From Wellhead to Ethane Cracker:
Shale Gas, Petrochemicals, and Health

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Community College of Beaver County
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“The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment.

Pennsylvania's public natural resources are the common property of all the people, including generations yet to come.

As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people.”
EHP Air Model

Highest Chemical Emissions

• Nitrogen oxides (NOx)

• Carbon monoxide (CO)

• Volatile Organic Compounds (VOCs)

• PM2.5

• HAPs

Emissions data: 50% of permitted emissions (PA-DEP)

Weather data: NOAA
## Royal Dutch Shell Ethane Cracker Plant
### Permitted Emissions

<table>
<thead>
<tr>
<th>Air Contaminant</th>
<th>Emission Rates (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>348</td>
</tr>
<tr>
<td>CO</td>
<td>1,012</td>
</tr>
<tr>
<td>VOCs</td>
<td>620</td>
</tr>
<tr>
<td>PM 2.5</td>
<td>159</td>
</tr>
<tr>
<td>HAPs</td>
<td>30.5</td>
</tr>
<tr>
<td>Ammonia</td>
<td>152</td>
</tr>
<tr>
<td>CO2</td>
<td>2,248,293</td>
</tr>
<tr>
<td>Exposure</td>
<td>Possible symptoms experienced</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Low</td>
<td>Less than 500 ug/m3 Eye and throat irritation</td>
</tr>
<tr>
<td>Moderate</td>
<td>500 to 1000 ug/m3 Eye and throat irritation, headache</td>
</tr>
<tr>
<td>High</td>
<td>1000 to 2500 ug/m3 Eye and throat irritation, headache, shortness of breath, palpitations, chest pain, changes in blood pressure and/or heart rate</td>
</tr>
<tr>
<td>Extreme</td>
<td>2500 to 5000 ug/m3 and above Eye, nose, throat irritation, headache, shortness of breath, palpitations, chest pain, changes in blood pressure and/or heart rate, impaired cognitive function such as confusion and difficulty concentrating</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Exposure to emissions (ug/m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heritage Valley Health System</td>
<td>2,861</td>
</tr>
<tr>
<td>CCBC</td>
<td>2,861</td>
</tr>
<tr>
<td>Aliquippa Elementary School</td>
<td>715</td>
</tr>
<tr>
<td>Western Beaver High School</td>
<td>1,073</td>
</tr>
<tr>
<td>Freedom Area High School</td>
<td>715</td>
</tr>
<tr>
<td>Beaver Valley Mall</td>
<td>13,234</td>
</tr>
</tbody>
</table>
Pennsylvania
(Updated 3/27/2019)

- 11,885 Active Unconventional Gas Wells
- 12,342 Violations
"Nurdles"
Flowback: What Comes Back Up

- **Drill Cuttings** (solid waste)
- **Contaminated Water**
  - Fracking chemicals
  - Salt (Brine)
  - Natural elements (lead, arsenic)
  - Naturally-occurring radioactive materials (NORMs) — radium 226
- **Non-fuel Gases** (VOCs, PAHs, hydrogen sulfide, radon)
- **Methane**
- **Liquid Fuels** (propane, butane, ethane)
Important points about UNG development

1. Emissions of toxics occur at every stage of the process.

2. Emissions don’t stay in one place.
   - trucks travel
   - winds blow
   - rivers and streams flow
   - what goes up comes down
   - climate, weather patterns, topography help determine exposure
Important points about UNG development

3. Gases leak accidentally and are vented on purpose.

4. Airborne emissions are often invisible.

5. Liquids leak & spill, on well pads and off well pads.

6. Chemicals that leak, spill, or are aerosolized remain a mystery.

7. Earth is a closed system. What happens here stays here.
Airborne Emissions — Exposure & Health Effects

> Emissions occur at every stage of UNG development and are typically invisible.

> Symptoms from exposure are well-known from decades of occupational research.

> Exposure to toxics based on several factors:

  — proximity to emissions
  — duration of exposure
  — individual susceptibility (age, gender, genetics, pre-existing conditions)
  — use of personal protective equipment

> Exposure may be continuous or episodic.

> Exposure may involve multiple chemicals from one or from multiple sources in the vicinity of the exposed person. (AGGREGATE EMISSIONS)
RESOLVED, That the Pennsylvania Medical Society urge and support a moratorium on new natural gas extraction using high-volume hydraulic fracturing in Pennsylvania; and be it further

RESOLVED, That the Pennsylvania Medical Society urge the Commonwealth of Pennsylvania to fund an independent health registry and commission research studies on the health effects of fracking.
Compendium of Scientific, Medical, and Media Findings
Demonstrating Risks and Harms of Fracking
(Unconventional Gas and Oil Extraction)

Fifth Edition
March 2018

> 1,300 peer-reviewed studies & investigative reports.

- 90% published since 2013
- 25% published in 2017

“There is no evidence that fracking can operate without threatening public health directly or without imperiling climate stability upon which public health depends.”

http://www.psr.org/assets/pdfs/fracking-compendium-5.pdf
Vulnerable Community Members

- Pregnant women and fetuses
- Infants and children
- Elderly
- Poor
- People and communities of color
- Pre-existing medical conditions
- Outdoor workers
- First Responders
THE EVIDENCE IS IN:
AIR POLLUTION FOLLOWS FRACKING

(See footnotes 50-135, 333, 444-45)
# Petro-Fracking Operations  
— Airborne Emissions —

<table>
<thead>
<tr>
<th>Fracking Chemicals</th>
<th>Carbon monoxide (CO)</th>
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<tbody>
<tr>
<td>Sand (silica dust)</td>
<td>Carbon dioxide (CO2)</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td>Nitrogen dioxide (NO2)</td>
</tr>
<tr>
<td>Polycyclic Aromatic Hydrocarbons (PAH)</td>
<td>Sulfur dioxide (SO2)</td>
</tr>
<tr>
<td>Particulate Matter (PM 2.5)</td>
<td>Methane (CH4)</td>
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\[
\text{VOCs} + \text{NO2} + \text{SUNLIGHT} = \text{OZONE}
\]

\[
\text{OZONE} + \text{PARTICULATE MATTER} = \text{SMOG}
\]
THE EVIDENCE IS IN:
LIVING NEAR FRACKING SITES RAISES the RISKS FOR PREGNANT WOMEN

(See footnotes 434, 436, 450, 472, 1075, 1080, 1081)
“Comparison of the most to least exposed, however, revealed lower birth weight... and higher incidence of SGA.”
… an association between UNGD and preterm birth… and high risk pregnancy.”
Increased incidence of LBW within 3 km of active fracking site, with highest incidence within 1 km.

1.1 million births in Pennsylvania between 2004-2013

29,000 births in U.S. per year within 1 km of active fracking site
“...we observed an association between density and proximity of natural gas wells within a 10-mile radius of maternal residence and prevalence of congenital heart defects and possibly neural tube defects.”
THE EVIDENCE IS IN:
LIVING NEAR FRACKING SITES HAS BEEN LINKED TO ASTHMA, RASHES, HEADACHES, AND CANCER

(See footnotes 438-498, 1063-1064)
Health symptoms in residents living near shale gas activity: A retrospective record review from the Environmental Health Project

Beth Weinberger a, Lydia H. Greiner b, Leslie Walleigh c, David Brown a

Highlights

- This is a retrospective symptom review of adults exposed to unconventional natural gas wells.
- We attributed symptoms to exposure only if no other cause could be identified.
- **Most commonly reported symptoms:** sleep disruption, headache, throat irritation.
- Our findings are **consistent with other studies using self-reported symptoms.**
# Top 10 Symptoms Associated with Proximity to UNGD

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<tbody>
<tr>
<td>1.</td>
<td>Sleep disruption</td>
</tr>
<tr>
<td>2.</td>
<td>Headache</td>
</tr>
<tr>
<td>3.</td>
<td>Throat irritation</td>
</tr>
<tr>
<td>4.</td>
<td>Stress/anxiety</td>
</tr>
<tr>
<td>5.</td>
<td>Cough</td>
</tr>
<tr>
<td>6.</td>
<td>Shortness of breath</td>
</tr>
<tr>
<td>7.</td>
<td>Sinus problems</td>
</tr>
<tr>
<td>8.</td>
<td>Fatigue</td>
</tr>
<tr>
<td>9.</td>
<td>Nausea</td>
</tr>
<tr>
<td>10.</td>
<td>Wheezing</td>
</tr>
</tbody>
</table>

Weinberger, B. et al, *Health symptoms in residents living near shale gas activity/ A retrospective record review from the Environmental Health Project*

Preventive Medicine Reports, 14 September 2017 (online)

UNGD activity metrics were statistically associated with increased risk of mild, moderate, and severe asthma exacerbations.
Associations between Unconventional Natural Gas Development and Nasal and Sinus, Migraine Headache, and Fatigue Symptoms in Pennsylvania

Aaron W. Tustin,1 Annemarie G. Hirsch,2 Sara G. Rasmussen,1 Joan A. Casey,3 Karen Bandeen-Roche,4 and Brian S. Schwartz1,2,5

Background: Unconventional natural gas development (UNGD) produces environmental contaminants and psychosocial stressors. Despite these concerns, few studies have evaluated the health effects of UNGD.

Objectives: We investigated associations between UNGD activity and symptoms in a cross-sectional study in Pennsylvania.

Methods: We mailed a self-administered questionnaire to 23,700 adult patients of the Geisinger Clinic. Using standardized and validated questionnaire items, we identified respondents with chronic rhinosinusitis (CRS), migraine headache, and fatigue symptoms. We created a summary UNGD activity metric that incorporated well phase, location, total depth, daily gas production and inverse distance–squared to patient residences. We used logistic regression, weighted for sampling and response rates, to assess associations between quartiles of UNGD activity and outcomes, both alone and in combination.

Results: The response rate was 33%. Of 7,785 study participants, 1,850 (24%) had current CRS symptoms, 1,765 (23%) had migraine headache, and 1,930 (25%) had higher levels of fatigue. Among individuals who met criteria for two or more outcomes, adjusted odds ratios for the highest quartile of UNGD activity compared with the lowest were [OR (95% CI)] 1.49 (0.78, 2.85) for CRS plus migraine, 1.88 (1.08, 3.25) for CRS plus fatigue, 1.95 (1.18, 3.21) for migraine plus fatigue, and 1.84 (1.08, 3.14) for all three outcomes together. Significant associations were also present in some models of single outcomes.

Conclusions: This study provides evidence that UNGD is associated with nasal and sinus, migraine headache, and fatigue symptoms in a general population representative sample.
Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates

Thomas Jemielita, George L. Gerton, Matthew Neidell, Steven Chilrud, Beizhan Yan, Martin Stute, Marilyn Howarth, Pouné Saberi, Nicholas Fausti, Trevor M. Penning, Jason Roy, Kathleen J. Propert, Reynold A. Panettieri Jr.

Published: July 15, 2015 • http://dx.doi.org/10.1371/journal.pone.0131093

Abstract

Over the past ten years, unconventional gas and oil drilling (UGOD) has markedly expanded in the United States. Despite substantial increases in well drilling, the health consequences of UGOD toxicant exposure remain unclear. This study examines an association between wells and healthcare use by zip code from 2007 to 2011 in Pennsylvania. Inpatient discharge databases from the Pennsylvania Healthcare Cost Containment Council were correlated with active wells by zip code in three counties in Pennsylvania. For overall inpatient prevalence rates and 25 specific medical categories, the association of inpatient prevalence rates with number of wells per zip code and, separately, with wells per km² (separated into quantiles and defined as well density) were estimated using fixed-effects Poisson models. To account for multiple comparisons, a Bonferroni correction with associations of p<0.00096 was considered statistically significant. Cardiology inpatient prevalence rates were significantly associated with number of wells per zip code (p<0.00096) and wells per km² (p<0.00096) while neurology inpatient prevalence rates were significantly associated with wells per km² (p<0.00096). Furthermore, evidence also supported an association between well density and inpatient prevalence rates for the medical categories of dermatology, neurology, oncology, and urology. These data suggest that UGOD wells, which dramatically increased in the past decade, were associated with increased inpatient prevalence rates within specific medical categories in Pennsylvania. Further studies are necessary to address healthcare costs of UGOD and determine whether specific toxicants or combinations are associated with organ-specific responses.

Correction

THE EVIDENCE IS IN:
FRACKING BRINGS NOISE POLLUTION, LIGHT POLLUTION, AND STRESS

(See footnotes 480-498)
“Stress” is one of the most frequently reported symptom by residents living in the Marcellus Shale region.
Psychosocial Impacts of UNGD

SOURCES OF STRESS

- **Noise** (drilling, fracking, flaring, pig-launcher venting, compressor blowdowns, truck traffic)
- **Odors** (diesel, hydrocarbon emissions, hydrogen sulfide)
- **Light** (sleep deprivation)
- **Traffic** (increased truck-related fatalities)
- **Crime** (violent crime, property crime, drug and alcohol abuse, STD’s)
THE EVIDENCE IS IN:
FRACKING JOBS ARE KILLING JOBS

(See footnotes 27, 28, 372-433)
THE EVIDENCE IS IN:

PIPELINES LEAK, CORRODE, SPILL, EXPLODE, INJURE, KILL, AND PROMPT EVACUATIONS

(See footnotes 30, 816-868)
THE EVIDENCE IS IN:

EMISSIONS FROM COMPRESSOR STATIONS ARE HIGHLY TOXIC

(See footnotes 816-17, 823, 826-28, 830-31, 838, 857)
Health Effects Associated with Stack Chemical Emissions from NYS Natural Gas Compressor Stations: 2008-2014

A Technical Report Prepared for the Southwest Pennsylvania Environmental Health Project underwritten by the Park Foundation

12 October 2017

“This report shows that every compressor station routinely releases large volumes of chemicals associated with a variety of diseases and disorders.”

— Raina Rippel, Director SWPA EHP

P.N. Russo & D.O. Carpenter

Institute for Health and the Environment
A Pan American Health Organization / World Health Organization Collaborating Centre in Environmental Health
University at Albany
THE EVIDENCE IS IN:
FRACKING ACCELERATES CLIMATE CHANGE

(See footnotes 29, 699-796, 848-850)
“The health impacts of climate change demand immediate action.”

Declaration on Climate Change and Health
2017
For More Information

> Breathe Project  www.breatheproject.org

> Children’s Environmental Health Network  www.cehn.org

> Climate Reality Project  www.climaterealityproject.org

> Pediatric Alliance  www.pediatricalliance.com

> Physicians for Social Responsibility - PA  www.psrphila.org

> SWPA Environmental Health Project  www.environmentalhealthproject.org
Additional Reading

- Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking — 5th Edition
  http://www.psr.org/assets/pdfs/fracking-compendium-5.pdf

- The ROGER Citation Database
  PSE's Repository for Oil and Gas Energy Research (ROGER)
  https://www.psehealthyenergy.org/our-work/shale-gas-research-library/

- Pittsburgh Regional Environmental Threats Analysis (PRETA)
  University of Pittsburgh Graduate School of Public Health

  https://journal.chestnet.org/article/S0012-3692(18)32723-5/fulltext

- 5th Intergovernmental Report on Climate Change (IPCC) - 2014 (AR5), 2018 (SR5)
  https://www.ipcc.ch

- 4th National Climate Assessment (NCA4) — Volume 1: 2017; Volume 2: 2018
  https://nca2018.globalchange.gov