



JOHNS HOPKINS  
BLOOMBERG SCHOOL  
of PUBLIC HEALTH

Indoor Environments 2023  - Radon and Vapor Intrusion Symposium

# Lung Cancer Risk Reduction Associated with RRNC: A study of Manheim Township, PA

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Yiguang Zhu, ScM

Paul A. Locke, MPH, JD, DrPH

Department of Environmental Health and Engineering

Johns Hopkins University

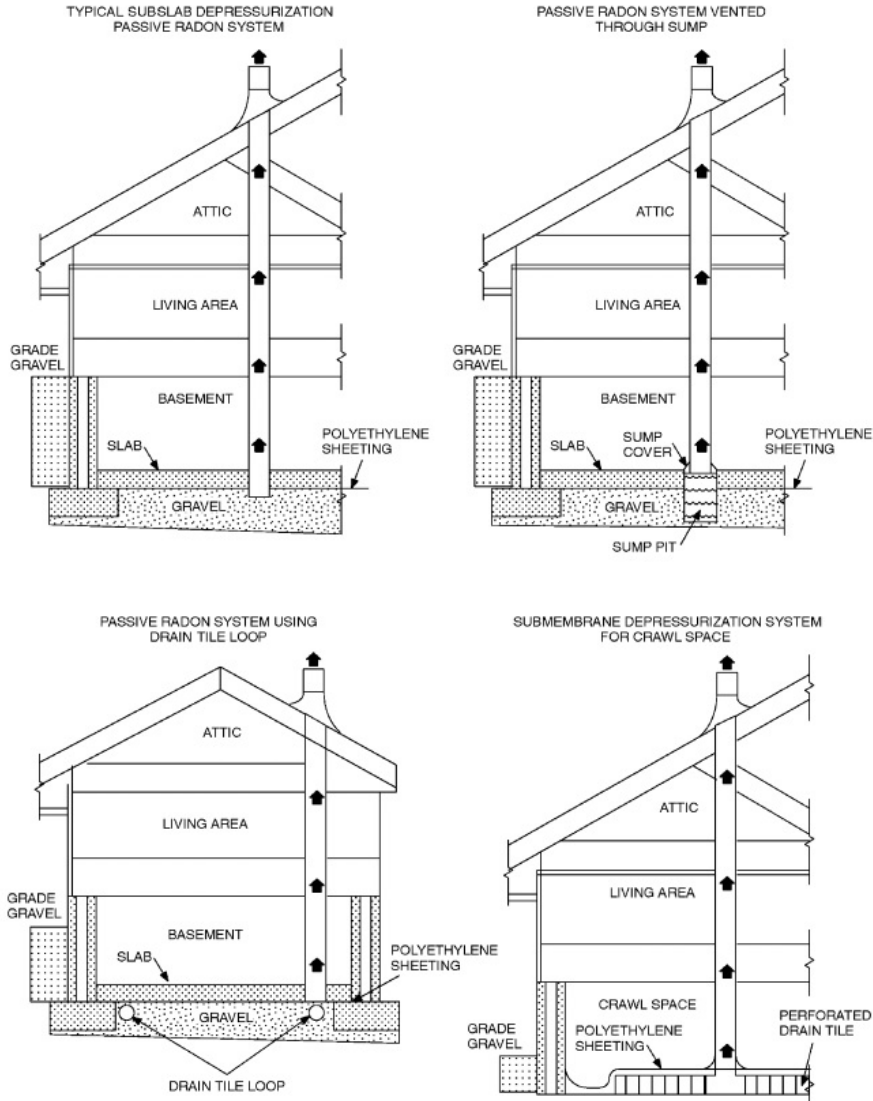


# Overview



- Introduction
  - ▶ Research background
  - ▶ Databases
- Statistical methods
  - ▶ Tobit Regression
  - ▶ Darby Model
- Results
- Cost-effectiveness analysis
- Conclusions

# Introduction - Research Background



- Radon-Resistant New Construction
  - ▶ Passive system
  - ▶ Active system
  - ▶ Previous research
- RRNC regulations
  - ▶ No federal regulations
  - ▶ State and local regulations

# Introduction - Research Background

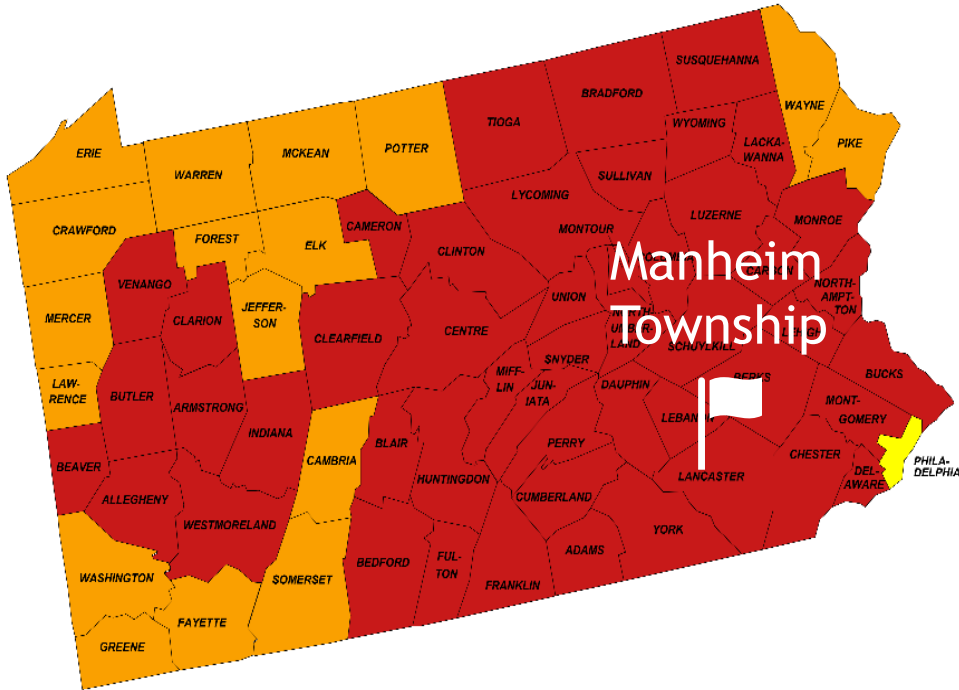
## PENNSYLVANIA - EPA Map of Radon Zones

<http://www.epa.gov/radon/zonemap.html>

The purpose of this map is to assist National, State and local organizations to target their resources and to implement radon-resistant building codes.

This map is not intended to determine if a home in a given zone should be tested for radon.

*All homes should be tested, regardless of zone designation.*



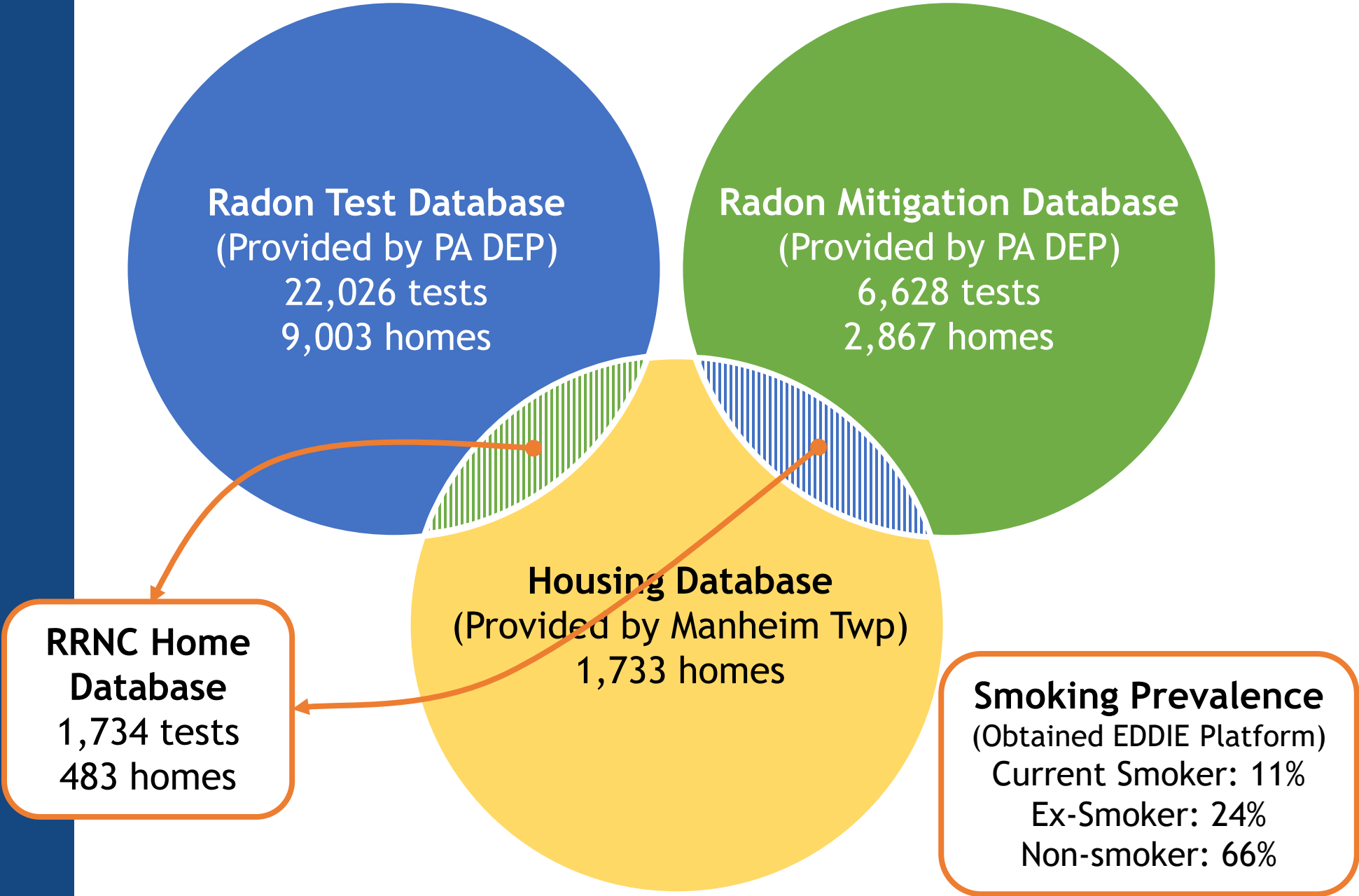
Manheim  
Township



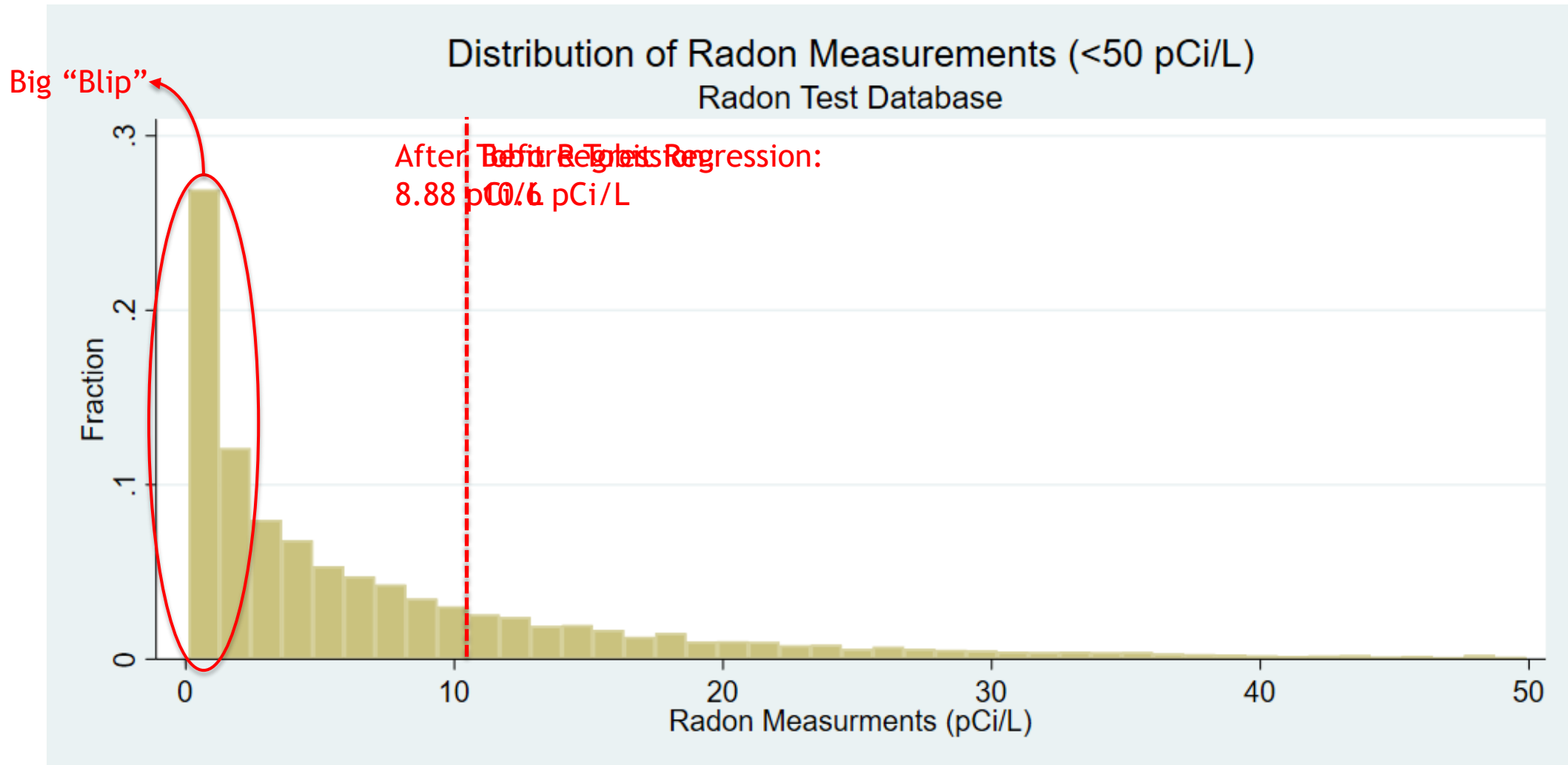
**IMPORTANT:** Consult the publication entitled "Preliminary Geologic Radon Potential Assessment of Pennsylvania" (USGS Open-file Report 93-292-C) before using this map. <http://energy.cr.usgs.gov/radon/gppinfo.html> This document contains information on radon potential variations within counties. EPA also recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential of a specific area.

- Manheim Township, Pennsylvania
  - ▶ Enacted RRNC Ordinances in 6/14/2004
  - ▶ EPA Radon Zone 1
- Favorable conditions
  - ▶ Well established databases by PA DEP
  - ▶ Large sample size

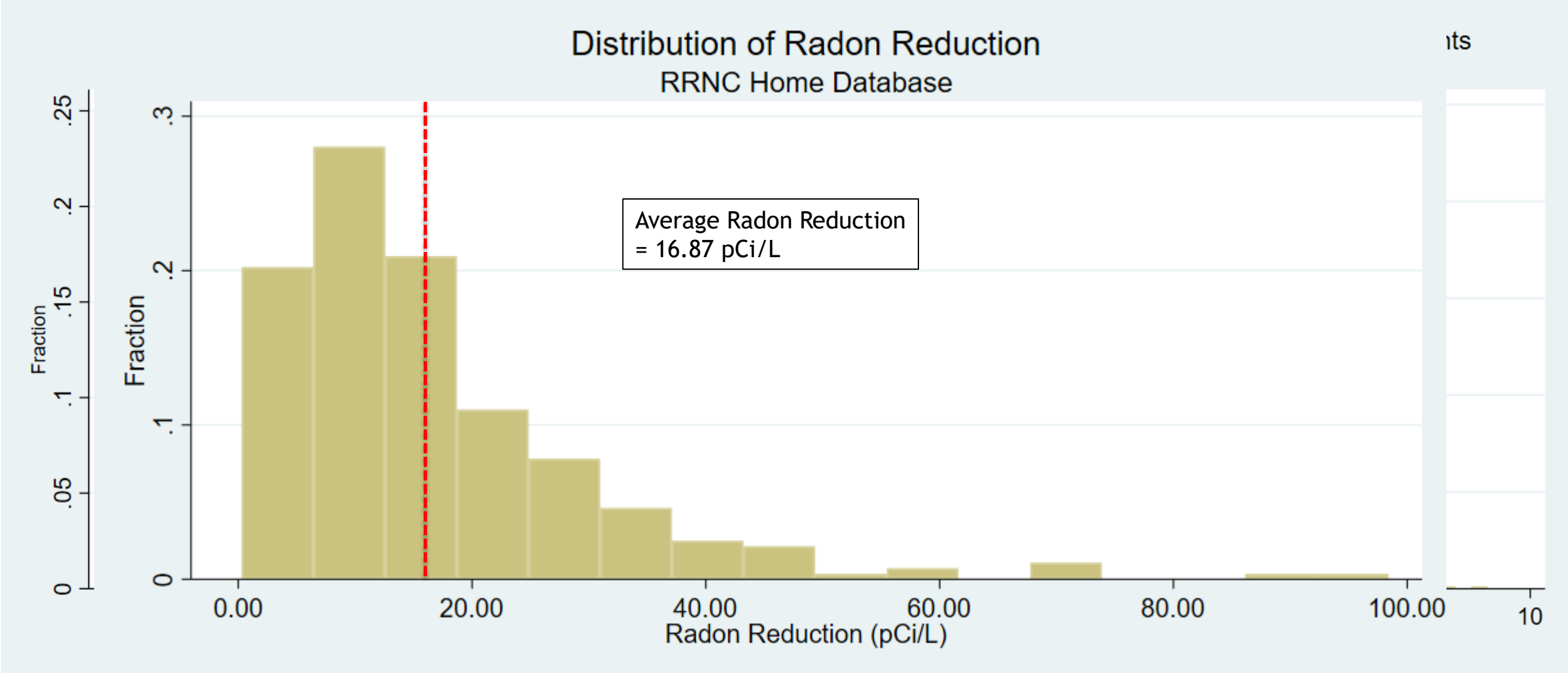
# Introduction - Databases



# Analysis Method for Truncated Data - Tobit Regression

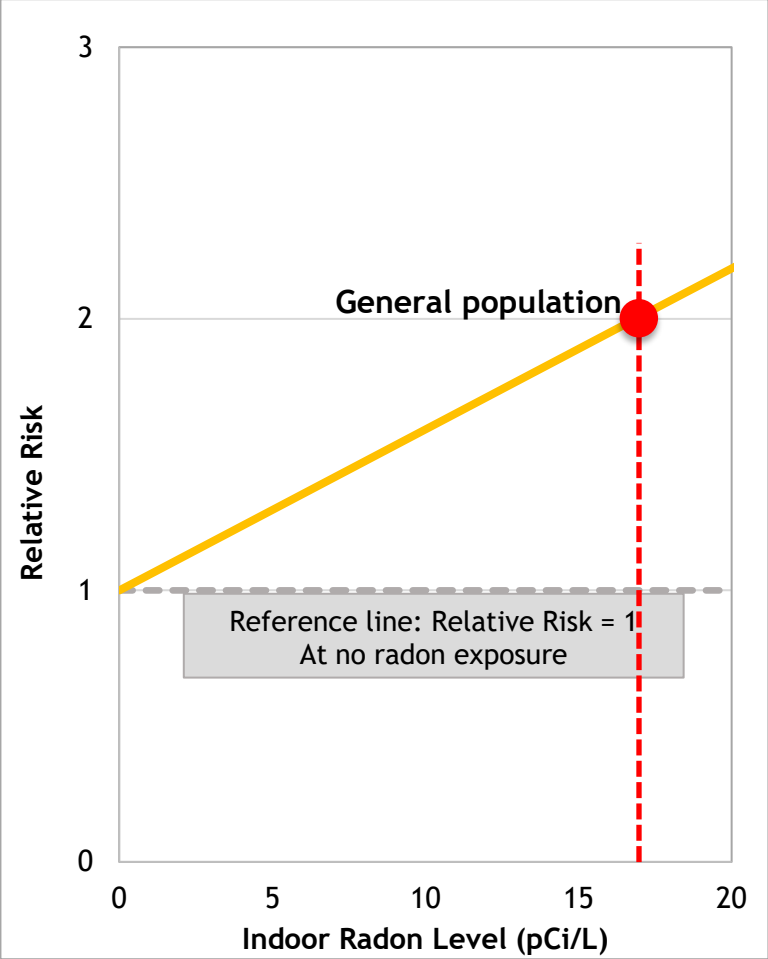


# Reduction in Radon Levels

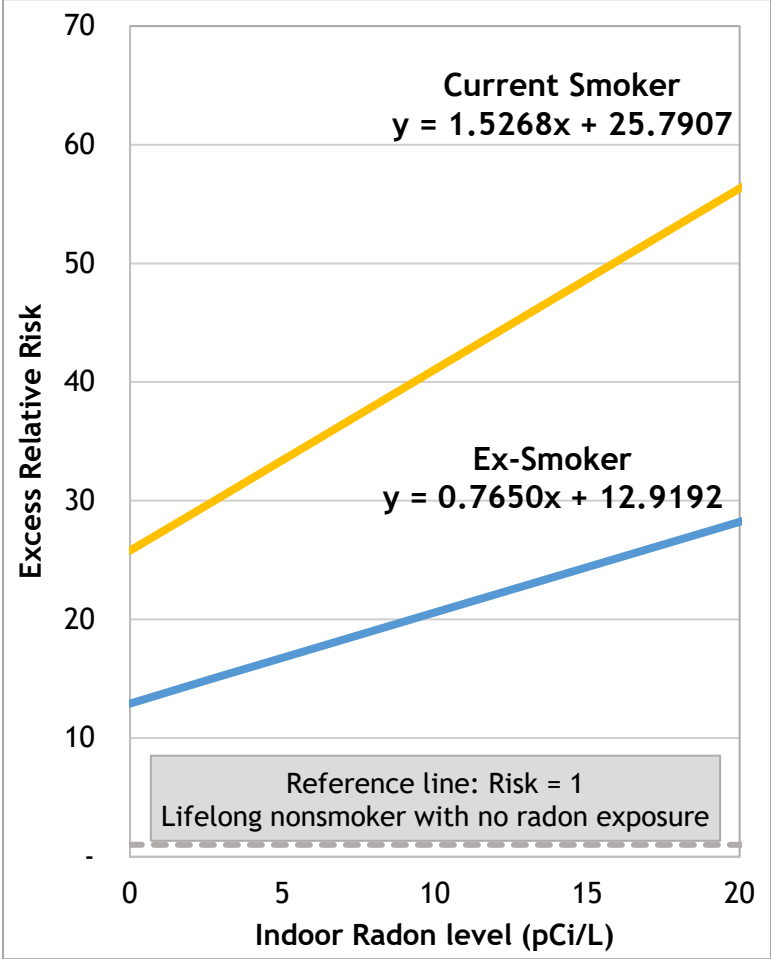


# Dose-Response Model - The Darby Model

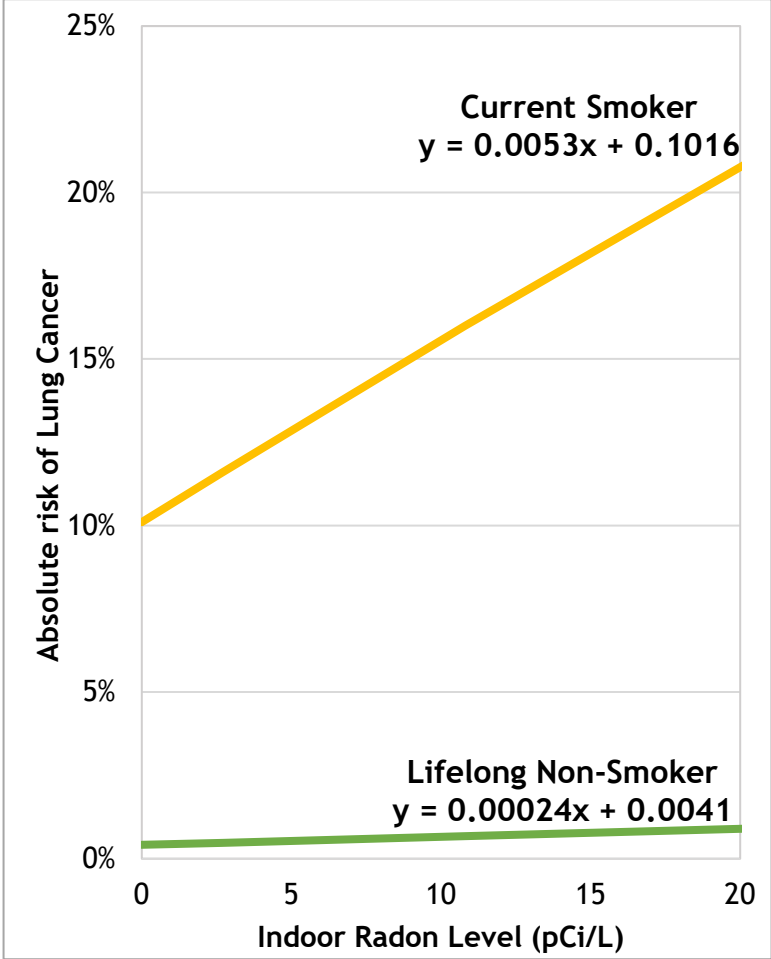
1. Simple linear Relationship



2. Excess relative risk

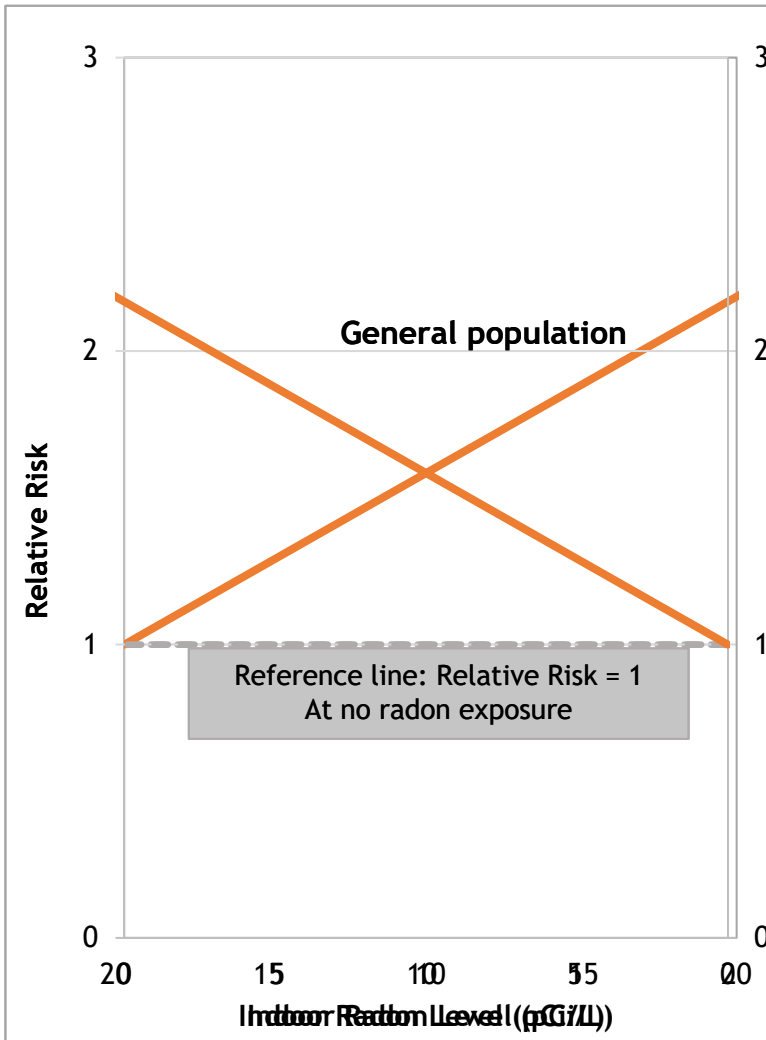


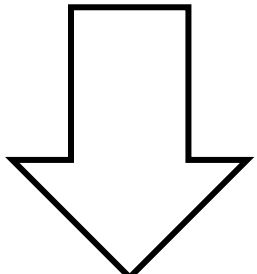
3. Cumulative absolute risk



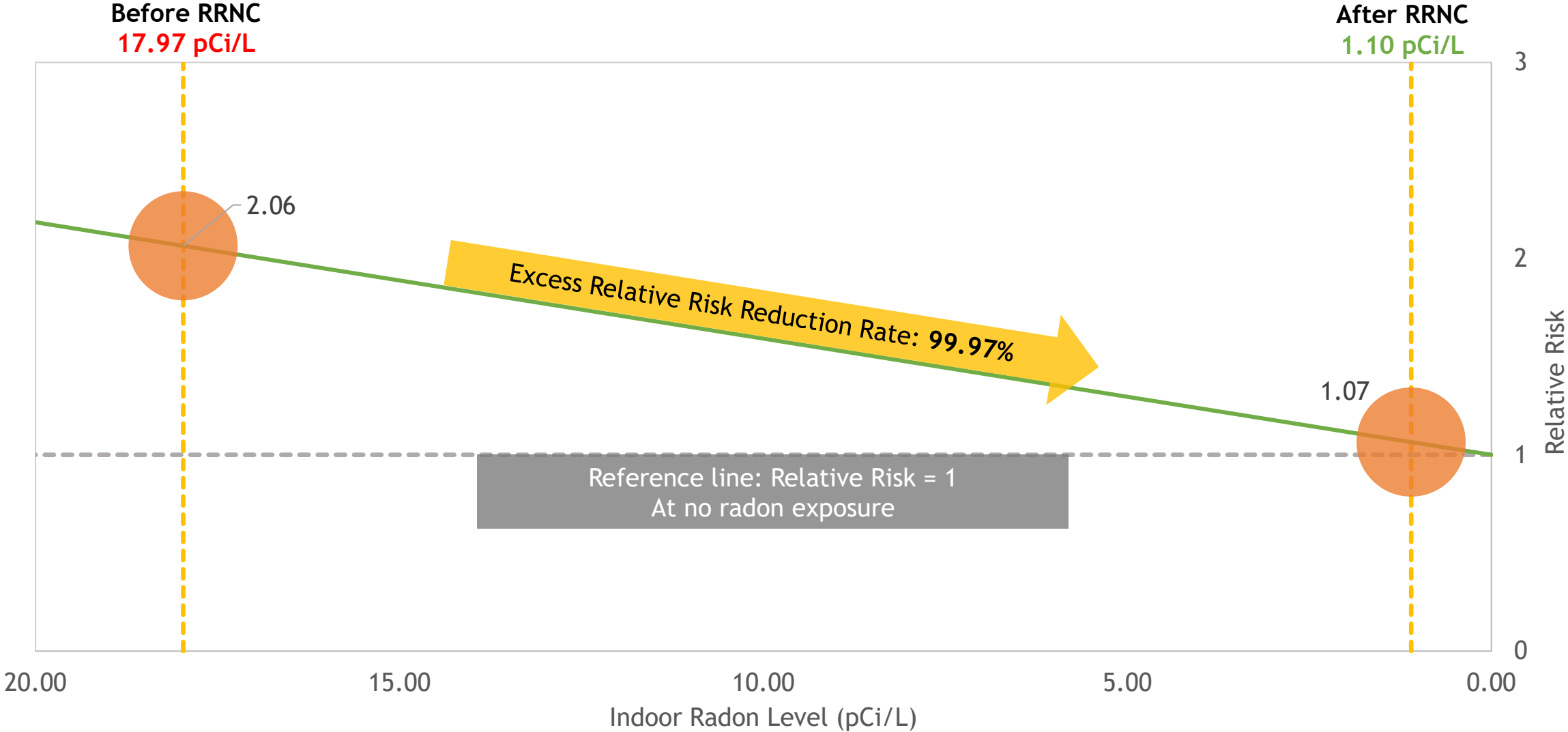


# The Darby Model - 1. Simple linear Relationship

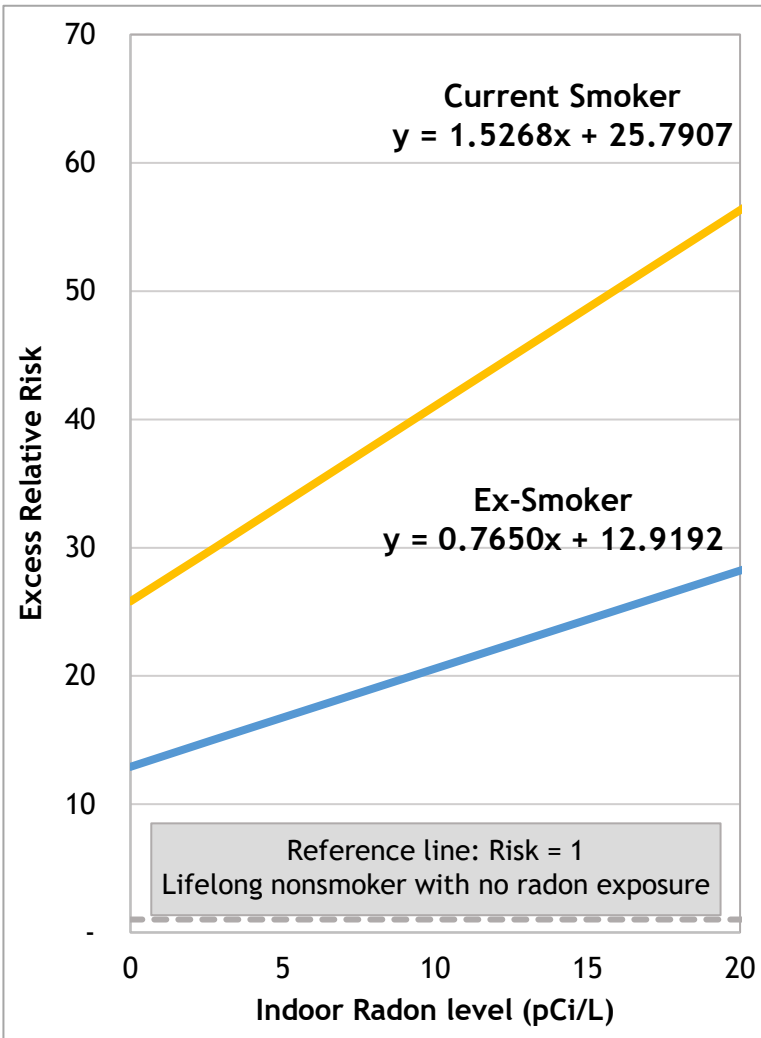


- In reference to lung cancer risk with 0 radon exposure
  - Radon increase 2.7 pCi/L → relative lung cancer risk increase 16%
- 
- Radon decrease 2.7 pCi/L → relative lung cancer risk decrease 16%

# Radon-Attributable Relative Risk Reduction in the General Population

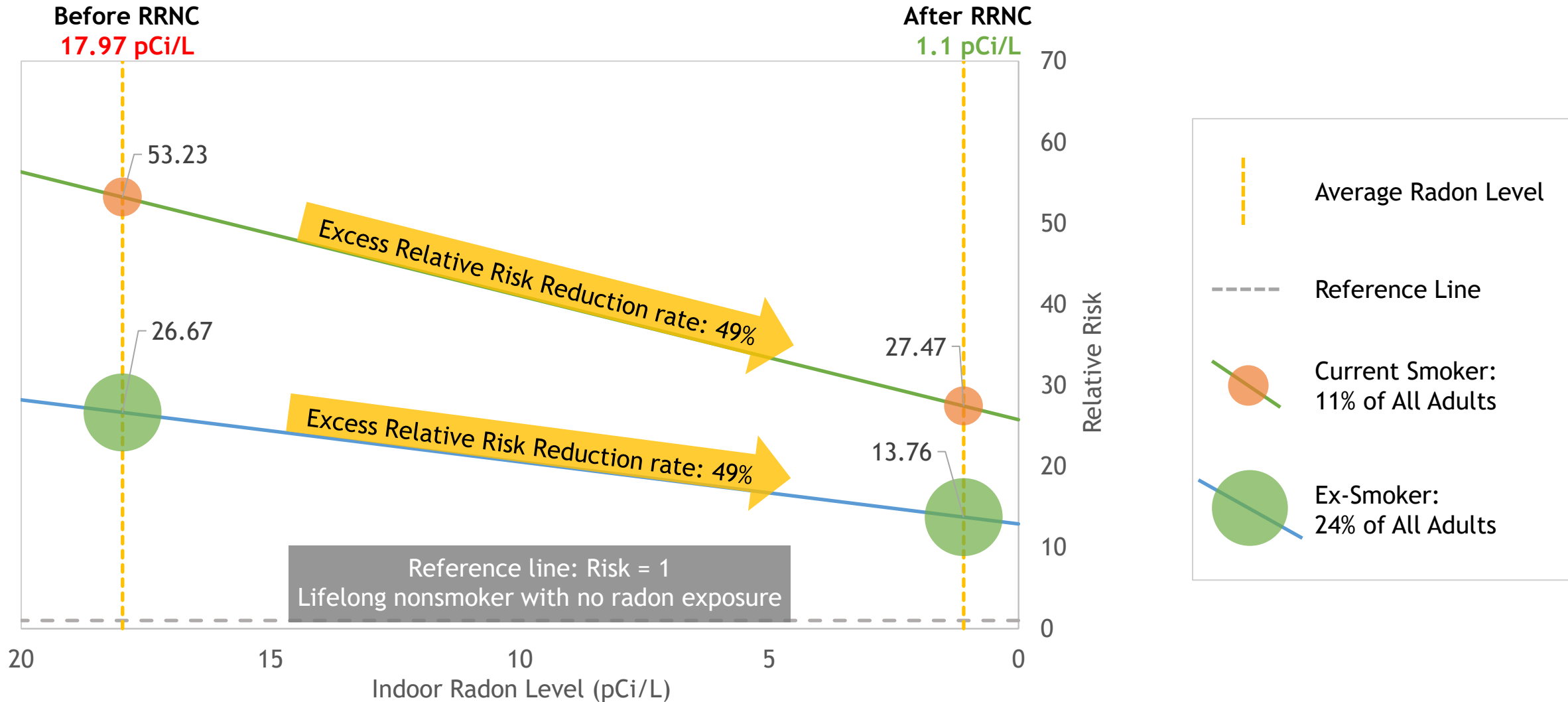


# The Darby Model - 2. Excess relative risk

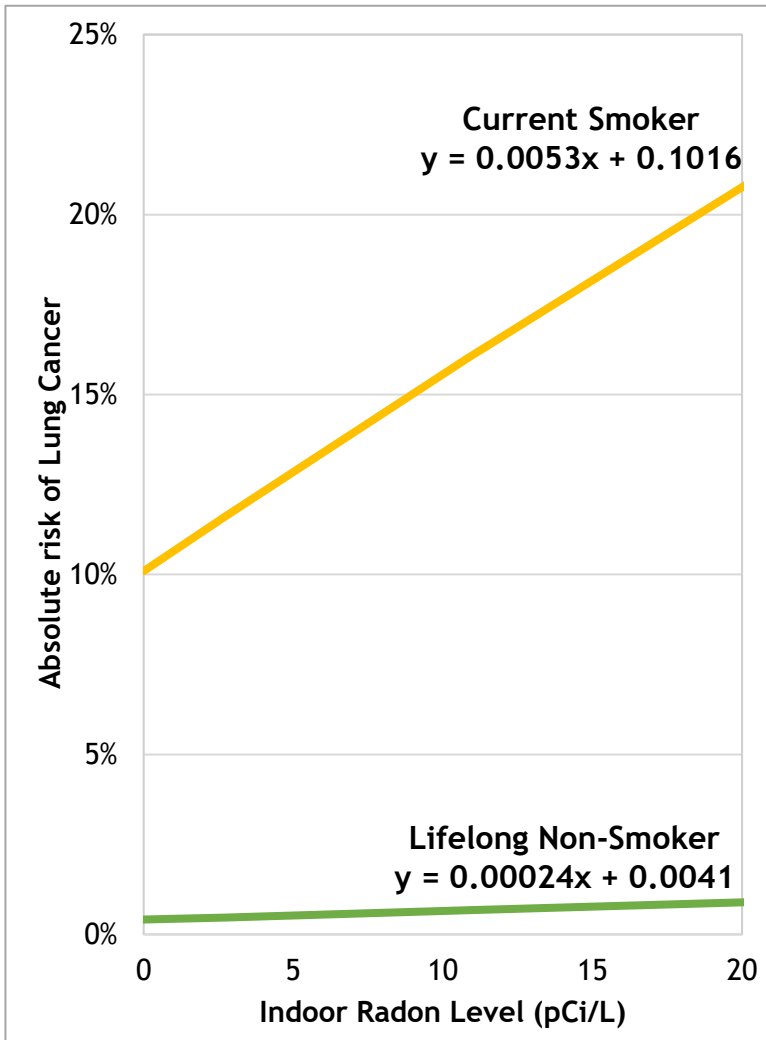


- Excess relative lung cancer risk associated with radon exposure
- In reference to lung cancer risk for lifelong nonsmoker with 0 radon exposure
- Point Estimations → Best-fitting straight lines & equations
  - ▶ Current Smokers:  $y = 1.5268x + 25.7907$
  - ▶ Ex-smokers:  $y = 0.7650x + 12.9192$

# The Darby Model - 2. Excess relative risk (Cont.)

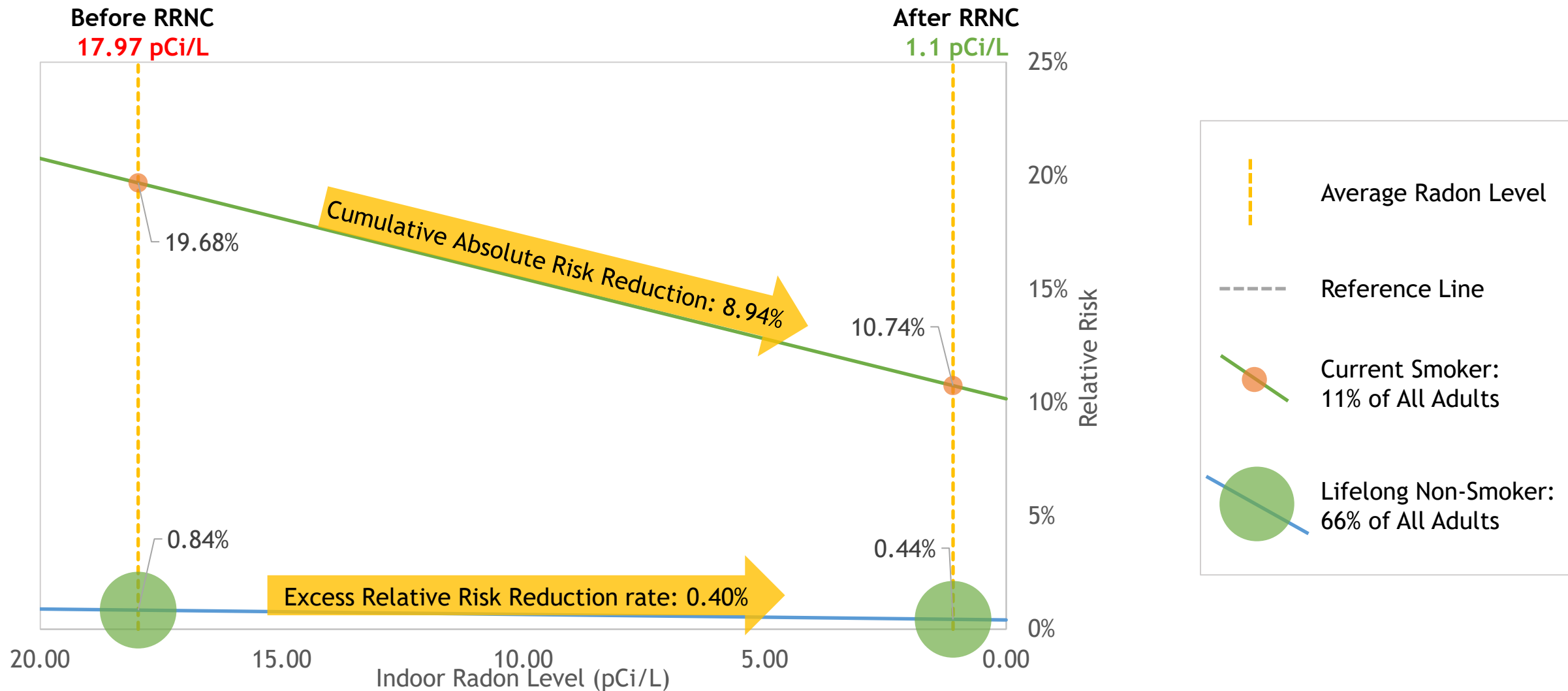


# The Darby Model - 3. Cumulative absolute risk



- Cumulative absolute risk of death from lung cancer by age 75
- Point Estimations → Best-fitting straight lines & equations
  - ▶ Current Smoker:  $y = 0.0053x + 0.1016$
  - ▶ Lifelong Non-Smoker:  $y = 0.00024x + 0.0041$

# The Darby Model - 3. Cumulative absolute risk (Cont.)



## The Darby Model - 3. Cumulative absolute risk (Cont.)

*Population × Smoking prevalence × Absolute risk reduction = Avoided lung cancer deaths*

*For smokers:  $40,548 \times 11\% \times 8.94\% \approx 400$  Deaths*

*For nonsmokers:  $40,548 \times 66\% \times 0.40\% \approx 110$  Deaths*

# Cost Effectiveness Analysis

Mitigation Methods	Number of Homes	Average Radon Reduction (pCi/L)	Average Mitigation Cost (\$)	Cost per 1 pCi/L Reduced* (\$/pCi/L)
Sub-slab Ventilation - Generic	2,087	11.44	928	140
Activate a Passive System	214	9.14	580	105
Sub-slab Pit Cut-Out	64	9.03	1105	157
Passive Depressurization	56	9.42	643	101
Modify an Existing System	18	8.17	1006	241
New Construction - Active Sys.	6	10.23	532	90
Perimeter Floor Ventilation	6	8.28	728	122
Slab-on-Grade Depressurization	4	9.07	776	142
Sub-slab Combo	4	17.56	1134	81
Depressurize Captive Membrane	2	7.15	1050	105
New Construction - Passive Sys.	2	8.58	618	93
<b>Summary</b>	<b>2,463</b>	<b>11.10</b>	<b>895</b>	<b>137</b>

\*: To calculate the average cost, negative radon reduction records were eliminated from the analysis.



# Conclusion

- RRNC reduced the 16.87 pCi/L indoor radon concentration
- RRNC Ordinances basically eliminate the radon-attributable lung cancer risk
- Spend \$137, reduce 1 pCi/L of radon
- Legislative action can reduce cancer risk

# Reference

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- ▶ the Board of Commissioners of Manheim Township. 2004. Ordinance 2004-7 An Ordinance Adopting the Uniform Construction Code and International Codes Incorporated Therein and Amending Any Ordinances Inconsistent Therewith.

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# Question & Answer



yzhu99@jh.edu  
plocke@jh.edu