

The Association between Mountaintop Mining and Congenital Anomalies in Appalachia



Michael Hendryx, PhD

Dec 1, 2011

Mountaintop Mining



- Removes the entire tops of mountains and ridges
- Explosives and draglines reach coal seams hundreds of feet deep
- Spoil is deposited into adjacent valleys
- Has permanently buried over 1,200 miles of streams
- Will impact >1.4 million acres
- Occurs in areas of southern WV, eastern KY, eastern TN, and western VA

Disparities in Mining Areas

	Appalachian Coal Mining	Other Appalachian	Rest of Nation
% college education*	11.7	13.8	17.1
Median household income *	\$28,054	\$32,596	\$36,753
Unemployment rate*	7.4	6.2	5.2
Poverty rate*	19.6	15.6	13.1

* Group differences significant at $p < .0001$

Area Resource File 2006 adjusted for age, race/ethnicity and sex

Median Household Income by County Coal Production

> 4 mil tons



\$28,163

Up to 4 mil tons



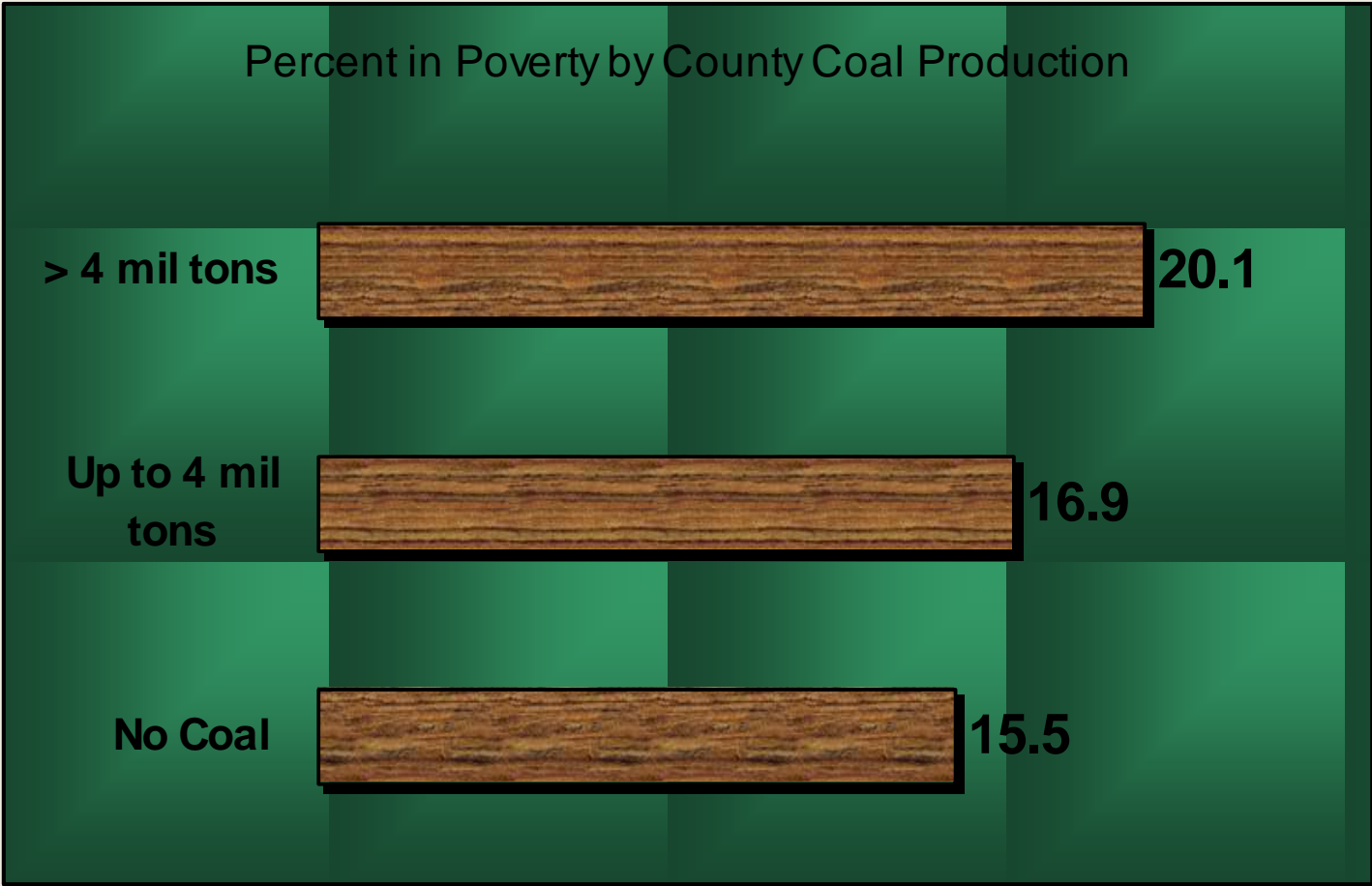
\$29,883

No Coal

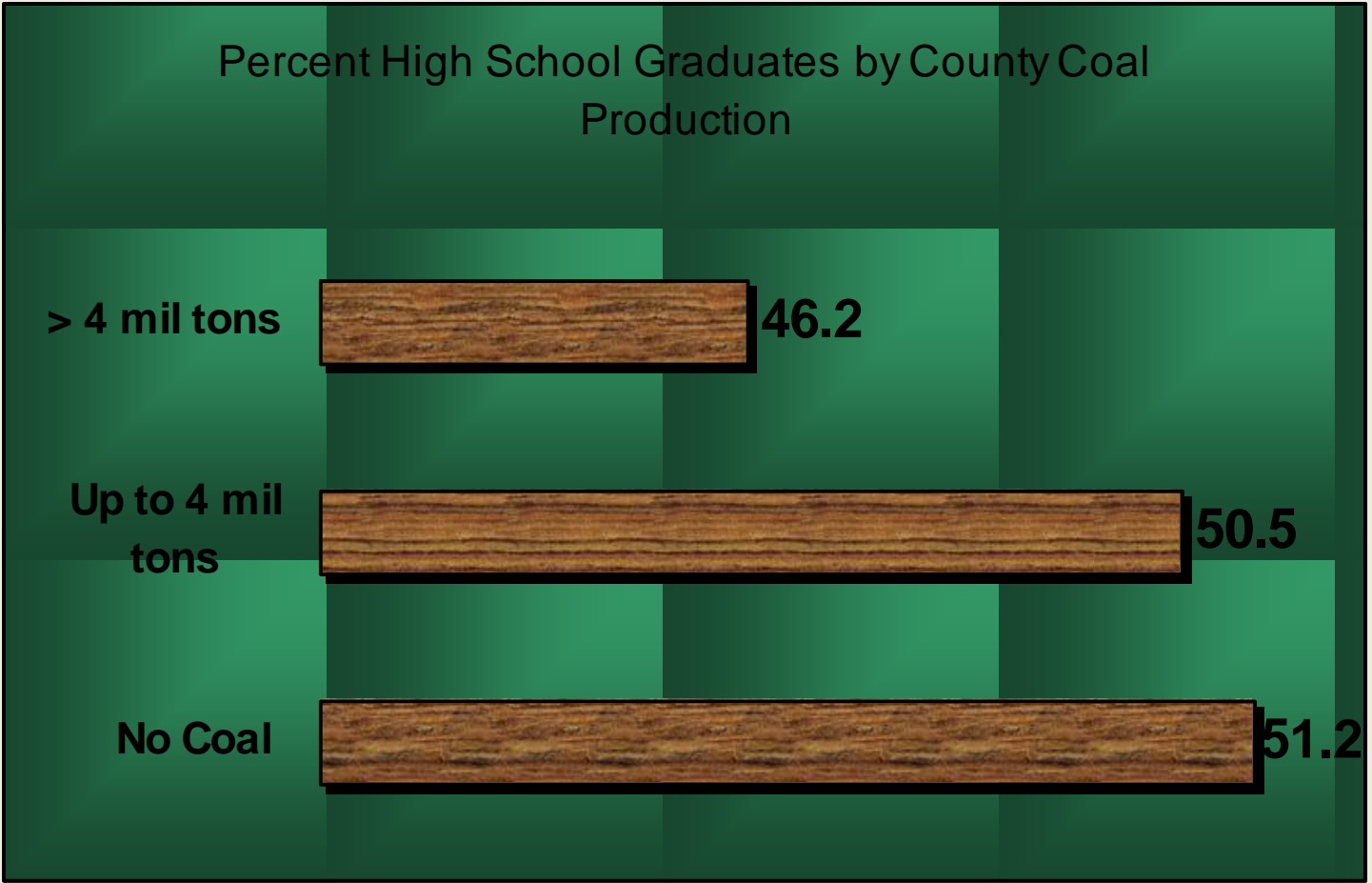


\$32,260

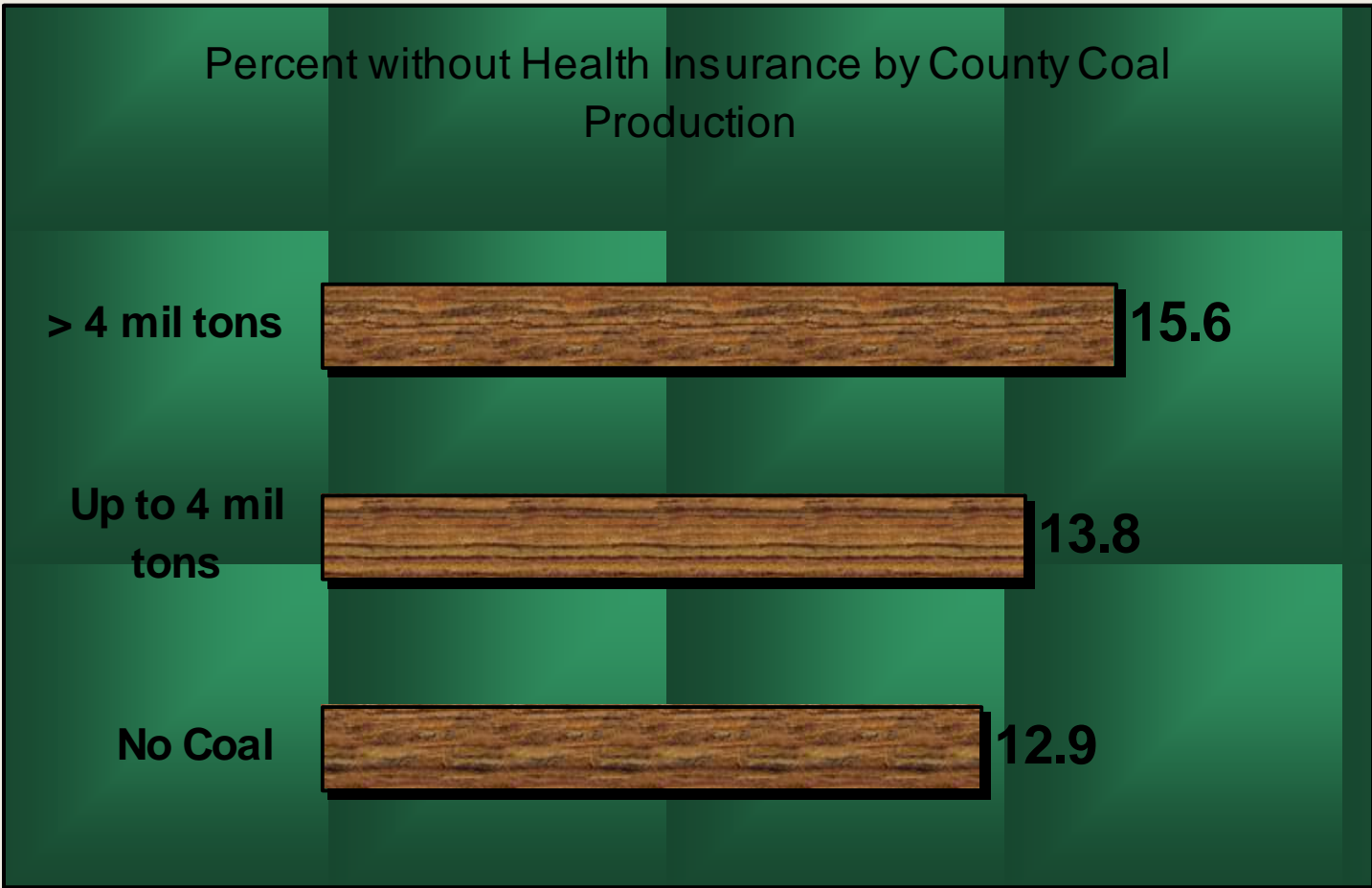
Sources: Area Resource File and WV Geological and Economic Survey



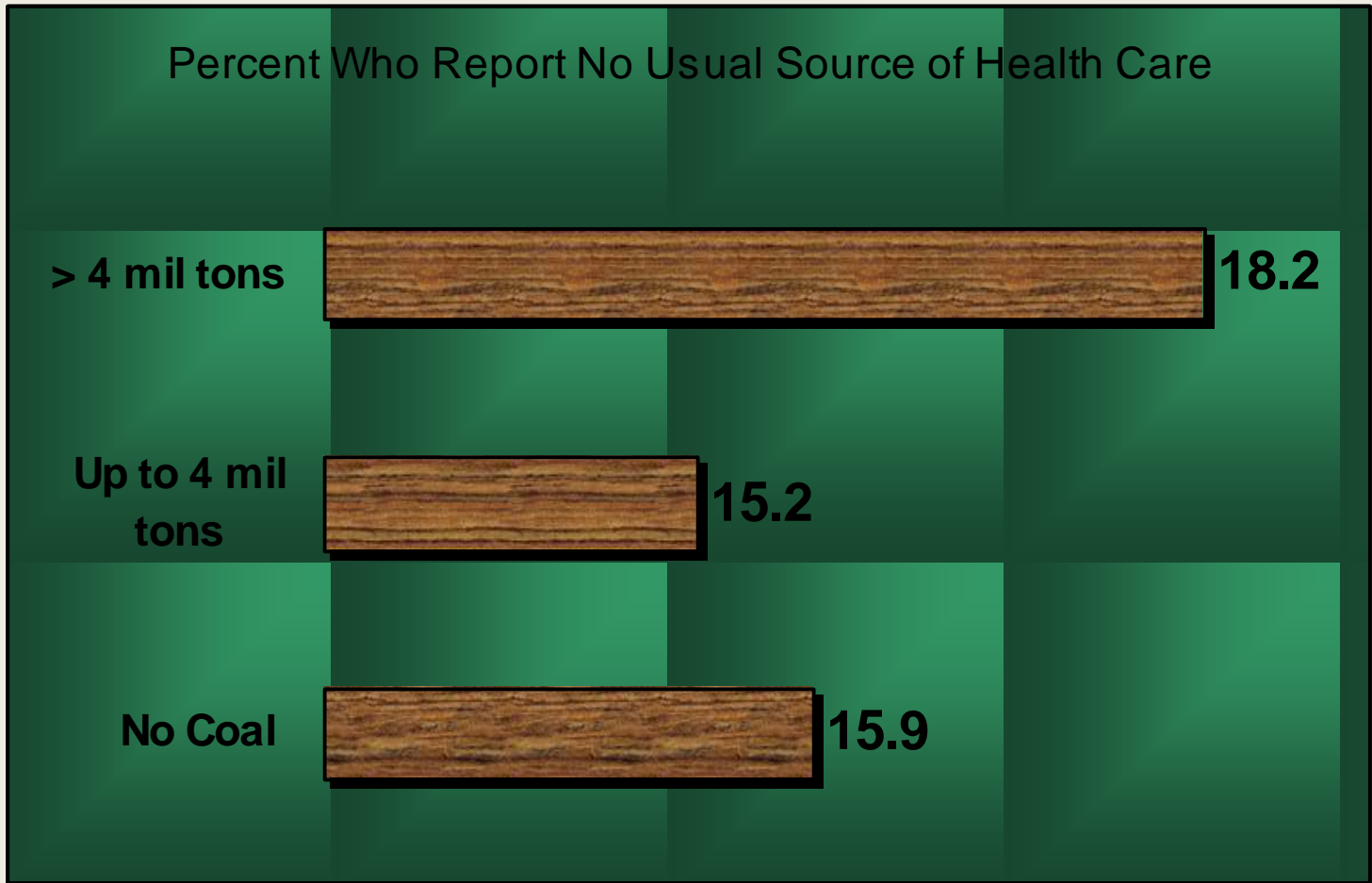
Sources: Area Resource File and WV Geological and Economic Survey



Sources: Area Resource File and WV Geological and Economic Survey

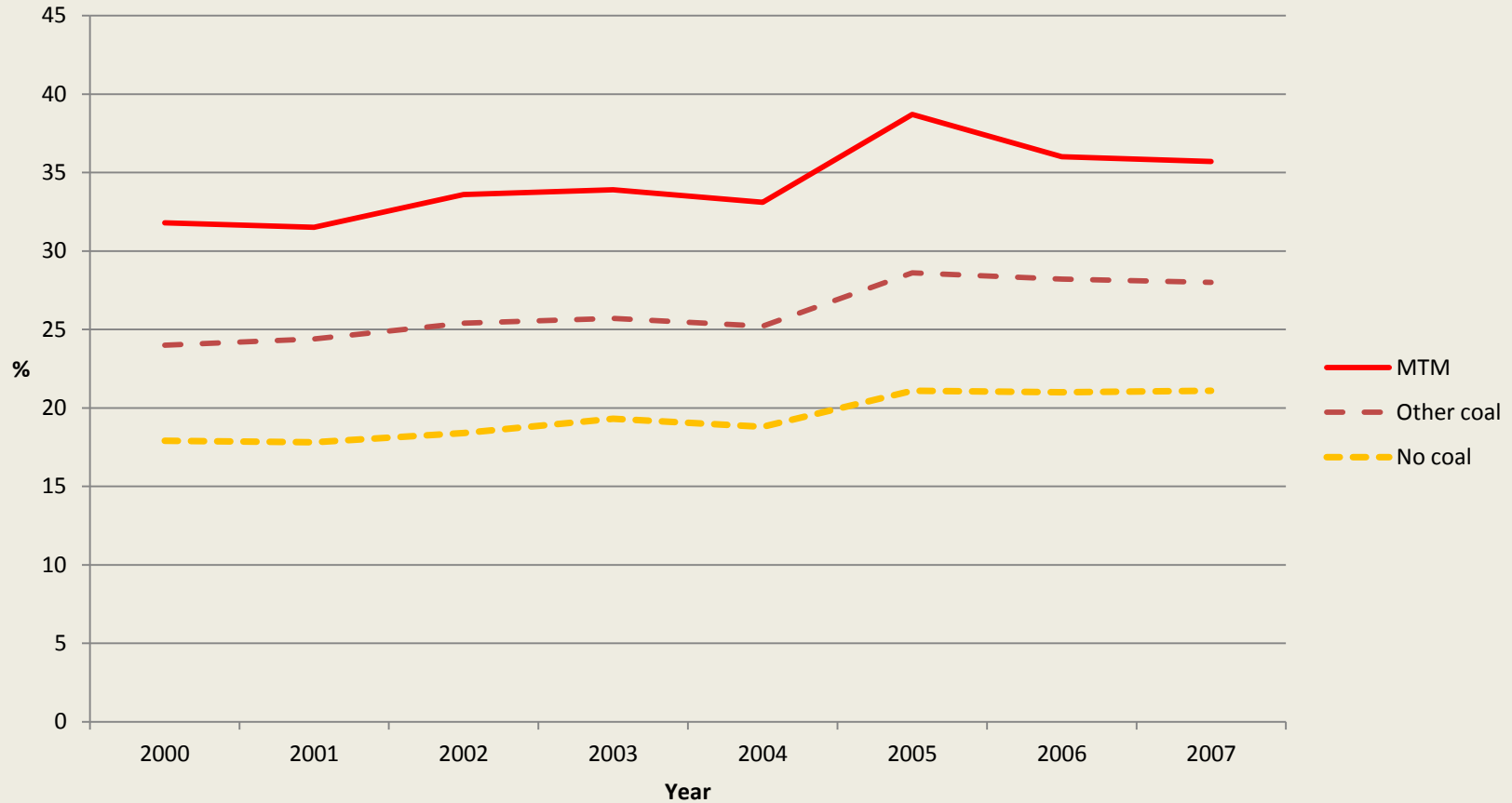


Sources: Area Resource File and WV Geological and Economic Survey



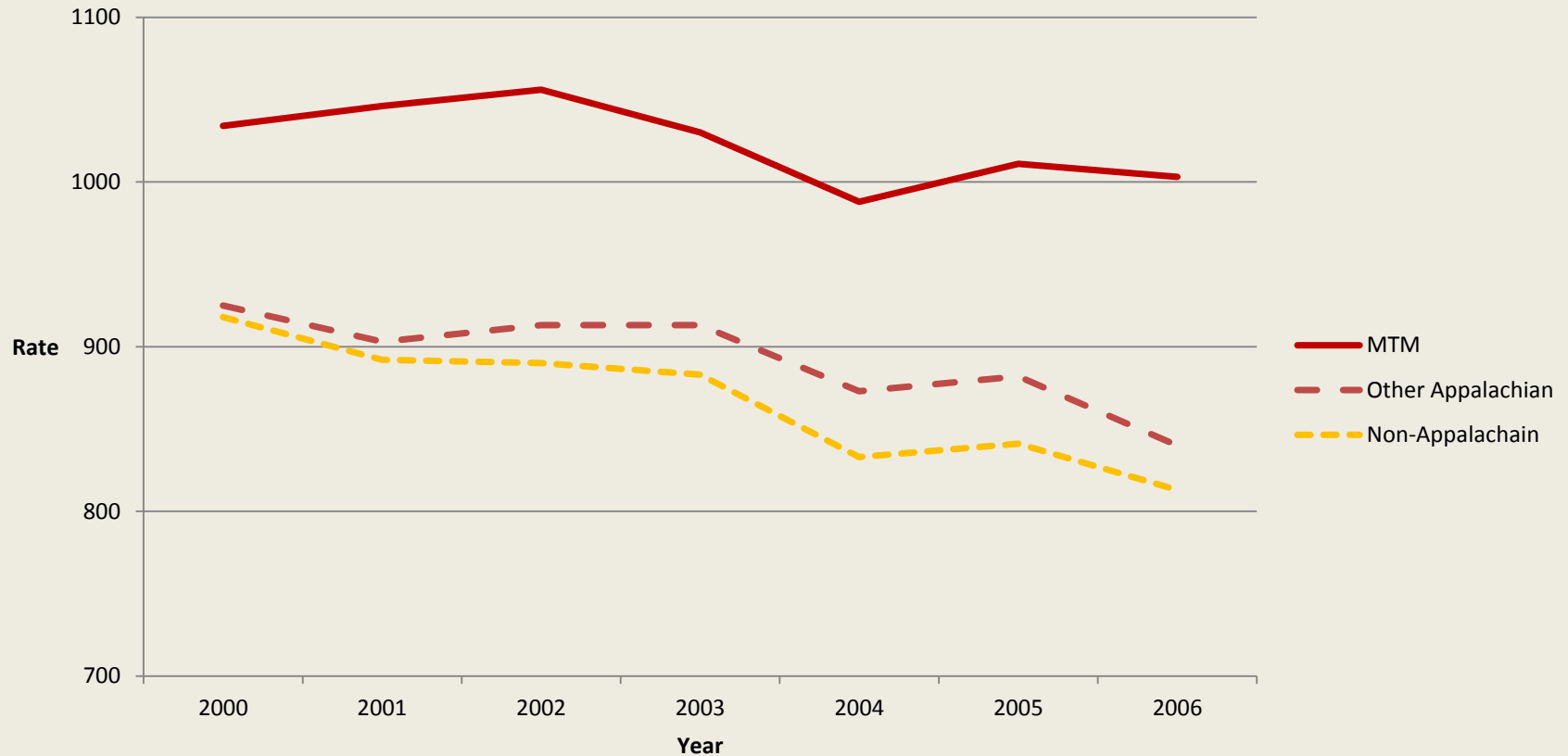
Sources: West Virginia IHP Survey and WV Geological and Economic Survey

Poverty Rates for Children 0-17 by Mining Activity 2000-2007 for KY, TN, VA, & WV



Source: Area Resource File 2008 and EIA

Age-adjusted mortality per 100,000 by MTM status



Evidence for Health Disparities

- Higher mortality rates for all causes, and for cancer, heart disease, lung disease, kidney disease
- Higher rates of self-reported illness for same types of problems: cancer, heart and lung disease, kidney disease
- Lower health-related quality of life
- Control for risk factors as available: age, poverty, education, smoking, obesity, race, doctor supply

Evidence for Health Disparities (continued)

- Become stronger as mining levels increase
- Present for women, men, and children
- Present across multiple data sources and health outcomes
- Become stronger in closer proximity to mining activity
- Concentrated in MTM areas
- Ecologic designs; lack of direct exposure assessment

Low Birth Weight

- Low birth rate are 16% higher in heavy mining areas; 14% higher in moderate areas of WV
 - Control for mother's age, smoking, drinking, education, prenatal care, marital status, medical risks
 - Ahern, Mullett, MacKay, Hamilton, Maternal & Child Health Journal 2010
- Higher LBW risk, as well as SGA and preterm births, concentrated in MTM areas
 - Zullig & Hendryx, in prep

Academic Performance

- Students in mining counties of WV are significantly more likely to fail standardized tests
 - Grades 3-8,10
 - Controlling for low income, county high school education rate, class size, teacher quality, school size
 - Approximately 1,600 excess fails per year.
 - Cain & Hendryx, Environmental Justice, 2010

Birth Defects in MTM Areas

- Analyzed all live births 1996-2003 in KY, TN, VA, and WV
 - Data from National Center for Health Statistics natality files
 - Data use agreement to access county of residence
 - Live singleton births, N=1,889,071
- Ahern, Hendryx, Conley, Fedorko, Ducatman, Zulig, Environmental Research 2011, 111, 838-846

Birth Defects in MTM Areas

- 22 types of defects recorded, grouped into 8 categories:
 - Circulatory/respiratory
 - CNS
 - Gastrointestinal
 - Urogenital
 - Musculoskeletal
 - Chromosomal
 - Other
 - Any

Birth Defects in MTM Areas

- Counties divided into those with MTM (N=37), other mining (N=49), or no mining (N=318)
 - Number of births:
 - 109,315 MTM
 - 112,771 other mining
 - 1,666,985 non-mining

Birth Defects in MTM Areas

- Conducted Poisson regression models to estimate the “prevalence rate ratio” or PRR of birth defects in MTM and other mining areas vs. no-mining reference
 - Controlled for mom’s age, smoking, drinking, race/ethnicity, infant sex, prenatal care, diabetes co-morbidity, and rural/urban setting
 - Examined effects for whole time and for earlier (1996-1999) vs. later (2000-2003) years
- Conducted spatial models to examine ‘spillover effects’
- Examined overall defects and by organ system

Birth Defects in MTM Areas: Results

- Unadjusted prevalence of any defect:
 - MTM: 235 per 10,000 live births
 - Other mining: 183 per 10,000
 - No mining: 144 per 10,000
- Overall PRRs:

	MTM	Other Mining
Age-adjusted only	1.63 (1.54, 1.72)	1.27 (1.20, 1.35)
Adjusted	1.26 (1.21, 1.32)	1.10 (1.05, 1.16)

Birth Defects in MTM Areas: Results

- Adjusted PRRs by organ system:

	MTM	Other Mining
Circulatory/respiratory*	1.93 (1.73, 2.15)	1.08 (0.94, 1.24)
CNS*	1.36 (1.11, 1.67)	1.18 (0.95, 1.46)
Gastrointestinal*	1.41 (1.17, 1.71)	1.02 (0.82, 1.28)
Urogenital**	1.35 (1.19, 1.54)	1.32 (1.15, 1.51)
Musculoskeletal*	1.30 (1.20, 1.41)	1.08 (0.99, 1.18)
Chromosomal	0.92 (0.72, 1.18)	0.85 (0.66, 1.09)
Other**	1.13 (1.04, 1.23)	1.12 (1.03, 1.22)

* Higher only in MTM group; ** higher in both groups

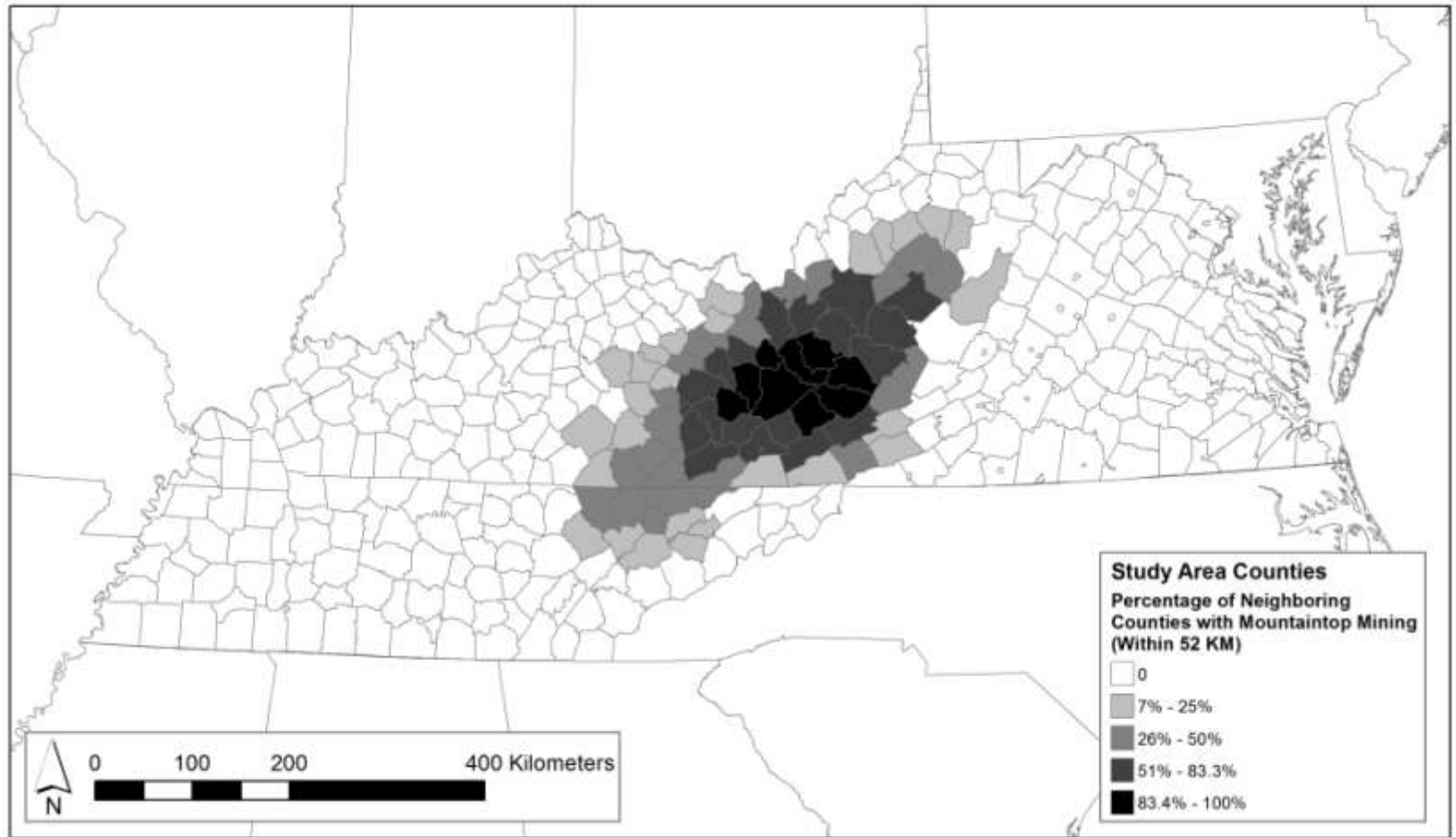
Birth Defects in MTM Areas: Results

- Adjusted MTM PRRs by early versus late period:

	1996-1999	2000-2003
Circulatory/respiratory*	1.20 (1.03, 1.41)	2.81 (2.43, 3.25)
CNS	1.42 (1.06, 1.91)	1.30 (0.95, 1.76)
Gastrointestinal*	1.30 (0.94, 1.80)	1.53 (1.18, 1.96)
Urogenital*	1.16 (0.94, 1.42)	1.62 (1.38, 1.93)
Musculoskeletal	1.31 (1.17, 1.46)	1.30 (1.15, 1.46)
Chromosomal	1.21 (0.89, 1.64)	0.68 (0.46, 1.03)
Other*	0.99 (0.88, 1.12)	1.29 (1.15, 1.45)
Any*	1.13 (1.06, 1.21)	1.42 (1.33, 1.52)

* Higher in later period

Birth Defects in MTM Areas: Spatial Analysis



Birth Defects in MTM Areas: Spatial Results

- Adjusted MTM PRRs by original versus spatial measure (2000-2003)

	Original	Spatial*
Circulatory/respiratory	2.81 (2.43, 3.25)	3.30 (2.69, 4.06)
CNS	1.30 (0.95, 1.76)	1.35 (0.88, 2.05)
Gastrointestinal	1.53 (1.18, 1.96)	1.48 (1.01, 2.20)
Urogenital	1.62 (1.38, 1.93)	1.77 (1.39, 2.21)
Musculoskeletal	1.30 (1.15, 1.46)	1.31 (1.11, 1.54)
Chromosomal	0.68 (0.46, 1.03)	0.57 (0.33, 1.01)
Other	1.29 (1.15, 1.45)	1.36 (1.18, 1.57)
Any	1.42 (1.33, 1.52)	1.47 (1.35, 1.61)

*Moran's I = .17, p<.001

Results: Summary

- Birth defects are significantly higher in MTM areas versus either other mining areas or no mining, controlling for other risks
- Effects are present across many organ systems
- Effects for some systems are stronger in more recent times
- Some suggestion of spatial effects
- Clearest results (significant overall, stronger in recent times, and possible spatial effects) for:
 - Circulatory respiratory, urogenital, other, and any

Results (continued)

- No difference in supply of OB/GYNs or primary care docs between groups
- Smoking increased risk by about 18% (MTM circ/resp in 2000-2003 higher by 181%; overall was 26% higher in MTM)
- Results are partially attributable to other behavioral or demographic risks, but a MTM effect remains
- No direct environmental assessments

Criticisms

- Didn't control for all risks, including SES
 - Controlled for education, prenatal care, behaviors
- No environmental exposure data
- Should include only singletons (we did)
- Why 1996-2003?
- Basis of MTM designations
- Imperfections in natality files (e.g., smoking)
- Basis of missing data (1,991,230 vs. 1,889,071)
- General increase over time
- Why effects for so many systems?
- Inbreeding

Birth Defects and Environmental Exposures

- Other research has suggested links between birth defects, and in particular heart defects, and
 - Particulate matter (PM) leading to oxidative stress
 - PAHs such as in diesel fuels
 - Trace elements such as lead or mercury
 - Radon falling as radioactive lead or plutonium

Environmental Impacts of MTM

- We know from other research that MTM:
 - Results in impaired surface and ground water
 - Generates local air pollution from explosives, extraction, transportation and processing
 - Contaminates water used in processing



MTM and Control Air Samples, Nov- Dec. 2010



Well water in the town of Rawl, West Virginia



Photo: Antrim Casky, 2008



Photo: Nat Geographic, 2006

Public Water Uncertainties

- From 2001 through 2009, there were 17,362 water quality violations reported to the EPA from West Virginia:
 - *86 per facility in MTM areas*
 - *15 per facility in rest of the state*
 - Most violations were failures to sample for organics as required
 - Possible health violations ~5 times higher
 - Hendryx, Fulk and McGinley, in prep

What We Don't Know Yet: The Links Between...

- Air and water quality (ambient monitoring data) to..
- Contact and exposure (micro environment data) to..
- Entry into the body (biomarkers of exposure and dose) to..
- Altered structure and function (inflammatory response) to..
- Adverse outcomes (defects)

Working Hypotheses

- Multiple routes
- Multiple agents
- Synergistic effects
 - Among agents
 - Between agents and other risks

The Precautionary Principle

- We know that MTM environments are not healthy environments, regardless of specific causes
- Lack of knowledge regarding exact causal relationships should not preclude action
- MTM areas are where health problems are most severe, regardless of cause, and should be the focus of interventions