# Radon Levels in Pennsylvania and the Rise in Incidence of Thyroid Cancer

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## Introduction

Thyroid cancer is on the rise, both in the United States and across the world. The rise in the incidence of thyroid cancer is especially notable in Pennsylvania. One of the few known environmental associations with thyroid cancer is a history of radiation exposure. In 1979, there was a nuclear accident and partial meltdown at Three Mile Island in central Pennsylvania. Our recent research, however, has not shown a rise in thyroid cancer to be associated geographically with this disaster site. Literature exists supporting the carcinogenic potential of radon: an odorless, colorless gas that accumulates in residential and commercial buildings. Additionally, Pennsylvania is known to have one of the highest levels of radon as compared to the rest of the United States.

We therefore sought to link rising radon levels with rising incidence of thyroid cancer to see if there is an association between radon levels in Pennsylvania and thyroid cancer incidence.

## Methods

Institutional review board approval was obtained for this study.

Publicly available de-identified databases as well as third-party databases were used for the study. Data was collected from the Pennsylvania Cancer Registry, which provided information on each case of thyroid cancer diagnosed in Pennsylvania residents from 1991 to 2009. This information was used to calculate thyroid cancer incidence for each geographic area in Pennsylvania.

Radon levels were measured in picocuries per liter of air. Through third-party radon testing agencies, the Pennsylvania Department of Environmental Protection accumulates and aggregates county level data on radon levels. This information is obtained by self-testing kits that are used and sent in by homeowners.

In performing an analysis of the data, county-level comparisons were made. A Poisson regression model with random effects was fit to the expected thyroid cases for a specific year and county. Other models were fit to include the previous year’s thyroid incidence and a possible lag effect of radon on thyroid cancer. SAS 9.3 (SAS Institute Inc., Cary, NC, USA) was used to perform the statistical modeling.

Additional analysis was performed to evaluate for possible clustering of radon concentrations and whether these clusters correlated with clusters of thyroid incidence. A Moran's I scatter plot was created to assess whether these data are geographically clustered or whether they are randomly dispersed.

## Results

From our data, 1263 (94%) observations out of a possible 1340 observations from 1991 to 2009 were used in the estimation. Those measurements that were missing data regarding location information were excluded. We created a model that looked at yearly changes in incidence rates, using the previous year’s thyroid cases as a predictor. Radon regression weight remained non-significant (beta = -0.00275, se = 0.07195, p = 3812).

Several different models incorporating various lag combinations were fit, where radon values were substituted by corresponding change variables or previous radon values. Using a variety of lag periods between 2 and 6 years, the Poisson regression model was re-evaluated. The values approached statistical significance with a lag period of 3 years (p=0.0634), but there were no statistically significant results (p=0.0634-0.4216). To adjust for possibly unreliable measurements of radon from year to year, a Bayesian model was created to create a confidence interval for the actual radon value from year to year.

As a final analysis, the Poisson regression model was applied to the third-party (Air Check, Inc.) dataset for the years 1995 to 2009. Again, data which was missing location data was discarded. A total of 959 of 1005 observations (95%) were used. Using this data set, the regression weight for the radon levels was not significant (beta = 0.00019, se = 0.01001, p-value = 9846). Overdispersion was similar to the original model.

In performing our cluster analysis, we found that both radon levels as well as thyroid incidences for the years measured showed statistically significant evidence rejecting the null hypothesis of random dispersion. For radon, the Moran statistic for levels from 2000 to 2004 (Moran’s I = 0.2739, p=0.002) suggests moderate clustering, where a Moran's I of 1.00 would be consistent with perfect clustering. Similarly, for thyroid cancer incidence from 2005 to 2009 the Moran statistic (Moran’s I=0.2177, p=0.02) shows moderate clustering.

## Discussion

Over the past 30 years, greater attention has been placed on radon levels in the household in light of evidence associating radon with lung cancer. Similarly, research has found links between radon measurements and cutaneous squamous cell carcinoma. Given the associations and causality between radon exposure and cancer, especially lung cancer, we considered an association between radon and thyroid cancer using a similar methodology, this study attempted to demonstrate a similar association between radon levels in Pennsylvania and thyroid cancer incidence.

Radon, via radioactive decay, releases α–particles, which is in contrast to radioactive iodine which releases γ-rays. As such, the radioactive particles from radon decay are heavier and penetrate soft tissues to a lesser degree than γ-rays. However, radon exists in a gaseous form and its decay particles and deposit in the airway and as such could subject the thyroid to additional radiation exposure.

The research did not demonstrate a correlation between radon levels and the rise in thyroid incidence in Pennsylvania. Even after accounting for possible variability in radon measurements from year to year, and also considering the possibility of a lag period between the radon levels and a measurable difference in thyroid cancer, no statistically significant correlation could be measured.

One of the limitations of this study is that this study was performed retrospectively and could only be performed on the data available from 1991 onwards. It is possible that the impact of radon on thyroid incidence has a lag period longer than what could be measured with our data set. Our measurements are based on third-party data that is collected by individuals – usually the owners of the residence. These measurements are usually not taken at a regular interval, and instead are usually taken at the time of selling a house (though not required) or whenever the homeowner chooses to check a measurement. This can be assumed to be a random sampling of the county radon levels. However, while the method of measurement is somewhat standardized, it too can be subject to some variables in how the radon is collected by the measurement apparatus.

## Conclusion

Our data does not demonstrate a statistically significant correlation between historical radon levels and the historical rise in thyroid incidence. While there are some limitations to the data set utilized, statistical methodology to correct for variability in measurements did not help to show a relationship. Despite there being high levels of radon present in various Pennsylvania counties, this did not match with similarly high thyroid incidence. Further research evaluating radon through sources, such as the water supply, may yield more information regarding a possible association with thyroid cancer.

## References

3. Gerusky T. The Pennsylvania Radon Story [Internet]. Pennsylvania Department of Environmental Protection; Available from: http://www.dep.state.pa.us/brp/radon_division/PA_Radon_Story1.htm