

FROM NEW YORK STATE TO NATIONWIDE

A Multivariate Geospatial Analysis on the Epidemiology of Indoor Radon Pollution and Its Link with Lung Cancer

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Introduction

Radon is a radioactive gas present in rocks and soils, which can be released into the air and the buildings through cracks and gaps in foundations, floors or walls. It is the second leading cause of lung cancer after cigarette smoking, and the leading cause of lung cancer among non-smokers. Previous studies have showed definitive evidence of an association between residential radon exposure and lung cancer.

US EPA sets a radon concentration of 4 pCi/L (picoCurie per liter) as the "action level", at which it is cost-effective to take action to reduce radon exposure by implementing preventive measures. EPA also recommends that people think about fixing their homes for radon levels between 2 pCi/L and 4 pCi/L. According to these two principles, EPA defines three "Radon Zones" (Table 1) and allocates every US counties into one of the three zones based on their predicted average radon levels.

Table 1. Definitions of EPA Radon Zones

Radon Zone	Radon Concentration
Zone 1	Higher than 4 pCi/L
Zone 2	Between 2 pCi/L and 4 pCi/L
Zone 3	Lower than 2 pCi/L

In this study, we tried to use various GIS methods to explore the associations among radon exposure, lung cancer, and smoking behaviors, in both the U.S. and New York State.

Methodology

GIS Data Source. Nationwide and New York statewide, county-level data of lung and bronchus cancer incidence rate during the 5-year period from 2009 to 2013 and county-level modeled estimate of percentage of adult population (18 years or older) who are current smokers between 2008 and 2010 were downloaded from the State Cancer Profile website. Data of all counties and their corresponding radon zones were downloaded from EPA's Report on the Environment (ROE) website, which were used as a rough estimate of nationwide county-level radon concentration. Data of township-level average of indoor radon test results were downloaded from New York State Department of Health's (NYS DOH) health data website, which include all test results done by test kit ordered through NYS DOH's Radon Program since 1987 and have both basement and first-floor radon concentration data.

Geocoding. Nationwide county-level data of cancer incidence and smoking behavior were joined to the latest shapefile of all US counties downloaded from US Census' TIGER website based on county FIPS code. The original radon zone dataset does not have a column of FIPS code, so it was firstly matched with a list of 2010 FIPS county codes downloaded from US Census website based on county names. For New York State, county-level data were joined to the shapefile of New York counties downloaded from New York State GIS program website based on the FIPS code, and city/township-level data were joined to the shapefile of cities/towns from the same website based on names of the cities/towns.

Geospatial Data Analysis. For both nationwide and New York statewide data, univariate choropleths of lung cancer incidence, percentage of current smokers, and radon exposure level were created. The classification method was based on Jenks natural breaks, and the cut-points were rounded to

near multiples of 0.5, 5 or 10. Hot spot analysis was conducted for New York State township-level choropleth of radon test results to see which places have a significantly higher level of indoor radon concentration.

Bivariate choropleths showing lung cancer incidence and percentage of current smokers simultaneously were created to identify places with low prevalence of smoking behavior but high burden of lung cancer. They were compared with choropleths and hot spot map of radon concentration to see whether the higher cancer incidence in these places can be linked to a higher level of radon exposure. The renderer and geoprocessing tools used in making bivariate choropleths are created by Aileen Buckley and downloaded from Esri's ArcGIS Blog (<https://blogs.esri.com/esri/arcgis/2015/09/15/making-bivariate-choropleth-maps-with-arcmap/>). The cut-point for classification are based on quartiles in the bivariate choropleths.

Findings

The Radon Zone 1, where the radon concentration is higher than EPA's "action level", mainly spreads from along the Appalachian Mountains to northern Great Plains and the Rocky Mountain area (Figure 1). The nationwide bivariate choropleth shows a majority of counties with relatively fewer current smokers but higher incidence of lung cancer are located in places with higher radon level (EPA Radon Zone 1 and 2), suggesting that the cancer incidence in these areas may be partially associated with higher level of radon exposure (Figure 1, Figure 4). The nationwide distribution of counties with higher incidence of lung cancer is largely consistent with the distribution of counties with higher prevalence of smoking (Figure 2, Figure 3). A majority of these counties are also located in EPA Radon Zone 1 and 2.

In New York State, counties with higher incidence of lung cancer and counties with higher prevalence of smoking behavior are generally consistent in most of the places (Figure 7, Figure 8). Bivariate choropleth shows some counties in southwestern Upstate and middle Hudson River Valley with fewer current smokers still have a higher incidence of lung cancer (Figure 9), which is generally consistent with the locations of clusters of towns with significantly higher radon level in the hot spot map (Figure 5, Figure 6).

Conclusion

The geospatial distribution of lung cancer incidence is consistent with the distribution pattern of high radon areas and the prevalence of current smoking, suggesting that indoor radon and smoking may be associated with lung cancer.

Data Sources:

NCI, US EPA, NYS DOH, US Census, NYS GIS Program

Geographic and Projected Coordinate:

NAD 1983 Contiguous USA Albers (for maps of contiguous U.S.)
 NAD 1983 Alaska Albers Equal Area Conic (for maps of Alaska)
 NAD 1983 Hawaii Albers Equal Area Conic (for maps of Hawaii)
 NAD 1983 UTM Zone 18N (for maps of New York State)



Figure 6. Hot Spot Analysis of Indoor Radon Test Result since 1987, by City/Town, New York State

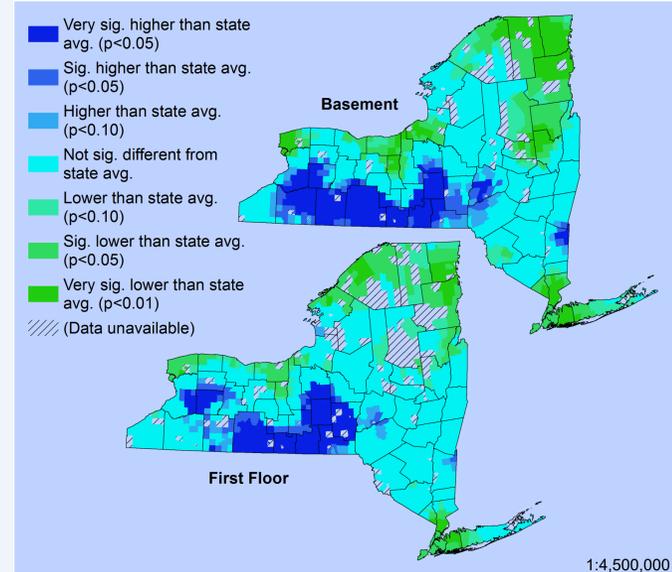


Figure 5. Indoor Radon Test Result since 1987, by City/Town, New York State

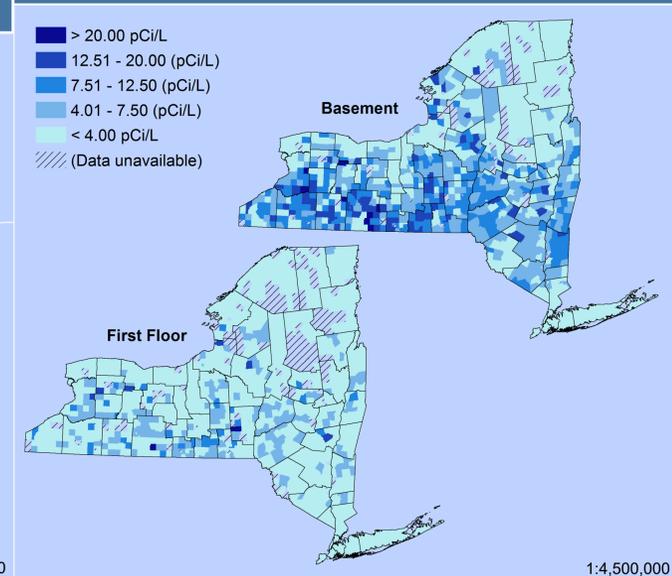


Figure 1. EPA Radon Zones, based on Predicted Average Indoor Radon Screening Level, by U.S. county

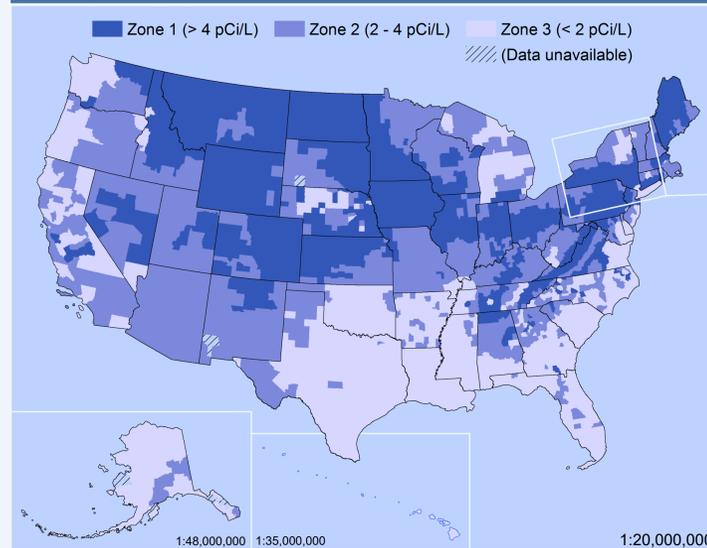


Figure 4. Lung & Bronchus Incidence Rate (cases per 100,000) during 2009-2013 and Estimated Percentage of Current Smokers Aged 18+ between 2008 and 2010, by US County

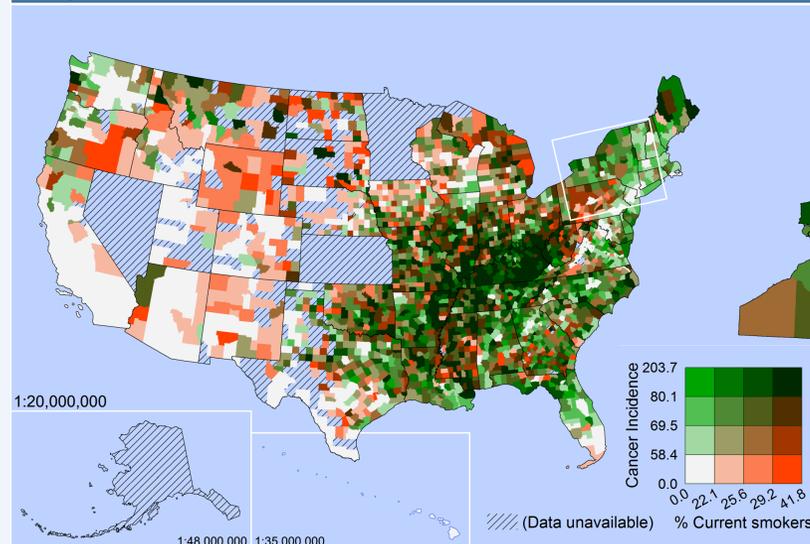


Figure 9. Lung & Bronchus Incidence Rate (cases per 100,000), 2009-2013 and Estimated Percentage of Current Smokers Aged 18+, 2008-2010, by New York State County

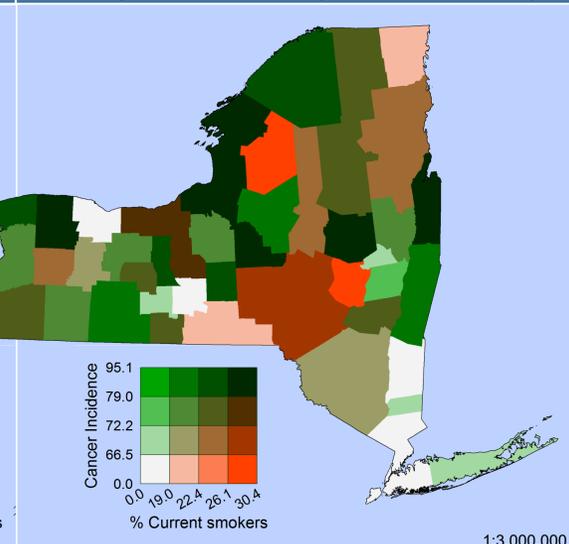


Figure 7. Lung & Bronchus Incidence Rate, by County, New York State, 2009-2013

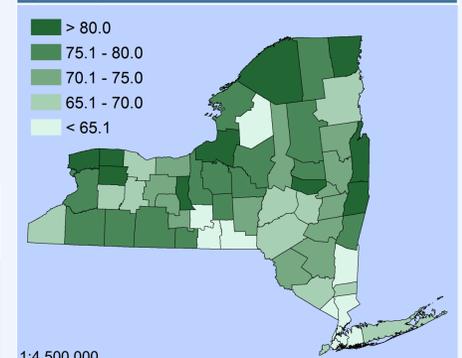


Figure 8. Estimated Percentage of Current Smokers Aged 18+, by County, New York State, 2008-2010

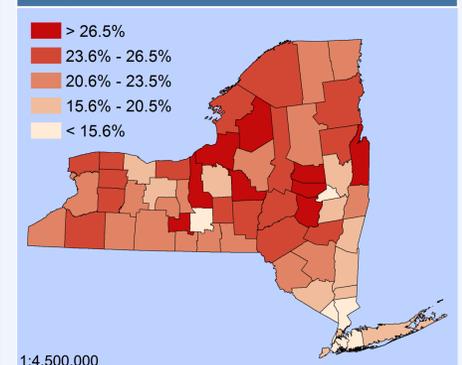


Figure 2. Estimated Percentage of Current Smokers Aged 18+, by US County, 2008-2010

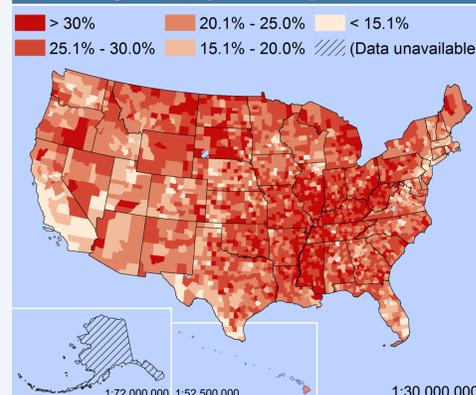


Figure 3. Lung & Bronchus Incidence Rate (cases per 100,000), by US County, 2009-2013

