Science underlying the ½ mile "Health Threat Radius"

Summary: The peer-reviewed, published studies listed at the end of this document support using a "health threat radius" of ½ mile for oilandgasthreatmap.com.

While not all of these studies involve specific ½ mile measurements, this research collectively presents measured air pollution above background levels and/or health impacts attributable to oil and gas development at distances between 0.1 miles and 2 miles of active conventional as well as unconventional oil and gas facilities (Apergis 2019, McKenzie 2018). All things considered, ½ mile is a conservative radius, particularly in light of Vinciguerra 2015 which attributed a spike in local emissions to natural gas facilities over 150 miles away.

Health: All studies that specifically deal with health indicate positive correlations between risks and/or prevalence of disease and proximity to facilities (Janitz et al. 2019, McKenzie 2014). ½ mile is the distance within which grave health impacts and/or dangerous levels of air toxins have been directly ascribed to oil and gas development (Holder 2019, Whitworth 2018).

What "Health Threat Radius" Means: Despite the fact that peer-reviewed research supports a ½ mile Health Threat Radius, dangerous levels of toxics do not always exist within a ½ mile radius of an active facility. Consequently the Radius indicates that those within it have cause for concern about potential health impacts from oil and gas pollution. It is not a declaration that those within it will have negative health impacts. It does not quantify the threat posed by this pollution.

Limitations/caveats:

- Some of these studies were conducted prior to current EPA regulation, but the prevalence of the pollutants and their detected proximity from oil and gas sources is the focus of this literature review.
- There is less current research that focuses on air pollution and related health impacts from conventional oil and gas production alone. More often than not, the health risks posed by these facilities are caused by leaks, blowouts, or other malfunctions which are difficult to predict and measure.

LITERATURE REVIEW

≤ ½ Mile health threat radius - All Oil and Gas Facilities

Birth defects and unconventional natural gas developments in Texas (Tang et al. 2021)

- Risk of neural tube defects (NTDs) increased with proximity to unconventional natural gas developments.
- Excerpt: “Mothers with the highest tertile of exposure to unconventional natural gas development **within 1 km of maternal address** had significantly increased odds for anencephaly, and spina bifida, compared to mothers without any exposure”.
- Conclusions we can draw: Risk of birth defects increased with proximity and density of unconventional natural gas development to maternal address. Some birth defects showed increased risk up to 7.5 km away.
- Publicly available

Flaring from Unconventional Oil and Gas Development and Birth Outcomes in the Eagle Ford Shale in South Texas (Cushing et al. 2020)

- Excerpt: “findings suggest that living within 5km of OGD wells and flaring activity may have had a significant adverse effect on birth outcomes among pregnant women in the Eagle Ford region.”
- Conclusion we can draw: Exposure to a high number of nightly flare events was associated with **50% higher odds of preterm birth and shorter gestation** compared to no exposure.
- Publicly available

Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations (Holder et al. 2019)

- This study “estimated distributions of incremental acute, subchronic, and chronic inhalation non-cancer hazard quotients (HQs) and hazard indices (HIs), and inhalation lifetime cancer risks for benzene.”
- Excerpt: “Maximum acute HQs and HIs were > 10 for highest-exposed individuals **500 feet from eight of nine modeled facilities** during O&G development.”
- Conclusion we can draw: Acute exposures were of greatest concern, primarily during O&G development and for a limited set of VOCs and critical-effect groups, **sometimes at distances out to 2,000 ft** from the well pad.
- Publicly available

Fracking and infant mortality: fresh evidence from Oklahoma (Apergis, Hayat, and Saeed, 2019)

- Excerpt: “The results clearly document that there is a unidirectional relationship between fracking activities and three alternative indexes of infants’ health at birth, as well as a significant impact of fracking on infants’ health indicators.”
- The primary analysis in this paper was done at a two-mile radius.
- Conclusion we can draw: “the **closer the mother’s residence at birth to fracking wells, the more negative are the effects** on the infants’ birth health.”
- Publicly available

The association between natural gas well activity and specific congenital anomalies in Oklahoma, 1997-2009 (Janitz et al. 2019)

- Conclusions we can draw: there is an increased prevalence of neural tube defects among children living **within 2 miles of natural gas activity** compared to children with no wells. The effect increased with the density of natural gas activity.
- Publicly available

Ambient Nonmethane Hydrocarbon Levels Along Colorado’s Northern Front Range: Acute and Chronic Health Risks (McKenzie et al. 2018)

- Excerpt: “We found that Colorado populations within 152 m of an O&G facility are more likely to experience neurological, hematological, and developmental health effects from acute inhalation exposures to benzene and alkanes.”
- The lifetime excess cancer risk estimates in this study “are **10-100 times greater** than those reported in previous risk assessments in O&G development areas that used USEPA guidance.”
- Conclusions we can draw: hematological and developmental hazard indices and cumulative lifetime excess cancer risks increase with proximity to the nearest O&G facility.
- Publicly available

Shale gas development and infant health: Evidence from Pennsylvania (Hill 2018)

- Conclusion we can draw: “babies born of **mothers who lived within 2.5 km** of at least one gas well during pregnancy experienced adverse birth outcomes.”
- There is evidence that effects persist at addresses out to 3.5 km of O&G activity.
- Publicly available

Drilling and Production Activity Related to Unconventional Gas Development and Severity of Preterm Birth (Whitworth, Marshall, and Symanski, 2018)

- This study examined phase and trimester-specific associations between unconventional gas development and preterm birth on women living within half a mile of unconventional gas development.
- Conclusions we can draw: women in the highest tertile of unconventional gas development production faced increased odds of preterm birth.
    - The association between unconventional gas development and preterm birth may be **strongest for extremely preterm births**.
- Publicly available

Community-Based Health and Exposure Study around Urban Oil Developments in South Los Angeles (Shamasunder et al.2018)

- Conclusion we can draw: residents living within 1,500 ft of oil developments in Los Angeles reported experiencing **significantly higher rates of asthma symptoms of coughing and wheezing** on a daily or weekly basis than residents in other neighborhoods.
- Publicly available

Hydraulic fracturing and infant health: New evidence from Pennsylvania (Currie, Greenstone, Meckel 2017)

- Excerpt: “For mothers living within 1 km, we find a **25% increase in the probability of low birth weight** (birth weight < 2500 g) and significant declines in average birth weight and in an index of infant health.”
- Conclusion we can draw: the introduction of fracking reduces health among infants born to mothers living within 3 km of a well site during pregnancy.
- Publicly Available

Health symptoms in residents living near shale gas activity: A retrospective record review from the Environmental Health Project (Weinberger et al. 2017)

- Conclusions we can draw: Adults who lived within 1 km of oil and gas development in Pennsylvania **experienced significant health impacts**.
    - Adults who worked in the oil and gas industry were excluded from the study as a way to restrict the study to the effects of oil and gas development on local communities.

- Excerpts: “The 51 adults included in this record review had reported at least one symptom on their health assessment, denied occupation exposure related to natural gas extraction and lived in Pennsylvania within 1 km of an unconventional natural gas well.”
    - “Symptoms most commonly reported were: sleep disruption, headache, throat irritation, stress or anxiety, cough, shortness of breath, sinus problems, fatigue, nausea, and wheezing.”
- Publicly available

Maternal residential proximity to unconventional gas development and perinatal outcomes among a diverse urban population in Texas (Whitworth, Marshall, and Symanski 2017)

- Excerpt: “The highest odds of preterm birth were found among women classified in the second tertile of the ½- mile metric compared to women with zero wells <= 10 miles of her residence.”
- Conclusion we can draw: there is an **association between maternal residential proximity to unconventional gas development activity and preterm birth and fetal death**.
    - The effect is strongest with women with higher densities of unconventional gas development within ½ mile of their residence.
- Publicly Available

Adequacy of Current State Setbacks for Directional High-Volume Hydraulic Fracturing in the Marcellus, Barnett, and Niobrara Shale Plays (Haley et al. 2016)

- Excerpt: “Current natural gas well setbacks in the Barnett Shale of Texas, the Marcellus Shale of Pennsylvania, and the Niobrara Shale of Colorado **cannot be considered sufficient in all cases to protect public health and safety**… [these] populations are susceptible to benzene and hydrogen sulfide exposure above health-based risk levels… However, distance is not an absolute measure of protection. **Unfortunately, there is no defined setback distance that assures safety**.”
- Conclusions we can draw: existing setback distances in TX, PA, and CO are not aggressive enough to ensure public health and safety. Prevalence of illness increases with proximity to wells.
- Publicly available

Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania (Rabinowitz et al. 2015)

- Conclusions we can draw: health impacts households within < 2 km of unconventional drilling, with **worst effects measured < 1 km (½ mile) including skin as well as respiratory ailments**

- Publicly available

Impact of Natural Gas Extraction on PAH Levels in Ambient Air (Palik et al. 2015)

- Conclusions we can draw: the closer you are, the higher risk you face = **30% more HAP < .1 mile of active facilities**, **however HAP levels measured at >1 mile away ("maximum exposure scenario") still exceed the EPA's acceptable range.**
- Download

Birth outcomes and maternal residential proximity to natural gas development in rural Colorado (McKenzie et al. 2014)

- Conclusions we can draw:
  1) correlation between negative birth outcomes and proximity to active conventional/unconventional gas wells = **increase in congenital heart defects (CHDs) in babies as mothers' residences get closer to wells** ("Births to mothers in the most exposed tertile (> 125 wells/mile) had a **30% greater prevalence** of CHDs")
  2) health **impacts measured within 1 mile to facilities = the lowest exposed tertile (1–3.62 wells/mile) showed increased rates of CHDs** when compared to households farther than 10 miles from facilities.
    - Notes: author confirmed that study encompasses conventional as well as unconventional wells. Study population = households with ≥ 1 gas wells within 10 miles.
- Publicly available

Understanding exposure from natural gas drilling puts current air standards to the test (Brown et al. 2014)

- Conclusions we can draw: peak exposure to VOCs measured **1 mile from a compressor station**
- Publicly available

Toward a better understanding and quantification of methane emissions from shale gas development (Caulton et al. 2014)

- Conclusions we can draw: **methane was found at dangerously high/peak levels** (2.6 ppm) 1.1 kilometers **(~.7 miles)** downwind from an active gas well.
- Publicly available

Human health risk assessment of air emissions from development of unconventional natural gas resources (McKenzie et al. 2012)

- Conclusions we can draw: "**Residents living ≤ ½ mile from [unconventional] wells are at greater risk for health effects** from NGD than are residents living >½ mile from wells...Cumulative cancer risks were 10 in a million and 6 in a million for residents living ≤½ mile and >½ mile from wells, respectively, with benzene as the major contributor to the risk."
    - Note: proximity to wells (i.e. ½ mile) was used to separate populations and their respective health and odor related complaints. The study itself did not set out to measure risk vis a vi distance.
- Download

Modeling the Shape of the Dependency of Airborne Benzene Concentration in the Air on Distance to Primary Oil and Gas Facilities (Dinu 2010)

- Conclusions we can draw: "maximum concentrations were predicted at approximately 800 m away" = **dangerous/peak levels of benzene detected up to 800 meters (½ mile)** from oil wells, gas wells, bitumen wells, other wells, and compressors and/or gas plants.
- Download

Supporting Evidence for Proposed Rule

Good summary of first two articles:
http://blogs.edf.org/energyexchange/2015/02/10/studies-provide-insight-on-two-overlooked-segments-of-oil-and-gas-industry/

Methane Emissions from Natural Gas Compressor Stations in the Transmission and Storage Sector: Measurements and Comparisons with the EPA Greenhouse Gas Reporting Program Protocol

- Excerpt: "Only 38% of the methane emissions measured by the comprehensive onsite measurements were reportable under the new EPA Greenhouse Gas Reporting Program (GHGRP) because of a combination of inaccurate emission factors for leakers and exhaust methane, and various exclusions."
- Conclusions we can draw: need for stronger regulation on transmission and storage sector, could be achieved through new EPA rules
    - Methods: this study *detected* methane, ethane, and other species from **.3 miles - 1.86 miles** from facilities; "The concentrations of the two tracers, methane, ethane, and other species were measured 0.5 − 3 km downwind of the site." Concentration at these locations is unknown.

- Publicly available

Methane Emissions from United States Natural Gas Gathering and Processing

- Excerpt: “the total CH4 emissions from gathering systems (facilities and pipelines) as predicted in this study (1875 +189/−185 Gg) are greater than that estimated for the transmission and storage sector in a recent study (1503 Gg +30%/−19%)”
- Conclusion: emissions from the gathering and processing sector are greater than those in the transmission and storage sector; necessary regulation could be achieved through new EPA rules
- Publicly available

Methane Emissions from Conventional and Unconventional Natural Gas Production Sites in the Marcellus Shale Basin (Omara et al. 2016)

- Excerpt: “The mean facility-level CH4 emission rate among UNG well pad sites in routine production (18.8 kg/h (95% confidence interval (CI) on the mean of 12.026.8 kg/h)) **was 23 times greater** than the mean CH4 emissions from CNG sites. However, CNG sites generally had much higher production-normalized CH4 emission rates compared to UNG sites, likely resulting from a greater prevalence of avoidable process operating conditions (e.g., unresolved equipment maintenance issues).”
- Conclusions we can draw: unconventional wells are worse emitters at the site level, but conventional wells are still the majority emitter “reflecting the large number of [conventional] wells and the comparably large fraction of [methane] lost per unit production.” Additionally, there are **major discrepancies in current inventories**, need for more research and broader regulation.
    - Methods: methane was *detected* and modeled from up to 1200 (.75 miles) meters from unconventional wells, and up to 488 meters (.3 miles) from conventional wells (table S3, p. 25 of the supporting documentation). Concentration at these locations is unknown.
- Publicly available