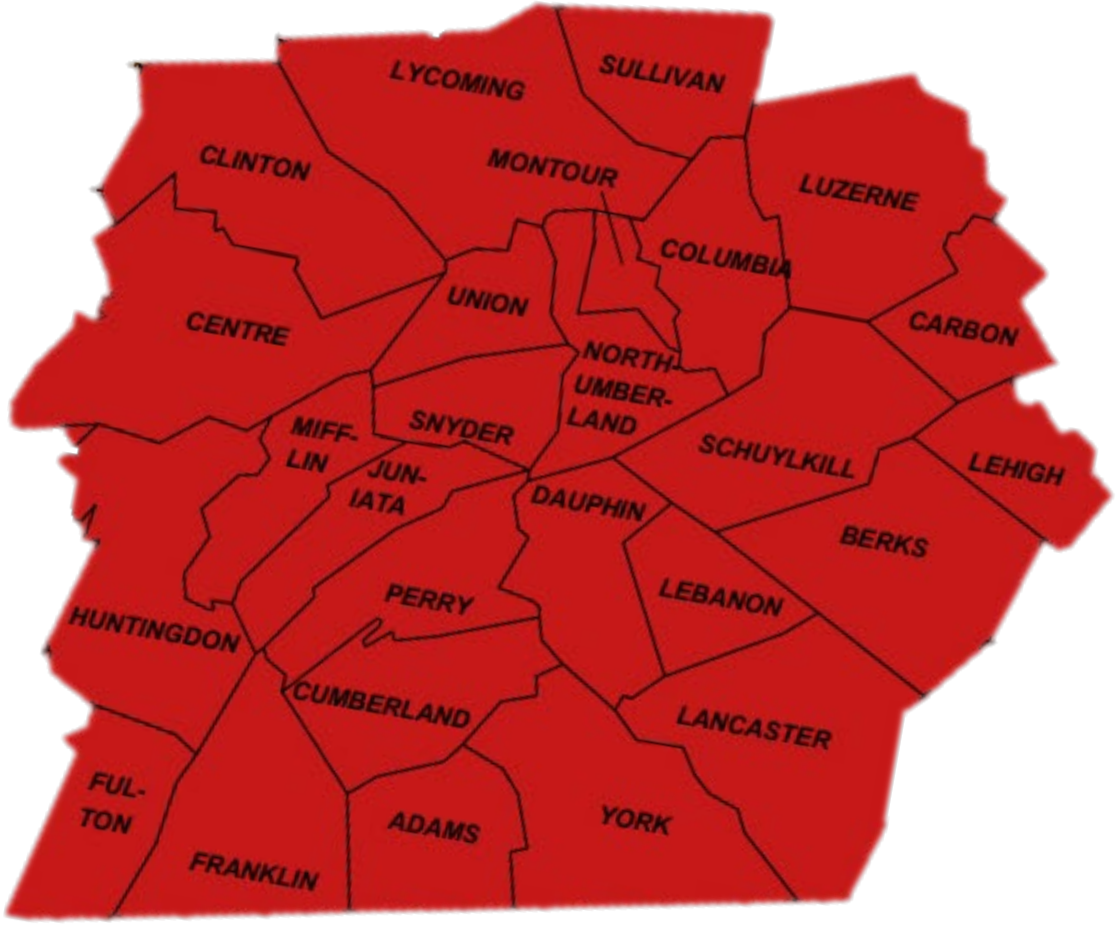
Catchment area radon risk zones



Big Takeaway: 100% of counties in our catchment area are classified as zone 1 for risk of radon exposure

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Project Goals

- Investigate the relationship between radon levels (RL) and LC mortality in the PSCI catchment area using geospatial techniques
- Use spatial analysis to identify counties with high RL, LC mortality rates, and current smoking prevalence
- Develop an equitable framework to address the potential radon issue in the PSCI catchment area

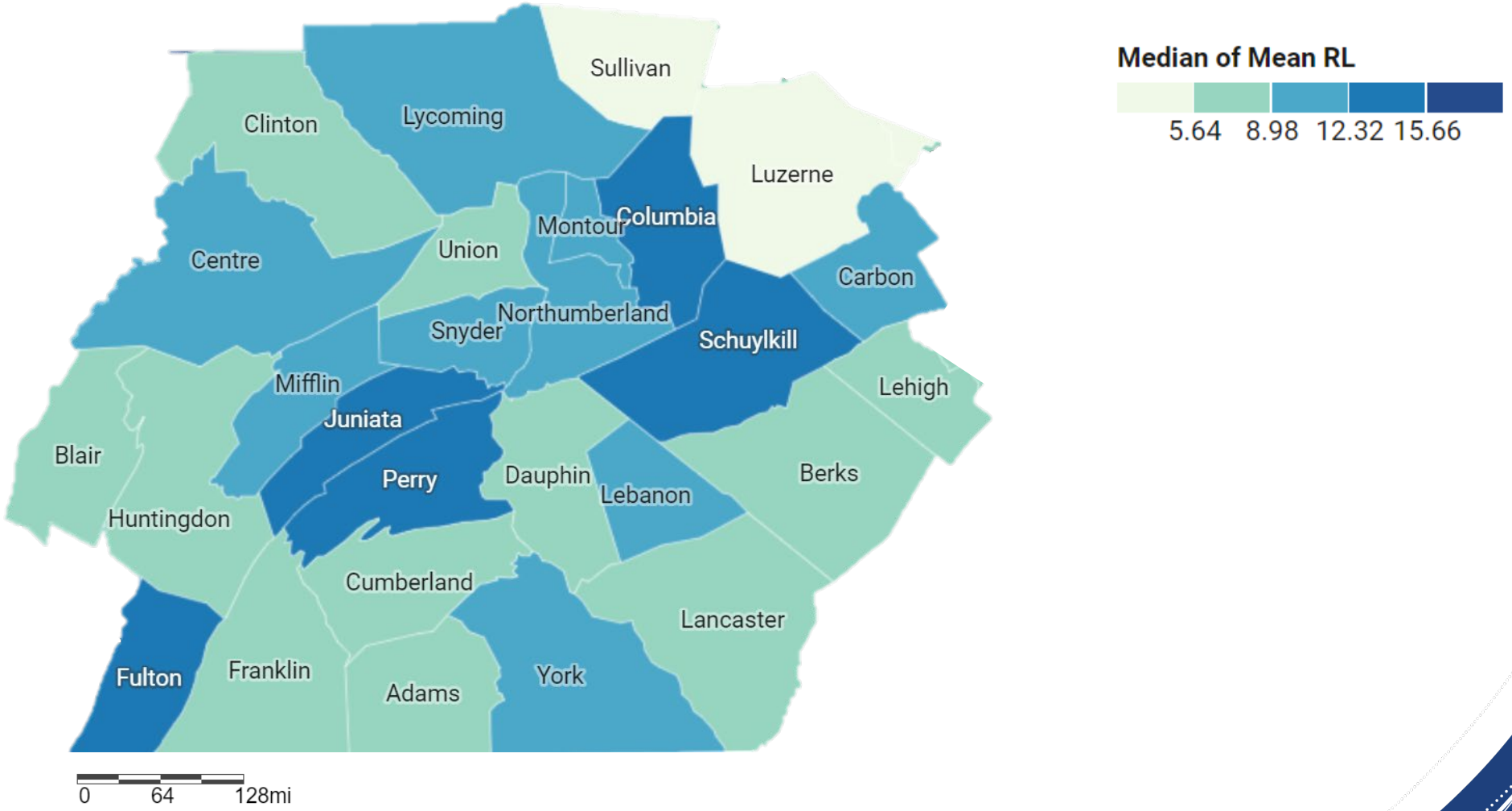
Questions we need to answer

1. **How does radon and lung cancer (LC) mortality affect the PSCI catchment area?**
2. Is there a significant relationship between radon exposure levels (REL) and LC mortality in the PSCI catchment area?
3. Which counties in our catchment have a high current smoking prevalence?

Specific Aim 1

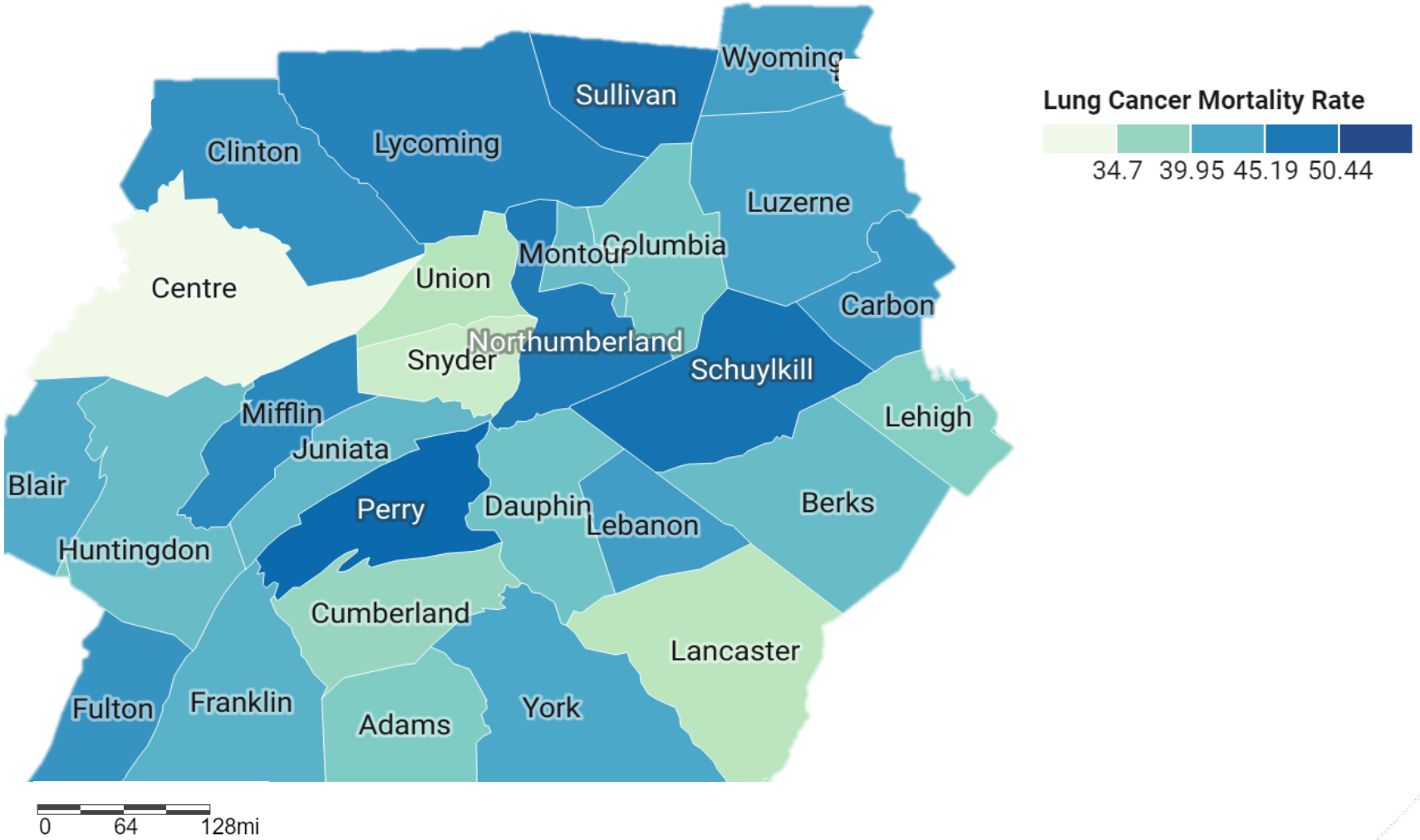
- **Hypothesis:** Counties in the PSCI catchment area will have high RL and high LC mortality rates
- **Specific Aim:** Analyze the current landscape of radon and lc mortality in the PSCI catchment area
- Quantitative and Spatial Method:
  - Median of Annual Mean RL (2010-2020)
  - Age-Adjusted LC Mortality Rate (2010-2020)
- Data Sources:
  - Radon data: PA-DEP (CDC Environmental Public Health Tracking Network)
  - LC mortality data: PA Department of Health

Radon in the PSCI Catchment Area, 2010-2020



Big Takeaway: 100% of counties in our catchment area had median RL ≥ to the EPA action level (4 pCi/L)

Lung Cancer Mortality in the PSCI Catchment Area 2010-2020



Big Takeaway: 85% of counties had an LC mortality rate ≥ than the state (34.3) national (32.4) average

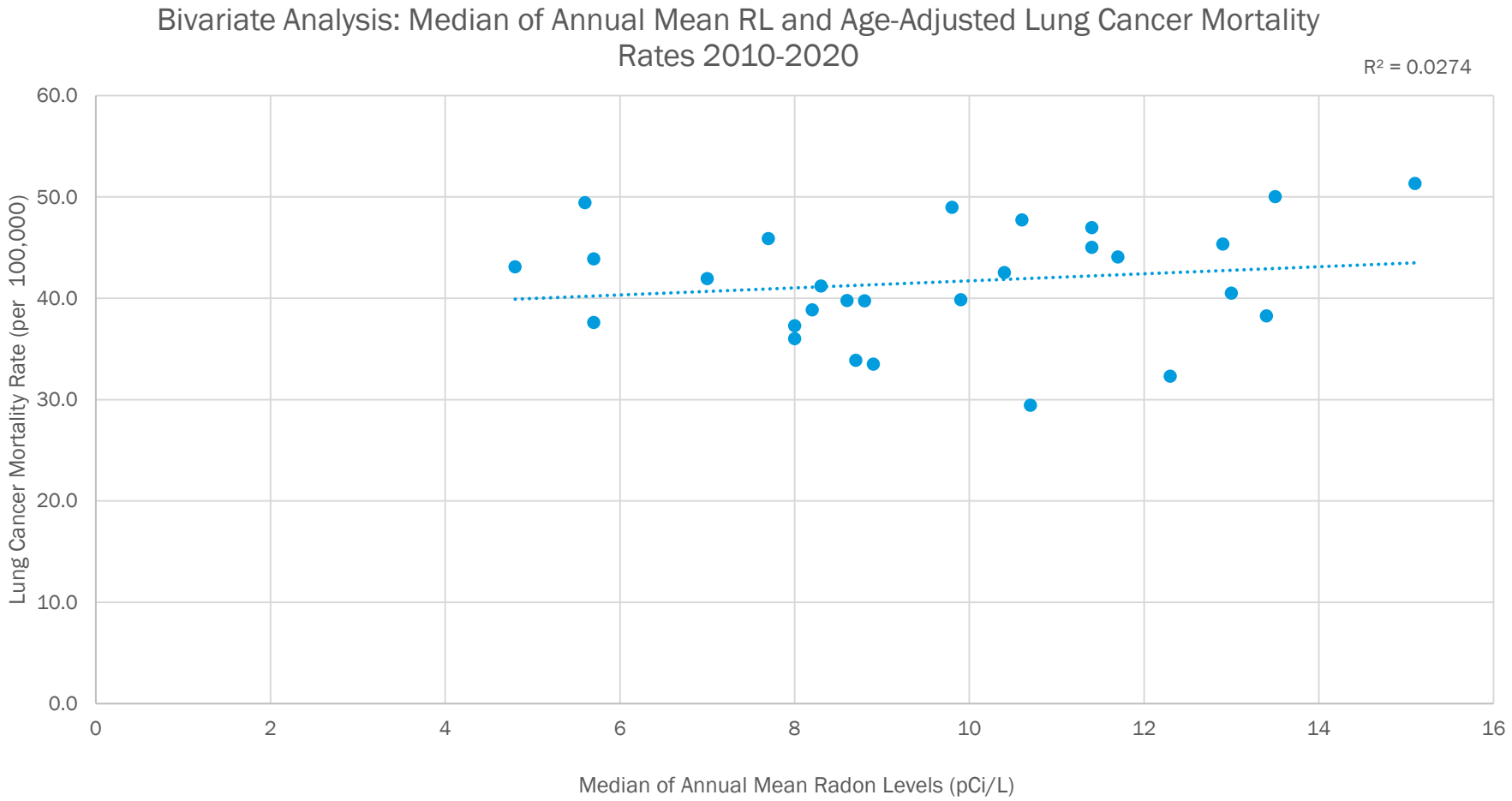
Questions we need to answer

1. How does radon and lung cancer (LC) mortality affect the PSCI catchment area?
2. **Is there a significant relationship between radon exposure levels (REL) and LC mortality in the PSCI catchment area?**
3. Which counties in our catchment have a high current smoking prevalence?

Specific Aim 2

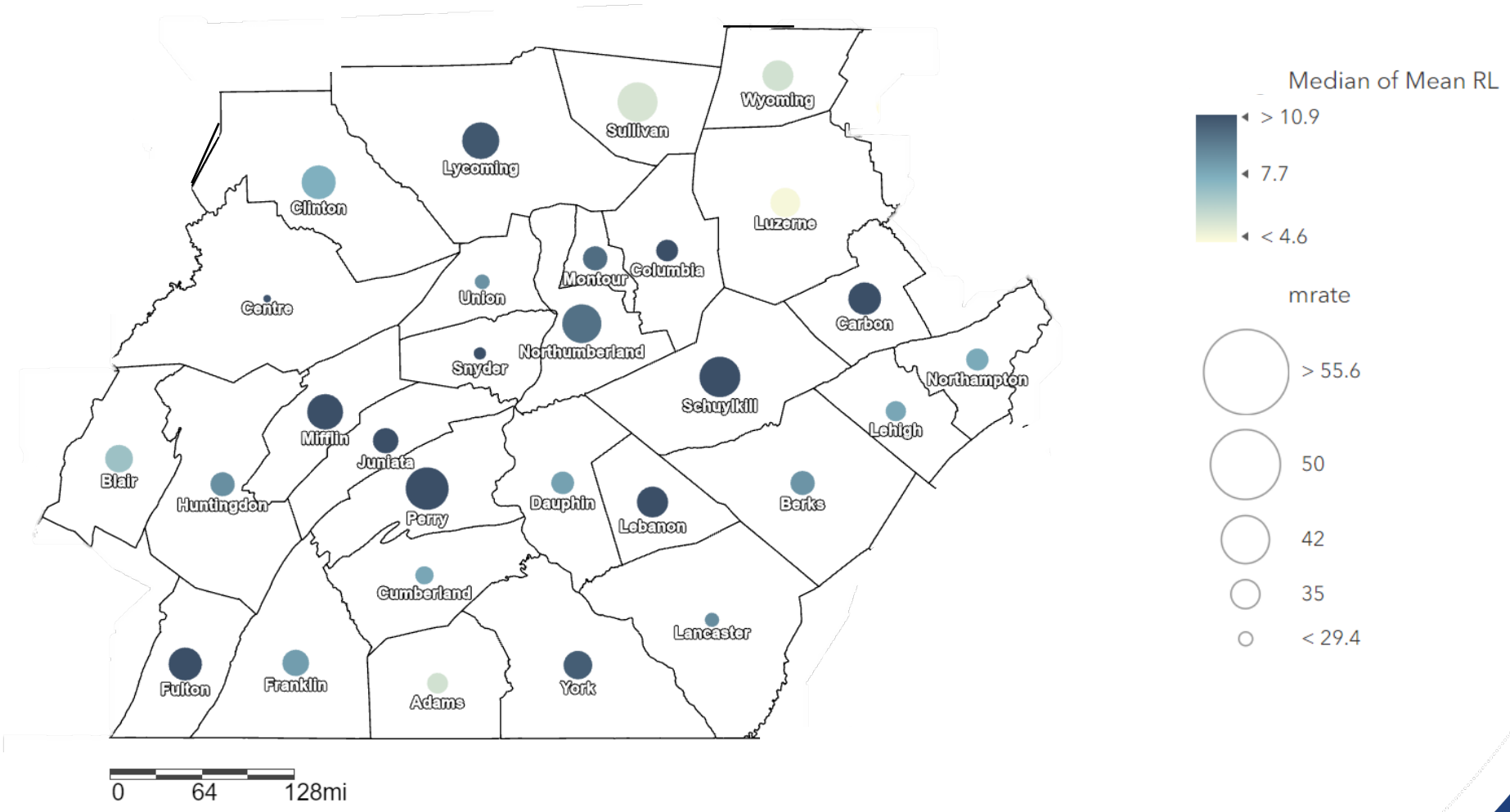
- **Hypothesis:** There is a significant relationship between radon exposure and lung cancer mortality in the PSCI catchment area
- **Specific Aim 2**: Assess the spatial correlation between radon exposure levels and lung cancer mortality rates in the PSCI catchment area
- Quantitative Methods:
  - Bivariate Analysis: Assess relationship between REL and LC mortality
  - Spearman Ranks Correlation: Assess significance of relationship
  - ArcGIS: Spatial Visualization

Bivariate Analysis Graph



Big Takeaway: There is a weak correlation (R^2= 0.02) between RL and LC mortality, found not significant by Spearman's Correlation (1.40)

Bivariate Analysis Map



Big Takeaway: 85% of counties had RL and LC mortality rates > the state (RL: 7.3, LC mortality: 34.3) & national (RL: 1.7, LC mortality: 32.4) averages

Questions we need to answer

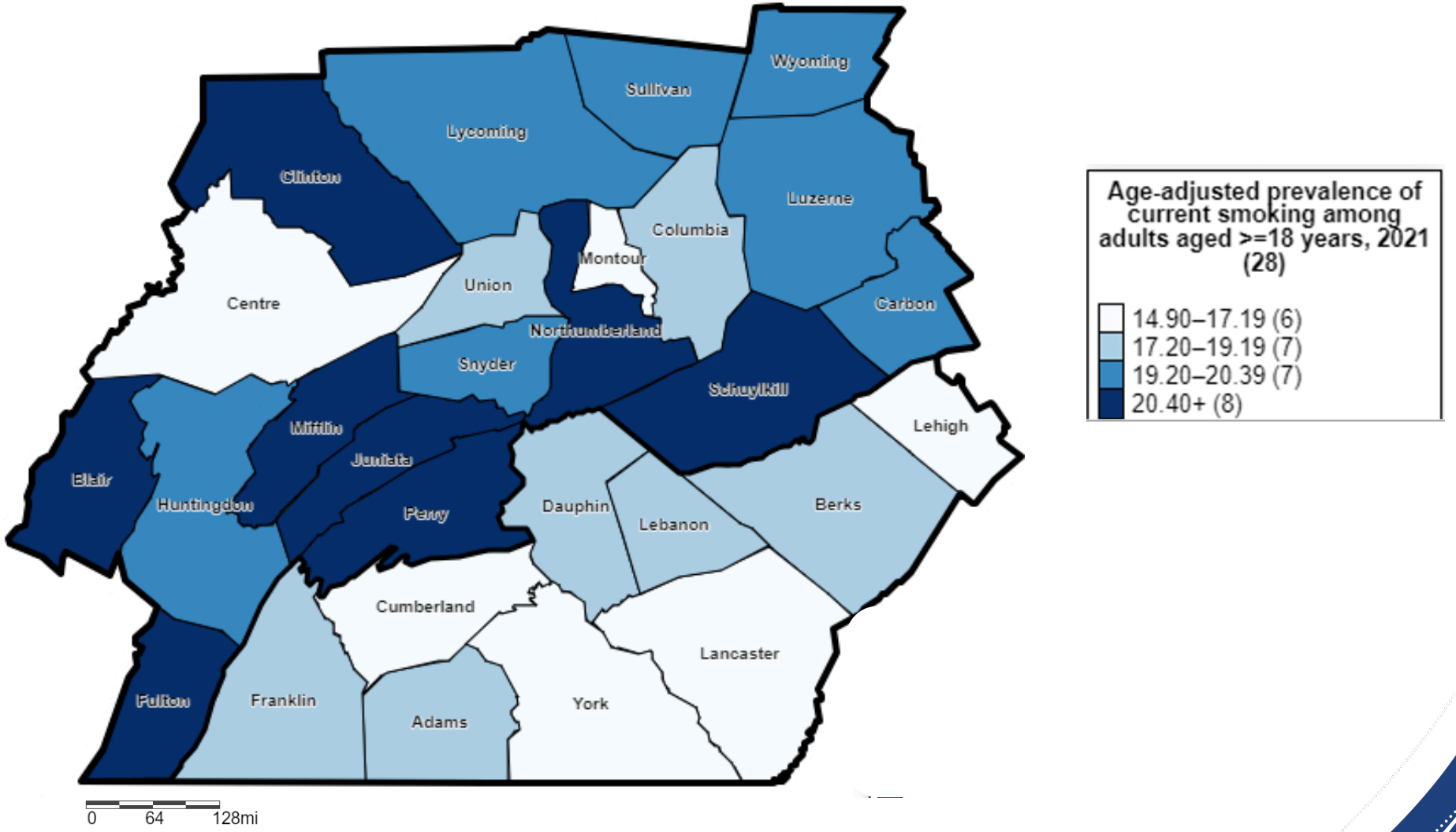
1. How does radon and lung cancer (LC) mortality affect the PSCI catchment area?
2. Is there a significant relationship between radon exposure levels (REL) and LC mortality in the PSCI catchment area?
3. **Which counties in our catchment have a high current smoking prevalence?**

Specific Aim 3

- Hypothesis: Majority of counties will have a high current smoking prevalence
- Specific Aim 2: Use geospatial techniques to visualize counties with high smoking prevalence
- Methods:
  - LionVu: PSCI Exploratory Spatial Visualization Tool
  - Smoking prevalence data: Centers for Disease Control, PLACES

https://app-phs.hmc.psu.edu/lionvu/

LionVu: Smoking in the PSCI Catchment Area



Big Takeaway: 78% of counties have a smoking prevalence and RL ≥ that state (7.3 & 17.2) and national average (1.3 & 13.7)

Conclusions

- All counties have median RL > EPA action level
- Counties also have high LC mortality rates and current smoking rates
- Spatial data allows the PSCI to develop a community risk-based framework to reach residents in the catchment area

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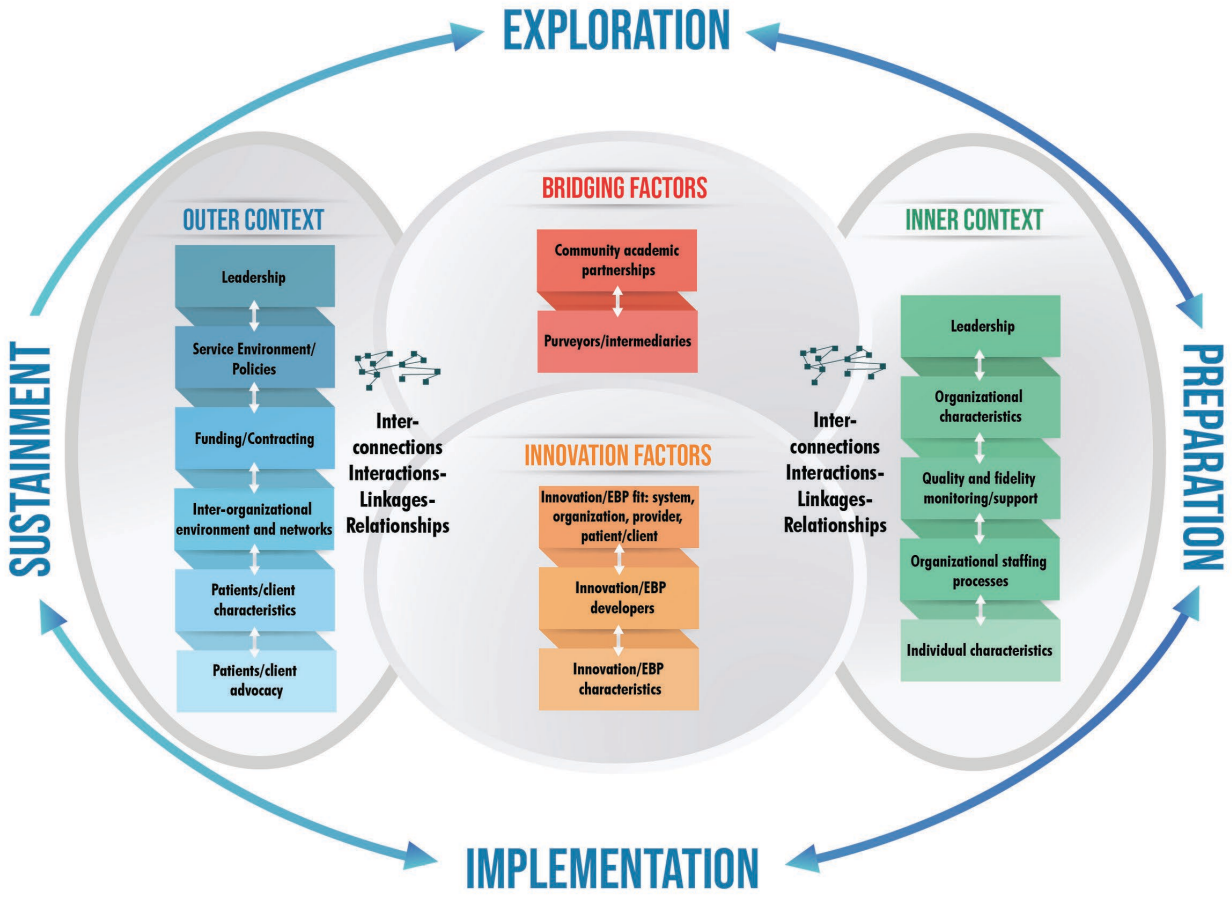
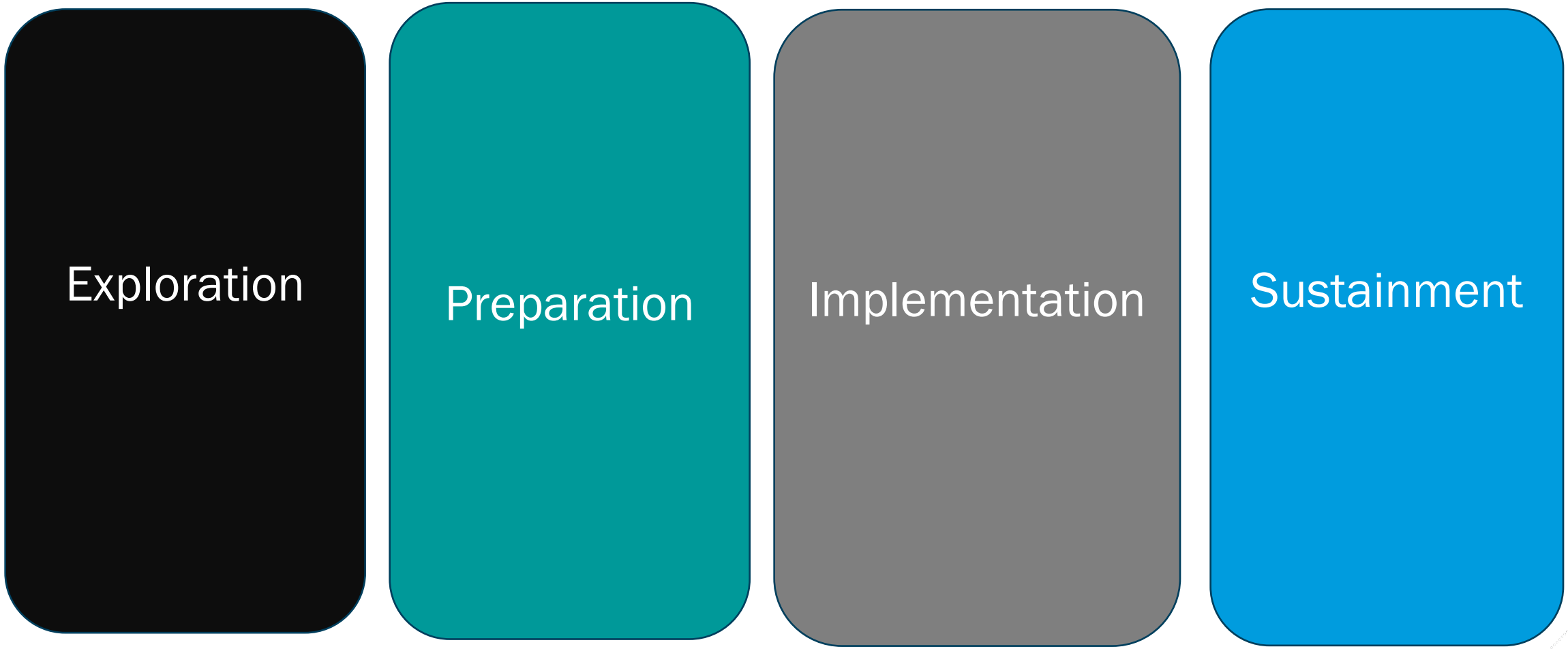
Implementation Science: EPIS Framework

- Goal: To integrate evidence-based practices and interventions on a community-based level in order to improve the impact on population health



https://episframework.com/

Pillars of EPIS Framework



Exploration

- Goal: Identify the scope of the radon issue on health, and disparities in testing, mitigation and community awareness
- PSCI Action Steps
  - Equity-centered radon risk analysis
  - Demographic and smoking behavior analysis
  - Establish community relationships
  - Needs assessment to understand current knowledge/barriers
  - Engage communities with an equity focus

Preparation

- Goal: Develop a comprehensive plan to address radon exposure and associated disparities with an equity focus
- PSCI Action Steps
  - Radon Health Justice Collective
  - Culturally competent radon outreach plans
  - Radon risk communication training for care practitioners
  - Secure funding
  - Equitable approach to allocate resources

Implementation

- Goal: Installation of radon awareness, testing, and mitigation programs within the PSCI catchment area (equity focus)
- PSCI Action Steps
  - Culturally competent public campaigns
  - Integrated practitioner/patient radon risk education
  - Equitable radon test kit distribution program
  - Radon health equity community forums
  - Collaboration with radon professionals

Sustainment

- Goal: Ensure long-term viability of health equity-based radon reduction programs
- PSCI Action Steps
  - Community feedback
  - Securing funding
  - Collection of long-term data

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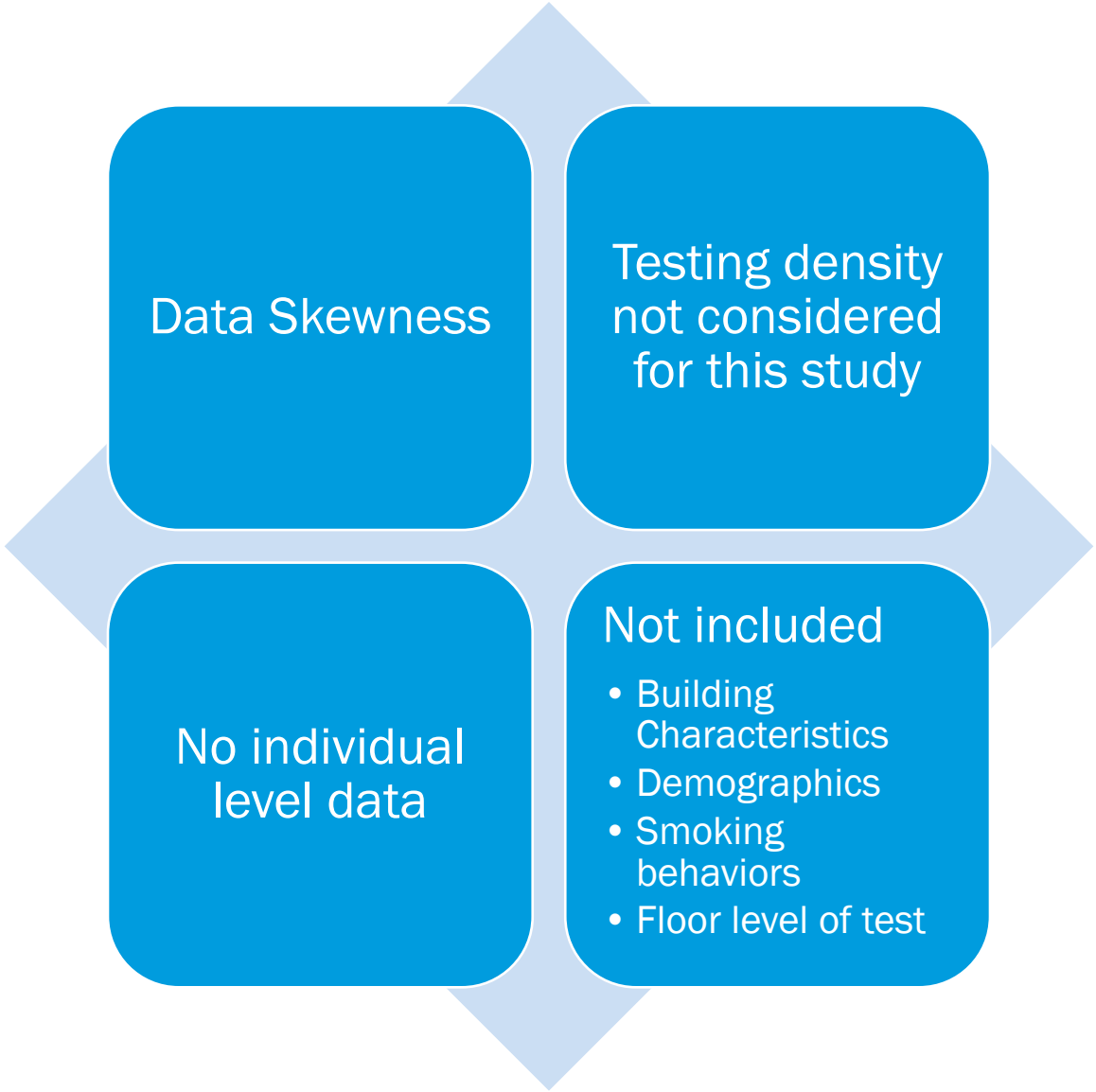
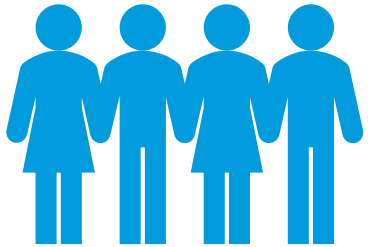
Limitations



Next Steps

Conduct a testing density analysis in the PSCI catchment area



Radon Knowledge Assessment for community members and practitioners in the PSCI catchment area

A Special Thanks

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Penn State College of Medicine

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Premier Youth Ambassador Program

Any questions?

PennState
Cancer Institute