

Tuesday, October 27, 2015
2:00 PM

Proximity to coal mining activity and cancer risk in Illinois: A geospatial approach

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Presenter Disclosures

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(1) The following personal financial relationships with commercial interests relevant to this presentation existed during the past 12 months:


No



Funding

The research that we will describe has been funded by the following grantor:


- The Caryl Towsley Moy, PhD, Endowed Fund for Collaborative Research



Objective

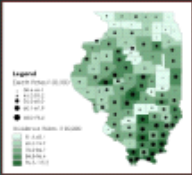
To determine the association between coal mining activity and cancer incidence and mortality.

- A distance-weighted exposure measure
- A coal production measure




Lung Cancer in Illinois

- Incidence rate is higher than the nation as a whole:
 - Illinois: 69.4 per 100,000
 - United States: 63.7 per 100,000
- Mortality rate is slightly higher than the nation as a whole:
 - Illinois: 49.7 per 100,000
 - United States: 47.2 per 100,000

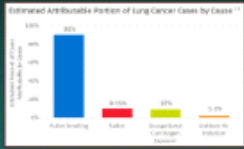


Source: State Cancer Profiles, www.statecancerprofiles.cancer.gov




Causes of Lung Cancer

- Active Smoking
- Radon Exposure
- Occupational Exposure
- Outdoor Air Pollution



Source: American Lung Association Fact Sheet Available at: <http://www.lung.org/press-room/cancer/factsheets/factsheets/lung-cancer-fact-sheet.html>
Alberg AL, Samet JM. Epidemiology of Lung Cancer. *Chest* 2002; 122:221-40.



Coal Mining in Illinois


- Two-thirds of Illinois is underlain with coal-bearing strata
- Illinois has the 3rd largest coal reserve in the country
- Illinois is the 4th largest coal producing state
 - production has increased 54.3% between 2001 and 2013




Data



- County-level data:
 - County-level cancer incidence and mortality rates (1987-2011) for all cancers, lung, colorectal, prostate, and breast (female only)
 - Coal production (1987-2011)
 - Distance-weighted exposure
 - Various covariates: smoking, socioeconomic deprivation, race, rurality
 - Socioeconomic deprivation (Ananthakrishnan et al., 2010)
 - Ranges 0 to 8
 - Includes:
 - Median income
 - % living in poverty
 - % nonwhite
 - % over 25 with HS degree

Source: Ananthakrishnan, AN, Hoffman BC, Sotres E (2010). Higher deprivation density is associated with lower incidence of late stage colorectal cancer. J Gen Intern Med 25(11): 1164-1171.



Coal Production Measure


- Annual coal production data obtained from the Energy Information Administration (1987-2011)
 - Aggregated at the county level
 - Summed over the years
 - Only 27 counties had recent mining
- Created categorical variable



Distance-Weighted Exposure Measure

- ARCGIS to create a single polygon for each of the 1,096 distinct mines in Illinois
- Calculated the distance between the center of each census tract and the center of the nearest mine
- Enables tract level populations to be considered at a county level
 - Modified formula developed by Hendryx et al.

Source: Hendryx M, Finkelstein E, Auerbach R, et al. (2010). A geographical information system based analysis of cancer mortality and population exposure to coal mining activities in West Virginia, United States of America. Computers, Environment & Urban Systems 34(2): 243-256.




Cancer Incidence/mortality and mine feature by County

Statistical Analysis

- Descriptive Statistics
- Spatial Statistics
- Correlations
- Stepwise Linear Regression



Results

	No mining history (n=27)	Mining prior to 1987 (n=48)	Recent mining (n=27)	P
Social Economic Deprivation Score	4.0 (3.8 ± 2.7)	3.0 (3.5 ± 2.6)	5.0 (5.0 ± 2.0)	0.06
Current/Former Smoker	47.0% (46.0% ± 8.5)	46.3% (47.1% ± 6.1)	50.0% (50.0% ± 5.2)	0.08
% African American	10% (6% ± 2)	5% (4% ± 1)	7% (6% ± 4)	0.40
% Rurality	48.8% (45.2% ± 31.0)	58.9% (56.8% ± 29.9)	43.0% (46.9% ± 18.6)	0.17


Results

Spatial Statistics

- Univariate Morans I
 - County level all cancer incidence ($\theta = 0.23, p=0.002$) and mortality ($\theta = 0.22, p=0.006$)
 - Cumulative coal production ($\theta = 0.26, p=0.001$)
- Spatially clustered

Correlations


- Distance exposure was associated with production ($r = 0.58, P<0.0001$), all cancer incidence ($r = 0.27, P<0.01$) and mortality ($r = 0.38, P<0.0001$)
- Production exposure was not associated with all cancer incidence or mortality



Results

Cancer Incidence


Cancer Type	Production Exposure		Distance Exposure		Adjusted R ²
	Standardized β	p	Standardized β	p	
All	0.063	0.55	0.227	0.06	0.16
Breast	-0.083	0.43	0.070	0.52	0.30
Prostate	0.086	0.23	0.043	0.72	0.13
Colorectal	0.168	0.03	0.075	0.52	0.15
Lung	0.083	0.48	0.308	0.004	0.36



Results


Cancer Mortality

Cancer Type	Production Exposure		Distance Exposure		Adjusted R ²
	Standardized β	p	Standardized β	p	
All	0.106	0.19	0.391	<0.0001	0.46
Breast	-0.040	0.62	0.057	0.64	0.12
Prostate	-0.282	0.02	0.123	0.28	0.21
Colorectal	0.133	0.10	0.046	0.69	0.21
Lung	0.014	0.41	0.338	0.0004	0.49




Conclusion

- Cancer incidence and mortality are both positively correlated with the distance weighted exposure measure
- Cancer Incidence:
 - Production exposure was associated with colorectal cancer
 - Distance exposure was associated with lung cancer
- Cancer Mortality:
 - Production exposure was negatively associated with prostate cancer
 - Distance exposure was associated with all cancer and lung cancer



Limitations

- Categorical coal production variable
- County level analysis
- Lack of distinction between mining features and types
- Temporal relationship between exposure/covariates and cancer incidence/mortality
- Ecological design



Future Research

- Environmental exposure to coal mining may play a role in increased cancer risk, but further research needs to be performed



Questions???

Thank you for your attention.

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Source: Mueller GS, Clayton AL, Zahnd WE, Hollenbeck KM, Barrow ME, Jenkins WD, Hane J. DE. Geospatial Analysis of Cancer Risk and Residential Proximity to Coal Mines in Illinois. *Statistical Ecology*. 2015; 35 (7):4000-4013.

