Oil and Gas Development: Evaluating the Health Implications
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URD is an Industrial Process

- Drilling in Garfield County
- Hydraulic fracturing in Garfield County
- Flowback in Garfield County
- Seven well pad in Greeley
Potential Environmental Stressors (Witter et al 2013)

- Air quality
- Water quality
- Traffic
- Noise, Light, and Vibrations
- Economic conditions
- Social conditions
- Health infrastructure
- Accidents/malfunction
Oil and Natural Gas Operations

- Can emit air pollutants:
  - Directly
  - Diesel Engines
  - Ozone precursors

- Water Pollutants
  - Spills
  - Leaks

Atmospheric benzene observations from oil and gas production in the Denver-Julesburg Basin in July and August 2014

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Abstract: High time resolution measurements of volatile organic compounds (VOCs) were collected using a proton transfer reaction mass spectrometry PTR-QMS instrument at the Plattfield Atmospheric Observatory (PAO) in Colorado to investigate how oil and natural gas (OGN) development impacts air quality within the Plattfield Gas Field (PFG) in the Denver-Julesberg Basin. The measurements were conducted in July and August 2014 in parallel with a 3-D modeling study of surface conditions from Calm and terrain resolved Observations: Model for the Arts (CABLES) field campaign. The PTR-QMS data were supported by a permeation study of an automotive sample and allows vertical and temporal variances of benzene in the basin to be evaluated. Benzene concentrations were 0.31 ppb at 7 a.m., 0.07 ppb at 9 a.m., 0.01 ppb at 11 a.m., 0.02 ppb at 1 p.m., and 0.01 ppb at 3 p.m. These benzene levels are associated with motor vehicles. The findings indicate that benzene is emitted from the PAO site, contributing to the overall benzene levels observed in the basin. The benzene levels were not associated with any particular source or activity. However, benzene was observed to be present at higher concentrations during the day, likely due to the increased activity associated with motor vehicles. Overall, the study highlights the importance of understanding the sources and sinks of benzene in the basin, which may have implications for public health and air quality.
Repeated peak exposure potentials at night, before sunrise
Scale of Exposure
Scale of Exposure

Figure 1: Density of multiple oil and gas well sites within a 1-mile radius in Colorado’s Piceance Basin

- Multiple oil and gas well site
- House
Public Health Studies: Level of Evidence

- **Predictive**
- **Epidemiological Studies/Population-Based**
- **Descriptive – Hypothesis Generating**

- **HIA**
  - Exposures Potential Health Effects Recommendations

- **Risk Assessment**
  - Estimate exposures and health risk

- **Case Series**
  - Document Health Outcomes

- **Ecological Studies**
  - Health outcomes and exposures at the group level

Increasing Level of Evidence
Conclusions from predictive and descriptive health studies

- People living nearest to the well pads may be at increased risk for neurologic, developmental, endocrine system, and respiratory health effects, as well as cancer and stress.
  - Inventories of chemicals used on O&G sites (Colburn et al. 2012, Ellison et al. 2016)
  - Chemical concentrations in air samples collected in Garfield County (McKenzie et al. 2012)
  - Survey of self-reported symptoms (Steinzor et al. 2013, Ferrar)
  - Human cell lines exposed to water samples from O&G areas (Kassotis 2014)
- Risk for exposures and health effects is greatest during the period of short-term, high air emissions that may occur during events such as during well-completions (McKenzie et al. 2012) and well unloadings (Allen et al. 2013) and may be higher at night (Halliday et al. 2016).
Conclusions from ecological Studies

• Cases of childhood central nervous system cancers higher than expected in Pennsylvania shortly after hydraulic fracturing introduced (Frysek 2013)
• Cases of childhood leukemia not higher than expected in Pennsylvania shortly after hydraulic fracturing introduced (Frysek 2013)
• More cases of bladder and thyroid cancer than expected in Pennsylvania counties with shale gas activity (Finkel 2016)
• Cardiology and neurology hospitalizations increase with increasing density of wells in zip code (Jemielita 2015).
Limitations of Ecologic studies
Analytic: The Proximity Studies

Predictive

Descriptive – Hypothesis Generating

Epidemiological Studies/Population-Based

Analytic

**HIA**
Exposures Potential Health Effects Recommendations

**Risk Assessment**
Estimate exposures and health risk

**Case Series**
Document Health Outcomes

**Case-Control Studies**
Identify individuals with and without health outcome and compare exposures

**Ecological Studies**
Health outcomes and exposures at the group level

**Cohort Studies**
Follow exposed and unexposed individuals and compare health outcomes

Increasing Level of Evidence
Location of the wells in relation to the home matters
Measure the distance of each O&B well from the home.
Inverse Distance Weighting (IDW)

inverse distance = \frac{1}{\text{distance of well from mother's home}}
Sum the inverse distances

• All wells 1 mile away: \(\text{IDW} = \frac{1}{1} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} = 4\)

• All wells 5 miles away: \(\text{IDW} = \frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5} = 0.8\)

• 2 wells 1 mile away, 2 wells 2 miles away = \(\frac{1}{1} + \frac{1}{1} + \frac{1}{2} + \frac{1}{2} = 2.4\)
Proximity to oil and natural gas wells and childhood acute lymphocytic leukemia and non-Hodgkin lymphoma

- Registry-based case-control study
- 743 children from the Colorado Central Cancer Registry
  - Residing in rural Colorado
  - Diagnosed between 2001 and 2013
  - Age 0-24 years at time of diagnosis
  - Geo-coded address to rooftop accuracy
- 87 ALL Cases
- 50 NHL Cases
- 528 control: children with non-hematologic cancers
  - 78 children with another type of leukemia or Hodgkin lymphoma excluded
More children with acute lymphocytic leukemia live in areas of high density oil and gas wells

McKenzie et al 2017

P= 0.035

P= 0.50

low = first tertile, < 4.9 wells per mile, medium = second tertile, 4.9 to 33.6 wells per mile, high = third tertile, more than 33.6 wells per mile. Adjusted for age, race, gender, SES, and elevation.

McKenzie et al 2017
Proximity studies other states

Health conditions more likely as proximity to UNGD wells/activity increases:

• Congenital heart defects and neural tube defects (McKenzie 2014)
• Low birth weight (Stacy et. al. 2015)
• Preterm birth and high risk pregnancy (Casey et. al. 2015)
• Asthma exacerbations (Rasmussen et. al. 2016)
• Nasal and sinus, migraine headache, and fatigue symptoms (Tustin et. al. 2016)
What do these studies tell us?

• These studies show that there are more people with these health outcomes living near O&G wells.

• None of these studies show that living near O&G wells caused the health outcome.
What the health studies do not tell us

• Baseline exposure: What were the concentrations of chemicals in air/water before O&G development?
• What actual exposures are:
  – What are people exposed to – if anything - and at what concentration/level?
  – Is O&G development the source of the exposures or is it something else?
  – If it is O&G, what activities are the source of the exposure?
  – Chemical stressors or non-chemical stressor?
• The distance O&G development should be to minimize potential for health effects
  – Likely no one “right” answer for this question
  – Highly dependent on activities
Current Studies at the Colorado School of Public Health

• Follow-on study for congenital heart defects (American Heart Association)
• Cumulative risk assessment considering chemicals in air and water, noise, traffic, and accidents (National Science Foundation)
• Describing populations living near oil and gas development (National Science Foundation)
• Quality of life and subclinical biomarkers: comparing Greeley and Fort Collins Populations (National Institute of Environmental Health Sciences)
• Childhood Cancers (University of Colorado Cancer Center)
Bibliography

- Rasmussen, S. G.; Ogburn, E. L.; McCormack, M.; et al., ASsociation between unconventional natural gas development in the marcellus shale and asthma exacerbations. *JAMA Internal Medicine* 2016