Environmental and Public Health Effects of Surface Coal Mining in Appalachia

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[1] This presentation represents joint work with coauthors: Trudy Ann Cameron and Gulcan Gil

Introduction

My research focuses broadly on various effects of pollution exposure including:

- information on exposure to pollution
- regulatory changes in the monitoring of pollution
- pollution exposure on human health

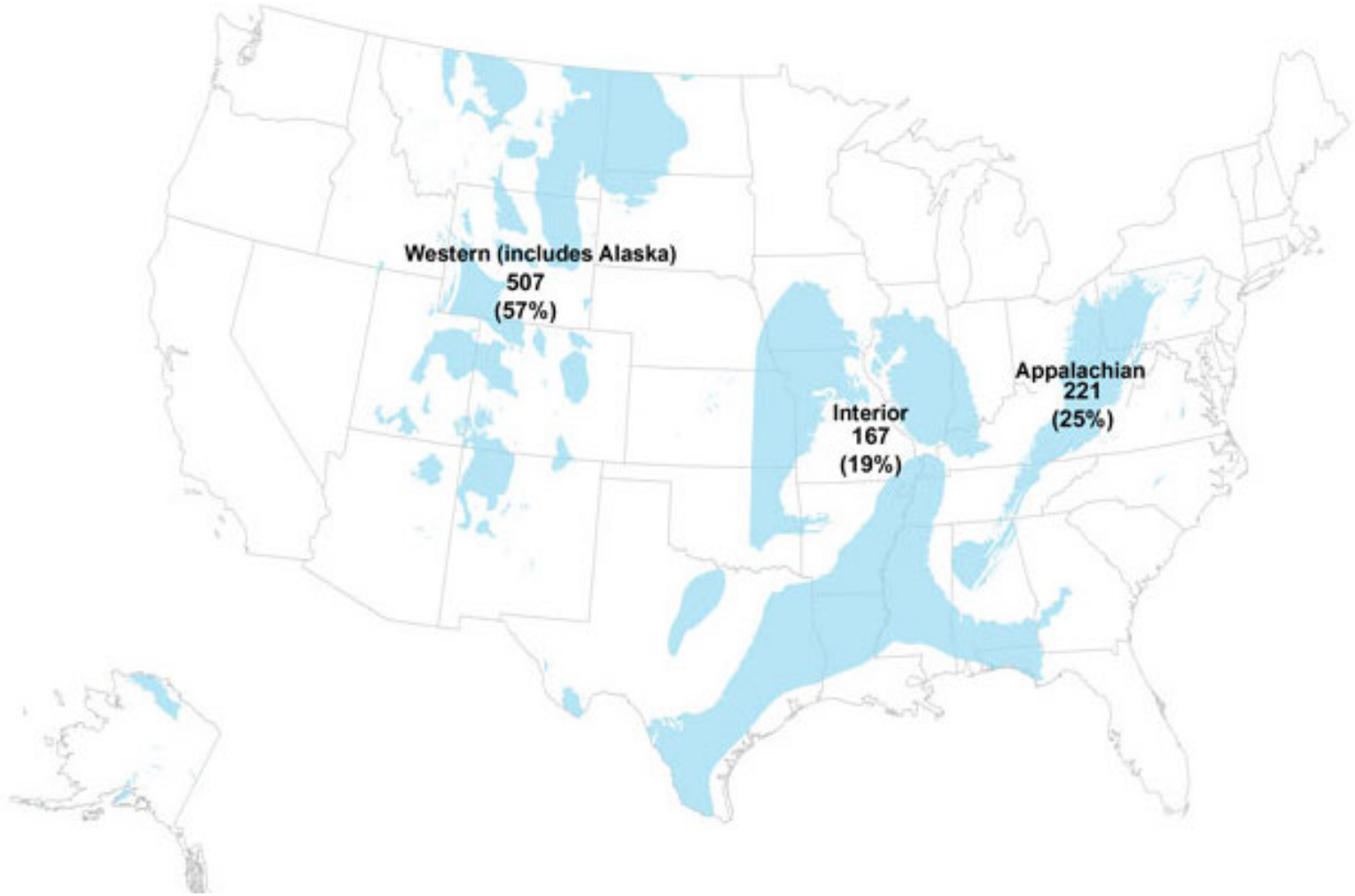
Introduction

- Does coal mining activity affect population pollution exposure and human health?
- Does the effect vary with mining technology?
- Has the effect changed over time with changes to environmental regulation?

Overview

- Run a difference-in-differences model of county-level mortality rates as a function of changes in coal mining activity, using a 30-year panel dataset from 1983 to 2013
- Use satellite observations of ambient particulate matter to test whether exposure to air pollution could be a potential mechanism

Where are the mines?



Surface Coal Mining

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Relevant Literature

- Coal mining and human health
  - Barnett et al. (2000); Lengerich et al. (2005); Hendryx, O'Donnell, and Horn (2008); Hendryx (2008, 2009); Ahern (2011); Aneja (2012); Kurth (2014)
- Environmental pollution and human health
  - Chay and Greenstone (2003); Dockery (2001); Pope and Dockery (2006); Cakmak (2007); Brook et al. (2010)
- Environmental regulation and pollution
  - Greenstone (2003); Bi (2017);

Data

- Coal mine locations and production
  - Mine Safety and Health Administration (MSHA)
- County mortality data
  - Center for Disease Control and Prevention (CDC)
- PM2.5 concentrations
  - Remotely-sensed satellite observations
  - EPA ground monitors
- Additional controls:
  - Surveillance, Epidemiology, and End Results Program (SEER)
  - Bureau of Economic Analysis (BEA)
  - Energy Information Administration (EIA)

Empirical Framework

- Regression: county-level mortality rates as a function of within-county variation in surface coal-mining activity

$$y_{it} = \beta_1 New\ Mining_{it} + \beta_2 Production_{it} + \gamma X_{it} + \alpha_i + \alpha_t + \epsilon_{it}$$

Empirical Framework

- Regression: county-level mortality rates as a function of within-county variation in surface coal-mining activity

$$y_{it} = \beta_1 New\ Mining_{it} + \beta_2 Production_{it} + \gamma X_{it} + \alpha_i + \alpha_t + \epsilon_{it}$$

- Identifying assumptions:
  - No locational sorting across counties that is systematically related to *both* coal mining activity and health
  - No other events simultaneously occurring with coal mining activity that affect health

Mortality Results

Elderly Mortality Rate (Age > 65)

	Other Coal States	Appalachia	MTR States
Mean	4,780.51	4,915.21	4,903.45
Std. Dev.	870.85	727.70	805.35

	Dependent variable:		
	Elderly Mortality per 100,000 Population		
	(1)	(2)	(3)
New Surface Mining	-16.95	152.51**	280.21**
	(47.50)	(75.83)	(122.24)
Surface Production	-0.01	1.95*	2.27**
(ongoing)	(0.08)	(1.06)	(1.10)
r2	0.14	0.17	0.17
N	27330	9378	5536

*p<0.1; **p<0.05; ***p<0.01

Note: Selected coefficients. All specifications include year and county fixed effects. Standard errors are clustered by county. Surface Production is measured in 100,000 short tons of coal.

PM2.5 Results

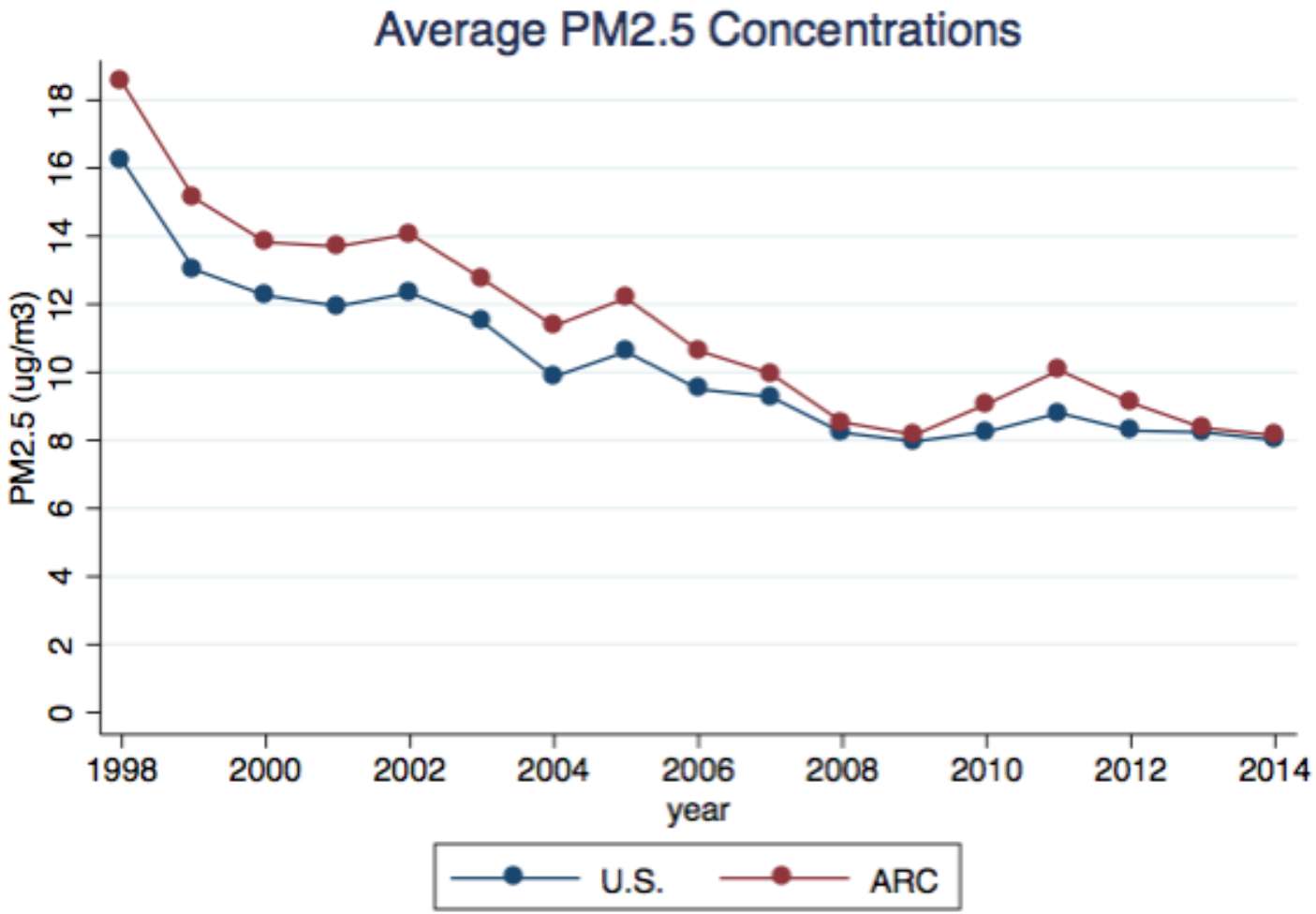
Annual Average PM 2.5 Concentrations (ug/m3)

	Appalachia	**MTR States**
Mean	11.53	11.16
Std dev.	3.07	3.01
	Dependent variable:	
	Area Weighted PM2.5 Concentration	
	(1)	(2)
New Surface Mining	0.25**	0.17
	(0.10)	(0.13)
Surface Production	0.0002	-0.0024
(ongoing)	(0.0013)	(0.0012)
r2	0.95	0.95
N	4240	2848

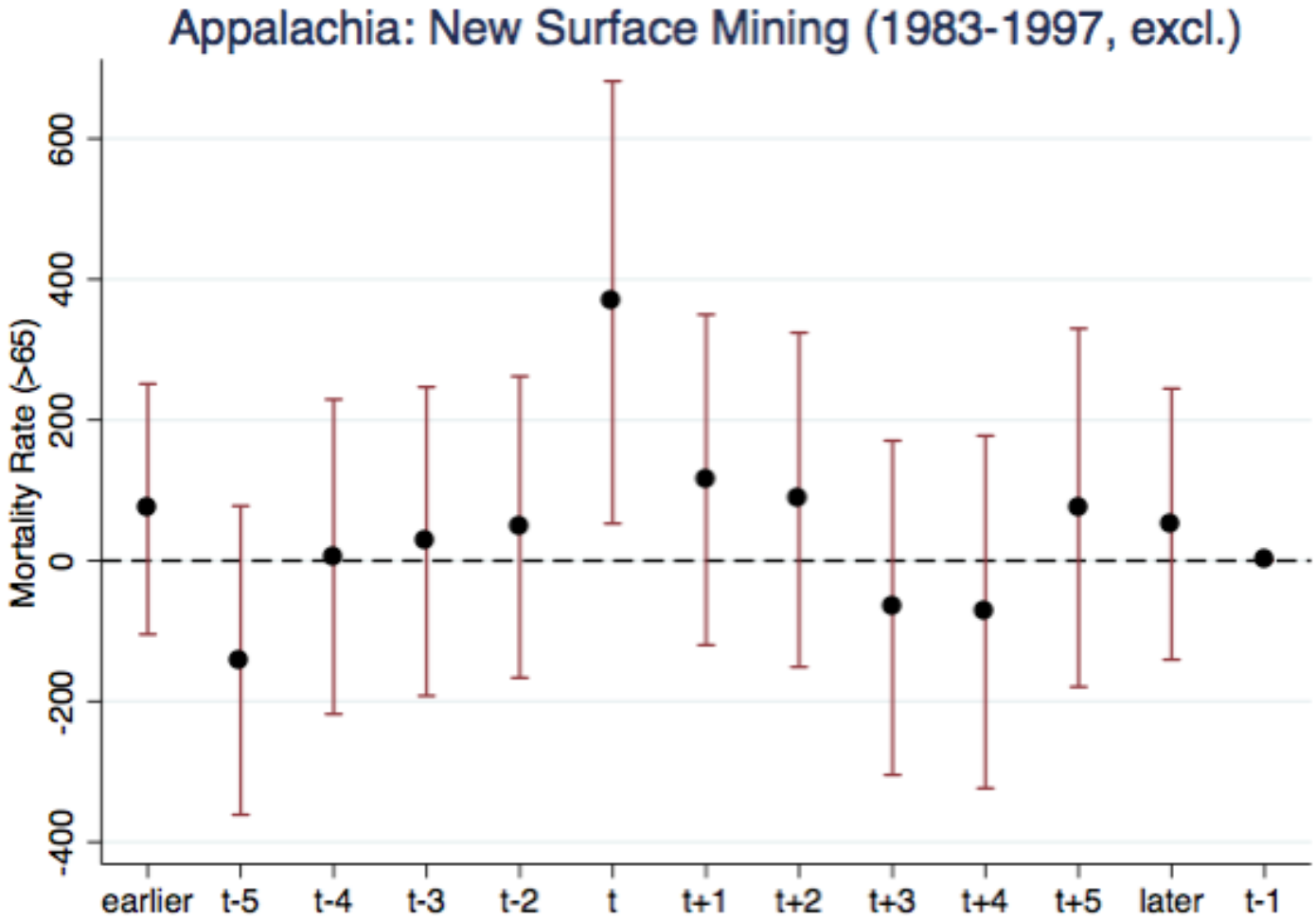
*p<0.1; **p<0.05; ***p<0.01

Note: Selected coefficients. All specifications include year and county fixed effects. Standard errors are clustered by county.

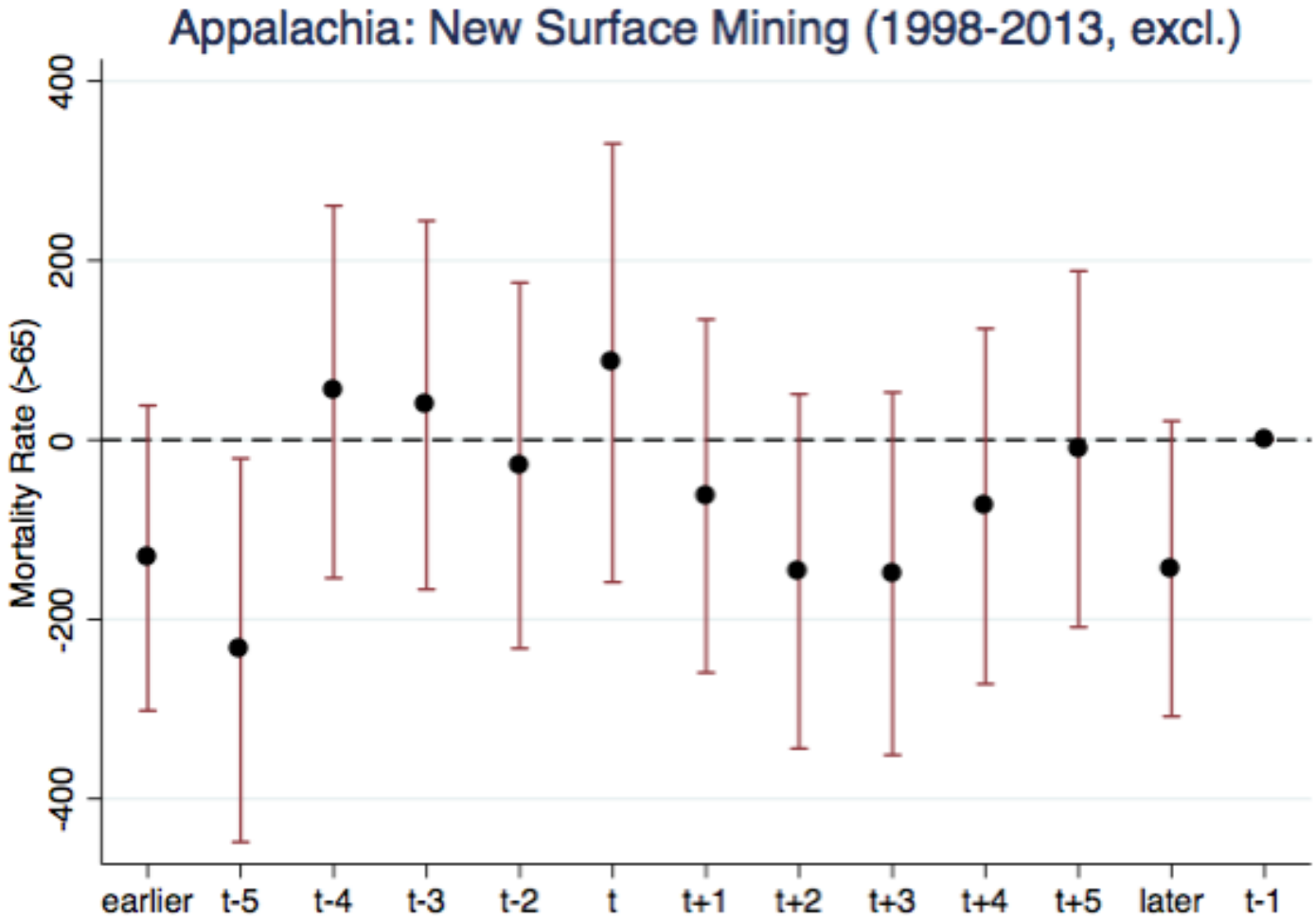
PM2.5 (Satellite)



Event Study


Appalachia: New Surface Mining (1983-1997, excl.)
Mortality Rate (>65)
600
400
200
0
-200
-400
earlier
t-5
t-4
t-3
t-2
t
t+1
t+2
t+3
t+4
t+5
later
t-1

Event Study


Appalachia: New Surface Mining (1998-2013, excl.)
Mortality Rate (>65)
400
200
0
-200
-400
earlier
t-5
t-4
t-3
t-2
t
t+1
t+2
t+3
t+4
t+5
later
t-1

Mortality Results

Elderly Mortality Rate (Age > 65)

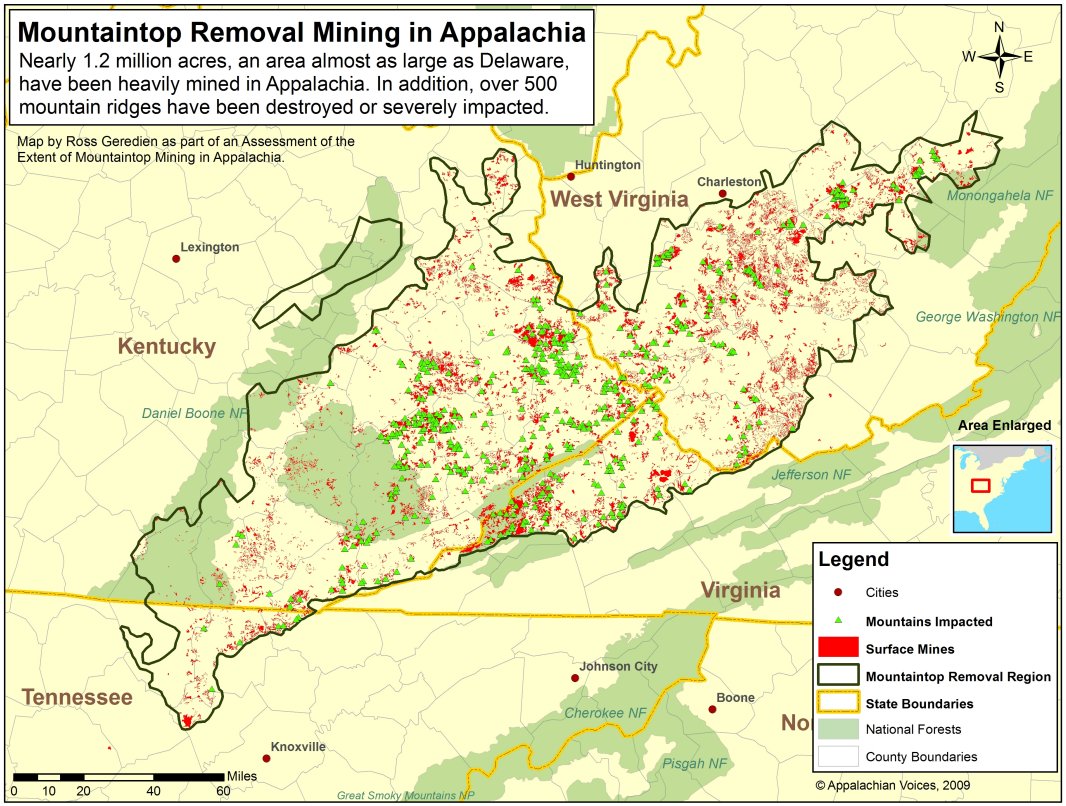
	Appalachia		MTR States	
New Surface Mining	152.51**	333.24*	280.21**	581.38**
	(75.83)	(170.63)	(122.24)	(253.82)
New Surface Mining * Post 1990		-252.26		-423.8
		(187.77)		(285.90)
Surface Production (ongoing)	1.95*	1.95*	2.27**	2.24**
	(1.06)	(1.06)	(1.10)	(1.10)
r2	0.17	0.17	0.17	0.17
N	9378	9378	5536	5536

*p<0.1; **p<0.05; ***p<0.01

Note: Selected coefficients. All specifications include year and county fixed effects. Standard errors are clustered by county. Surface Production is measured in 100,000 short tons of coal.

Directions for Future Research

- Test for health effects from traditional surface mining vs mountain top removal mining using Skytruth data



Directions for Future Research

- Incorporate natality data from the National Center for Health Statistics for analysis of coal mining on infant health
- Individual analysis of infant health using linked birth and death records
  - Allow for heterogeneity across demographic groups
  - Include additional time-varying controls
- Short vs long term health effects
- Incorporate analysis of water quality near coal mines (Storet)

Thank you!

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Summary Statistics - Appalachia

	Mean	Std. Dev.	Min	Max
Demographics				
Population	55,744	99,379	2,114	1,420,640
Personal Income per Capita ($000)	19.80	7.97	5.07	96.02
Coal Activity				
Active Coal Mining	0.46			
Active Surface Coal Mining	0.42			
Surface Production >1m short tons	0.12			
Mortality (Rates per 100,000 population)				
Total Age-Adjusted Internal Mortality	863	127	264	1,549
Cancer	141	31	19	382
Cardiovascular Disease	379	94	86	916
Respiratory Disease	78	28	0	282
Kidney Disease	15	10	0	153
Internal Mortality by Age				
Infant Mortality (<1 year)	706	599	0	9,677
Child Mortality (1-14 years)	12	17	0	263
Adult Mortality (15-64)	310	84	57	796
Elderly Mortality (>65 years)	4,918	729	1,357	8,451
PM2.5 Concentrations (ug/m3)				
Area Weighted Annual Average	11.53	3.07	5.99	23.81

Mortality Results

Elderly Mortality by Cause of Death

(a) Appalachian Coal Region

	All Internal	**Cardiovascular**	**Respiratory**	**Cancer**	**Kidney**
	Dependent variable:				
	Elderly Mortality by COD per 100,000 Population				
	(1)	(2)	(3)	(4)	(5)
New Surface Mining	152.51**	55.96	24.72	22.52	11.79
	(75.83)	(45.97)	(19.86)	(26.48)	(8.60)
Surface Production	1.95*	0.59	-0.20	0.28	0.05
(ongoing)	(1.06)	(0.59)	(0.22)	(0.27)	(0.12)
r2	0.17	0.62	0.11	0.10	0.16
N	9378	9378	9378	9378	9378

Note: Selected coefficients. All specifications include year and county fixed effects. Standard errors are clustered by county.

Mortality Results

Elderly Mortality by Cause of Death

(b) MTR States

	Total Mortality	**Cardiovascular**	**Respiratory**	**Cancer**	**Kidney**
	Dependent variable:				
	Elderly Mortality by COD per 100,000 Population				
	(1)	(2)	(3)	(4)	(5)
New Surface Mining	280.21**	95.95	51.27	28.89	18.79
	(122.24)	(65.78)	(32.20)	(43.53)	(12.64)
Surface Production (ongoing)	2.27**	0.66	-0.38	0.07	0.13
	(1.10)	(0.57)	(0.24)	(0.26)	(0.14)
r2	0.17	0.57	0.09	0.12	0.12
N	5536	5536	5536	5536	5536

Note: Selected coefficients. All specifications include year and county fixed effects. Standard errors are clustered by county.