

# Children's Health and Unconventional Natural Gas Development

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# Outline

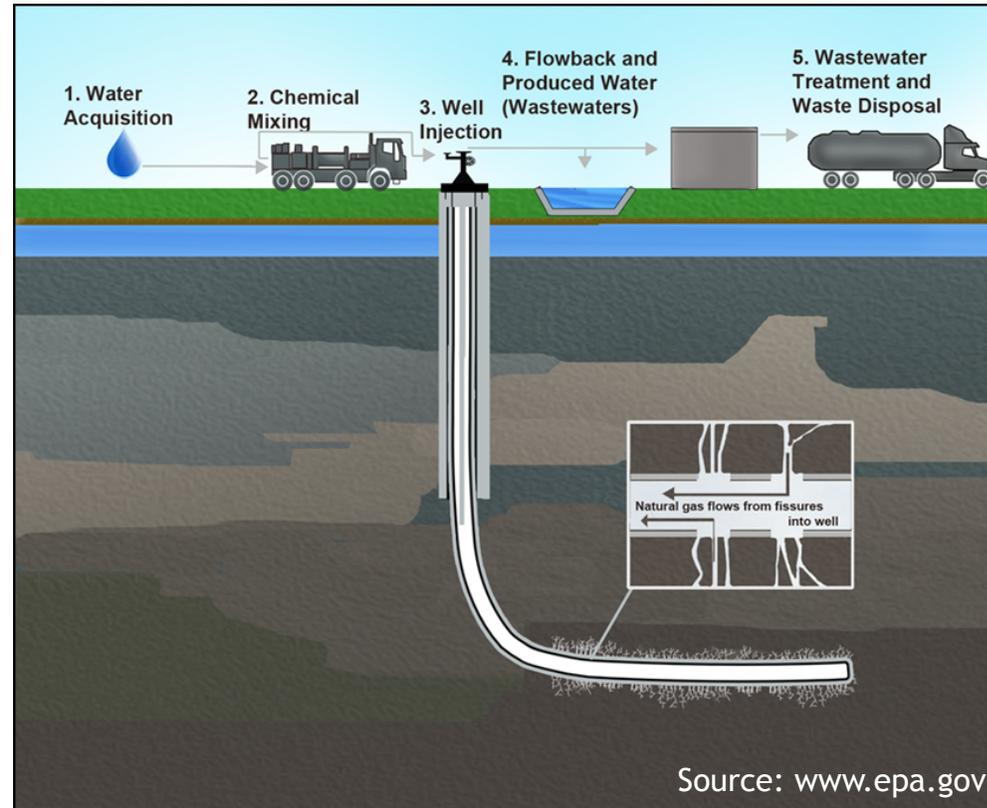
- ▶ Background
  - ▶ Unconventional natural gas development (UNGD)
  - ▶ Air and water pollutants
  - ▶ Health effects
- ▶ UNGD and Children's Health
  - ▶ Proximity metrics
  - ▶ Adverse birth outcomes
  - ▶ Childhood cancer
- ▶ Recommendations for Future Work



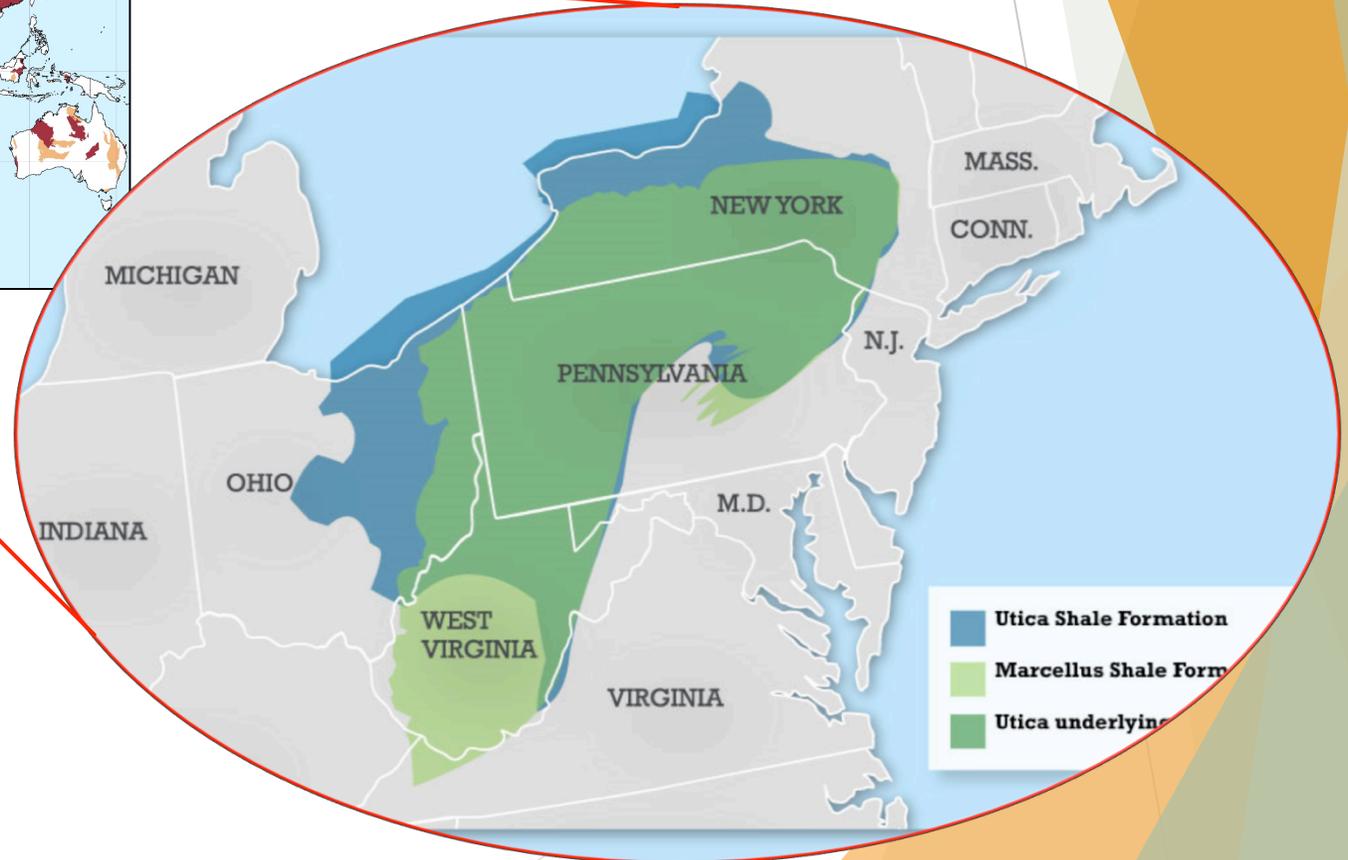
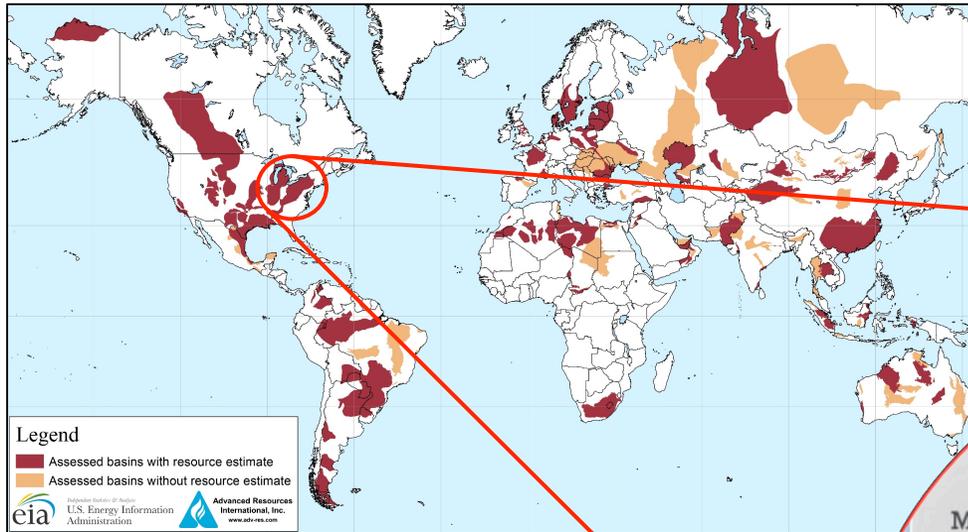
# Background

# Processes Involved in Unconventional Oil & Gas Development

- ▶ Horizontal drilling
- ▶ Hydraulic fracturing (fracking)
  - ▶ Involves pumping large amounts of water, mixed with sand and other chemicals, under high pressure to fracture shale around the well



# Shale Plays at Home and Around the World



# Examples of Pollutants

## ▶ Water pollutants

- ▶ Flowback water storage, treatment, and disposal perhaps “riskiest”
- ▶ Brings back with it hydrocarbon products, chemical additives required to fracture shale, naturally-occurring contaminants from shale itself
- ▶ Metals (Ba, Mg, Sr), salts, radioactive isotopes
- ▶ Endocrine disruptors

## ▶ Air pollutants

- ▶ From diesel-powered drill rigs, hydraulic fracturing pumps, trucks transporting materials to and from drilling sites, completion venting
- ▶ NO<sub>x</sub>, particulate matter (PM<sub>2.5</sub>), VOCs

# Human Health Impacts



Noise, odors, and stress  
Birth outcomes (birth weight,  
preterm birth, birth defects)  
Nasal and sinus symptoms  
Asthma exacerbations  
Migraines



# UNGD and Children's Health

# Where Does the Research Stand?

- ▶ Research out of Colorado, Pennsylvania, Texas
- ▶ Much of the work on UNGD and health effects still uses proximity metrics as a surrogate for exposure
  - ▶ Useful when a public health problem is new, exposure data may be lacking
  - ▶ Analysis via geographic information systems (GIS) software (e.g., inverse distance weighting)
  - ▶ Disadvantages:
    - Hypothesis-generating
    - May not account for geological, meteorological, or other factors affecting the movement of pollutants through water, soil, or air

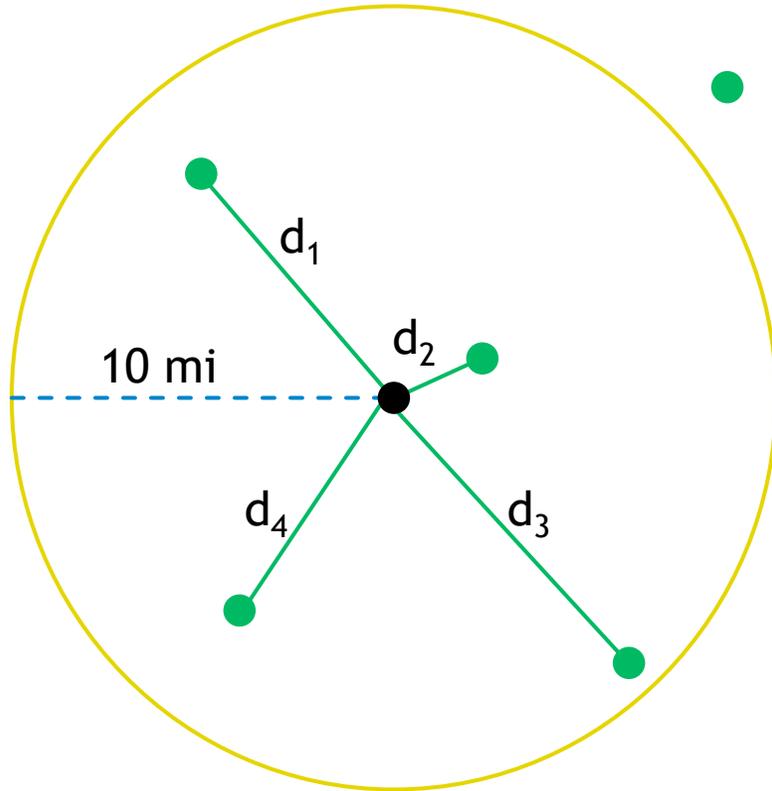
# Proximity Metrics

- ▶ Inverse distance weighted (IDW) well count commonly calculated for each mother living within 10-miles of UNGD (McKenzie et al. 2014)

$$IDW \text{ well count} = \sum_{i=1}^n \frac{1}{d_i}$$

- ▶ *IDW well count*: inverse distance weighted count of active, unconventional natural gas wells within a 10-mile radius of maternal residence in the birth year
- ▶  $n$ : the number of existing unconventional wells
- ▶  $d_i$ : the distance of the  $i$ th individual well from the mother's residence

# Proximity Metrics (continued)



- $IDW \text{ well count} = \sum_{i=1}^n \frac{1}{d_i}$

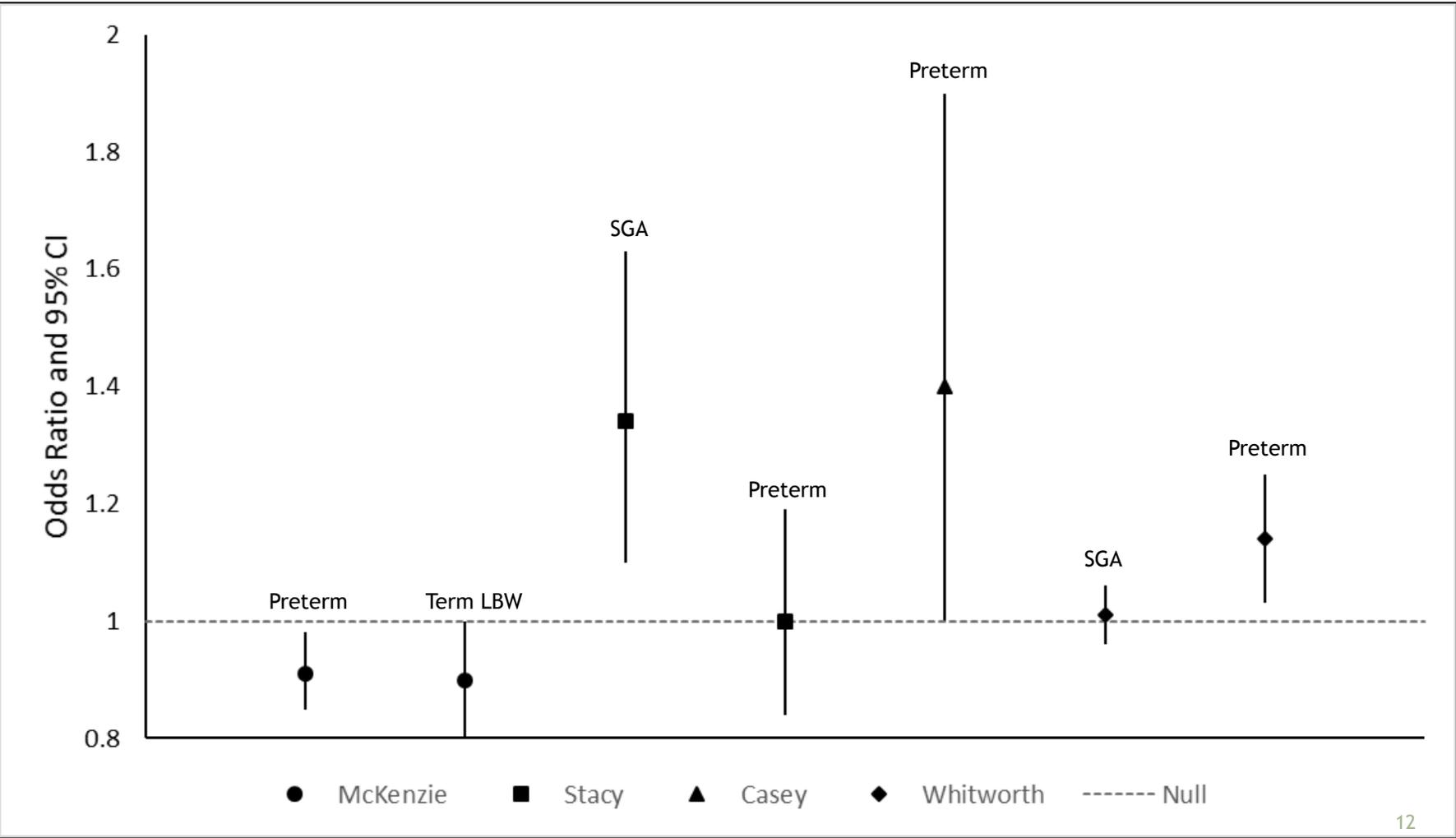
**Example:**

If  $d_1=8$ ,  $d_2=1/2$ ,  $d_3=9$ , and  $d_4=4$ :

$$IDW \text{ well count} = 1/8 + 2 + 1/9 + 1/4$$

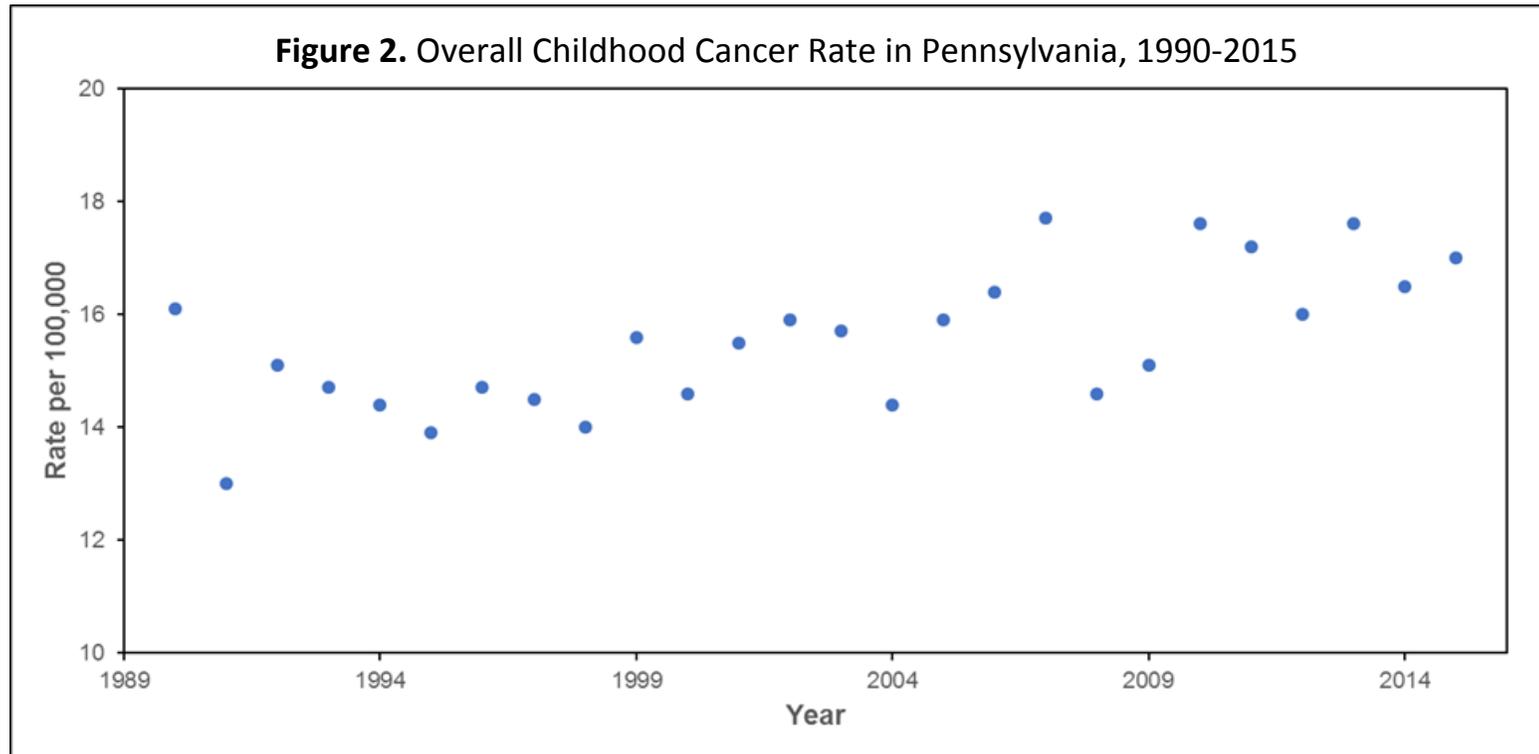
$$IDW \text{ well count} \approx 2.5$$

Figure 1. Adjusted odds ratios (OR) and 95% confidence intervals (CI) from studies examining birth outcomes and proximity to UNGD. ORs reported for the most vs. least exposed from each study.



# Childhood Cancer in Pennsylvania

- ▶ Cancer in children is relatively rare but remains the leading cause of death by disease past infancy among children in the United States. Little is known about the causes.
- ▶ Incidence among U.S. children <15 years of age: 16 per 100,000



# Childhood Cancer in Pennsylvania

In the news... increasing community concerns regarding environmental contributions, including UNGD, to childhood cancers in southwestern PA, particularly Ewing's sarcoma.

THE WALL STREET JOURNAL

U.S.

## After String of Rare Cancer Cases, Pennsylvania Investigates Potential Link to Fracking

Spate of Ewing's sarcoma diagnoses in Washington County sparks probe: 'We want them to look at everything,' one father who lost a son said



### For public health: Tom Wolf should order study of fracking and child cancer

...must support efforts to help put the public's mind at ease

JUN 18, 2019 6:00 AM

JUNE 28, 2019 | 9:23 AM

## 'Something's wrong here': Washington County parents want Pa. to look deeper at whether fracking could be related to cancer cases

Pediatrician: Plenty of other potentially harmful environmental hazards in the area

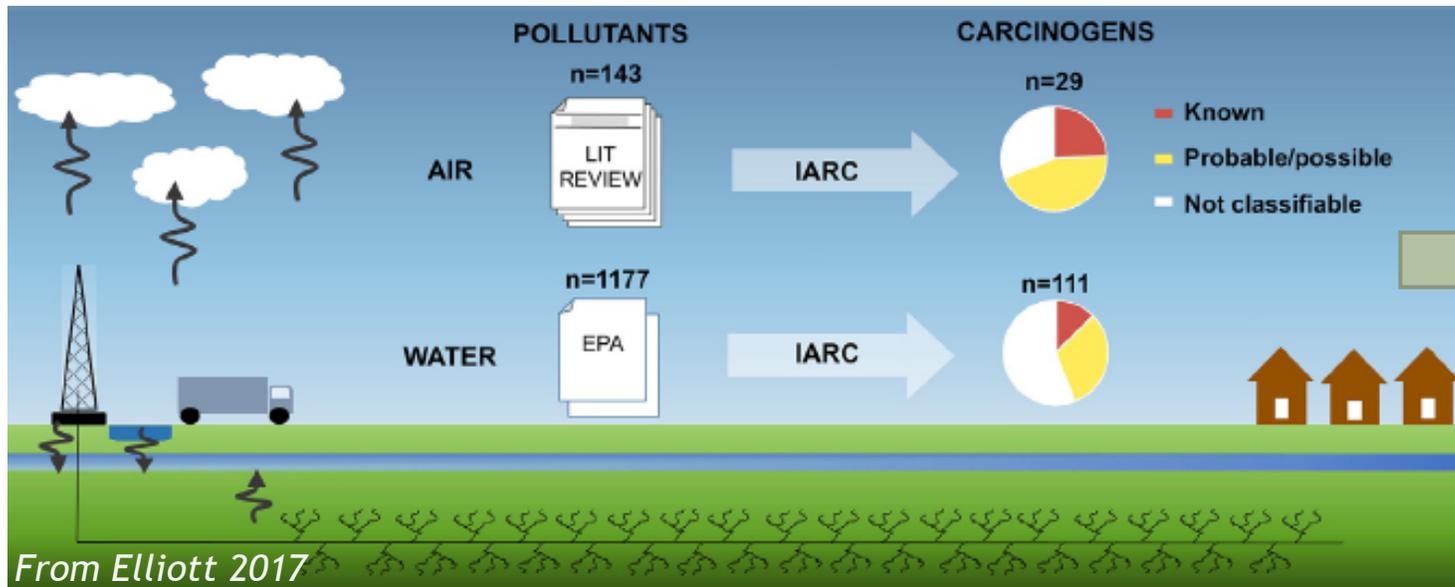
Reid Frazier

# Childhood Leukemia

- ▶ Leukemia is a cancer that occurs when the bone marrow produces abnormal white blood cells. It is often described as being either acute or chronic.
- ▶ Almost all childhood leukemia is acute.
  - ▶ Acute lymphocytic leukemia (ALL)
  - ▶ Acute myelogenous leukemia (AML)
- ▶ Risk factors include:
  - ▶ Intrinsic (error in stem cell replications)
  - ▶ Extrinsic (environmental factors, i.e. benzene exposure)
  - ▶ Genetic (chromosomal mismatch)
  - ▶ Unknown

# UNGD and Childhood Cancer

- ▶ Several studies have noted potential carcinogenic exposures related to UNGD activities
- ▶ A review by Elliott et al. (2017) identified 20 leukemogenic water and air pollutants associated with UNGD



Twenty unique compounds had evidence of ↑ risk for leukemia and/or lymphoma, including:

- Benzene
- 1,3-butadiene
- Cadmium
- Diesel exhaust
- Several polycyclic aromatic hydrocarbons (PAHs)

# UNGD and Childhood Cancer

- ▶ A human health risk assessment (McKenzie 2012) of air emissions in Garfield County, CO found that residents living  $\leq 0.5$ -mile of UNGD had greater cumulative cancer risks compared to those living  $> 0.5$ -mile
  - ▶ Driven mostly by benzene exposure
- ▶ Fryzek et al. (2013) compared incidences of the two most common childhood cancers, leukemia and central nervous system (CNS) tumors, in PA counties before and after drilling.
  - ▶ Observed numbers of cancer cases, however, were close to expected both before and after.
  - ▶ Lag period between drilling activities and clinically observable cancer too short?
- ▶ In McKenzie et al. (2017), 5 to 24-year-olds diagnosed with ALL were 4.3 (95% CI: 1.1-16) times as likely as controls to live in close proximity to UNGD (i.e., in their highest exposure group)
  - ▶ No association between UNGD and ALL among 0 to 4-year-olds, nor for non-Hodgkin lymphoma.



# Pennsylvania Study (In Progress)

- ▶ We obtained birth records, and childhood cancer records linked to their birth records, through an IRB-approved application process with the Pennsylvania Department of Health
- ▶ Using this virtual cohort to investigate a number of pre- and postnatal risk factors for childhood cancers (*Stacy et al., Am J Epidemiol, 2019*)
- ▶ Infants born from 2007-2015, when UNGD was expanding in PA.
- ▶ Similar to our (Stacy et al. 2015) and others' previous work, we calculate an inverse distance weighted (IDW) well count accumulated for all active, unconventional natural gas wells drilled within 10-miles of the mother's residence.
- ▶ Examining different periods of exposure: prenatal versus postnatal
  - ▶ Pregnancy and early childhood are sensitive time periods of development, including for environmental onslaughts that may affect health later in life

# Recommendations for Future Work

# Where Do We Go From Here?

- ▶ A growing body of literature suggests that communities living close to UNGD may be at greater risk for certain health outcomes, particularly infants and children.
- ▶ There is evidence that proximity to these activities is associated with increased risk for several birth defects, preterm birth, and reduced fetal growth. However, results differ somewhat by region and study population.
- ▶ Epidemiologic studies using UNGD proximity/density metrics are primarily hypothesis generating.
  - ▶ What specific agent(s) might be responsible for the associations we're seeing?

# Where Do We Go From Here?

- ▶ Future studies would greatly benefit from using more granular estimates of exposure or conducting more individualized exposure assessments.
  - ▶ Portable sampling equipment
  - ▶ Measurement of biomarkers of exposure in biospecimens collected from study participants (e.g., measuring PAH- or benzene-DNA adducts in blood)
- ▶ GIS methods may also aid in estimating personal exposure to UNGD
  - e.g., use of global positioning system technology to integrate study population activity data with measured concentrations of environmental contaminants

# Acknowledgments and Conflicts of Interest

- ▶ My mentor, Dr. Jian-Min Yuan
- ▶ Our collaborators at the University of Pittsburgh
- ▶ I have no conflicts of interest to disclose.
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