Exposures and Health Impacts of Unconventional Oil & Gas Development

Nicole C. Deziel, PhD, MHS
Assistant Professor, Yale School of Public Health

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Problem Scope

- 25-30,000 wells hydraulically fractured (HF) annually in the US (EPA 2016)
- ~4 million people live within 1 mile of a HF well (Czolowski 2017)
- Drinking water sources for 9 million people within a mile of an HF well (EPA 2016)
- UOG waste water contains toxic and radioactive compounds (Shih 2015, Elliott 2016)
- HF-related activities have affected drinking water resources (e.g., Jackson 2013, Llewellyn 2015)
- UOG sites release air pollutants (e.g., carcinogens) (Elliott 2017, McKenzie 2012)
- Water and air quality monitoring and human health data are insufficient
Multiple Potential Exposures/Stressors

- Population Mixing
- Social Stressors
- Stress
- Water Availability
- Noise
- Light
- Occupational Exposures
- Environmental Justice
- Social Cohesion Disruption
- Air Pollutants
- Greenhouse Gases
- Water Contamination
- Traffic
- Traffic Accidents
Limited but Growing Epi Literature

- **Childhood leukemia** (McKenzie 2017, Fryzek 2013)
- **Respiratory symptoms** (Rabinowitz 2014, Rasmussen 2016, Tustin 2016)
- **Self-reported dermal irritation** (Rabinowitz 2014)
- **Migraine, fatigue symptoms** (Tustin 2016)
- **Hospitalizations** (Jemielita 2015)
- **Risk Assessments** (McKenzie 2012, Regli 2015)
Challenges in Exposure Assessment in Epidemiologic Context

- Proximity/density metrics and models better suited for air emissions
- Models don’t identify underlying etiologic agents
- Limited feasibility to conduct detailed monitoring on large-scale populations
- Only single-state studies to date
- Registry and records-based
Increasing Detail in Exposure/Activity Modeling

Physically-based hydrogeological models

Activity model (incorporates proximity, density, well attributes, literature-based emission weights)

Inverse distance-weighted well count

Distance to Nearest Well

Zip code # UO&G wells

County-level # UO&G wells

Increasing precision
Limited but Growing Water Literature*

<table>
<thead>
<tr>
<th>Author Year</th>
<th>State</th>
<th># Samples</th>
<th>Primary Analytes</th>
<th>Geospatial Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elliott submitted</td>
<td>OH</td>
<td>66</td>
<td>VOCs, GRO, DRO linked to reprotox/carcinogenicity</td>
<td>Inverse distance well count, distance to nearest well</td>
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<tr>
<td>Drollette 2015</td>
<td>PA</td>
<td>64</td>
<td>GRO, DRO</td>
<td>distance to nearest well, distance to nearest violation</td>
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<tr>
<td>Jackson 2013</td>
<td>PA</td>
<td>141</td>
<td>methane, ethane</td>
<td>distance to nearest well</td>
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<tr>
<td>Osborn 2011</td>
<td>PA</td>
<td>68</td>
<td>methane</td>
<td>distance to nearest well</td>
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<tr>
<td>Alawattegama 2015</td>
<td>PA</td>
<td>33</td>
<td>methane, major ions</td>
<td>drilling activity over time</td>
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<tr>
<td>Fontenot 2013</td>
<td>TX</td>
<td>100</td>
<td>major ions</td>
<td>distance to nearest well</td>
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<tr>
<td>Hildenbrand 2015</td>
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<td>550</td>
<td>metals/ions, alcohols</td>
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<tr>
<td>Hildenbrand 2017</td>
<td>TX</td>
<td>77</td>
<td>ions/bromides/chlorides</td>
<td>distance to nearest well</td>
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</tbody>
</table>

*partial list
Challenges & Opportunities for Water Exposure Studies

• Shift emphasis from methane to contaminants of greater public health concern

• Use hydrologic-based inferences to:
  – Reduce uncertainty in contaminant source attribution
  – Strengthen proximity-based metrics of exposure

• Leverage new analytical techniques to identify chemicals in frac fluids and UOG wastewater
## Limited but Growing Air Quality Studies*

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>State</th>
<th>Example Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmadi &amp; John</td>
<td>2015</td>
<td>TX</td>
<td>ozone</td>
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<tr>
<td>Brantley</td>
<td>2015</td>
<td>CO</td>
<td>VOCs, HAPs</td>
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<tr>
<td>Brown</td>
<td>2014</td>
<td>PA</td>
<td>PM2.5, VOCs</td>
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<td>Bunch</td>
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<tr>
<td>Eapi</td>
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<td>Elliott</td>
<td>submitted</td>
<td>OH</td>
<td>VOCs</td>
</tr>
<tr>
<td>Goetz</td>
<td>2015</td>
<td>PA</td>
<td>methane, VOCs, NOx</td>
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<tr>
<td>Halliday</td>
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<td>CO</td>
<td>benzene</td>
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<td>Karion</td>
<td>2015</td>
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<td>methane</td>
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<tr>
<td>Lavoie</td>
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<td>methane</td>
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<td>Macey</td>
<td>2014</td>
<td>AK, CO, OH, PA, WY</td>
<td>VOCs</td>
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<tr>
<td>Walters</td>
<td>2015</td>
<td>WI</td>
<td>PM</td>
</tr>
</tbody>
</table>

*partial list
Challenges & Opportunities of Air Exposure Studies

• Differences in:
  – Modeling vs measurements
  – Reported UO&G proximity information
  – Sampling location
  – Sampling methods
  – Sampling duration
  – Target analytes
Study Quality

• Peer review
• Existing standards
  – STROBE (2007)
  – Journal guidelines
  – Navigation Guide (Woodruff 2014)
References

References


• Eapi GR, Sabnis MS, Sattler ML. Mobile measurement of methane and hydrogen sulfide at natural gas production site fence lines in the Texas Barnett Shale. J Air Waste Manag Assoc 2014; 64: 927-44.


