

Southwest Pennsylvania Environmental Health Project Technical Reports

Expert Opinion on Health Impacts Related to UOGD

“Expert opinion confirms what has been found by multiple sources of data – reports from communities, gray literature and peer-reviewed literature; that health effects are associated with UOGD.”

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This Delphi study was conducted to determine expert consensus on the relationship between health outcomes and exposure to unconventional oil and gas development (UOGD). The potential for public health impacts from UOGD has increased dramatically in recent years, and there is active debate about the type and intensity of potential health outcomes. This national debate needs the full attention of the medical community, research scientists, policy-makers and regulators of the oil and gas industry.

When the available data are inconclusive on a specific topic, the Delphi is a proven method for reaching convergence of expert opinion. This Delphi, conducted by the Southwest Pennsylvania Environmental Health Project (EHP), consisted of a panel of 18 professionals with expertise in public health, medicine, environmental sciences, policy and risk analysis.

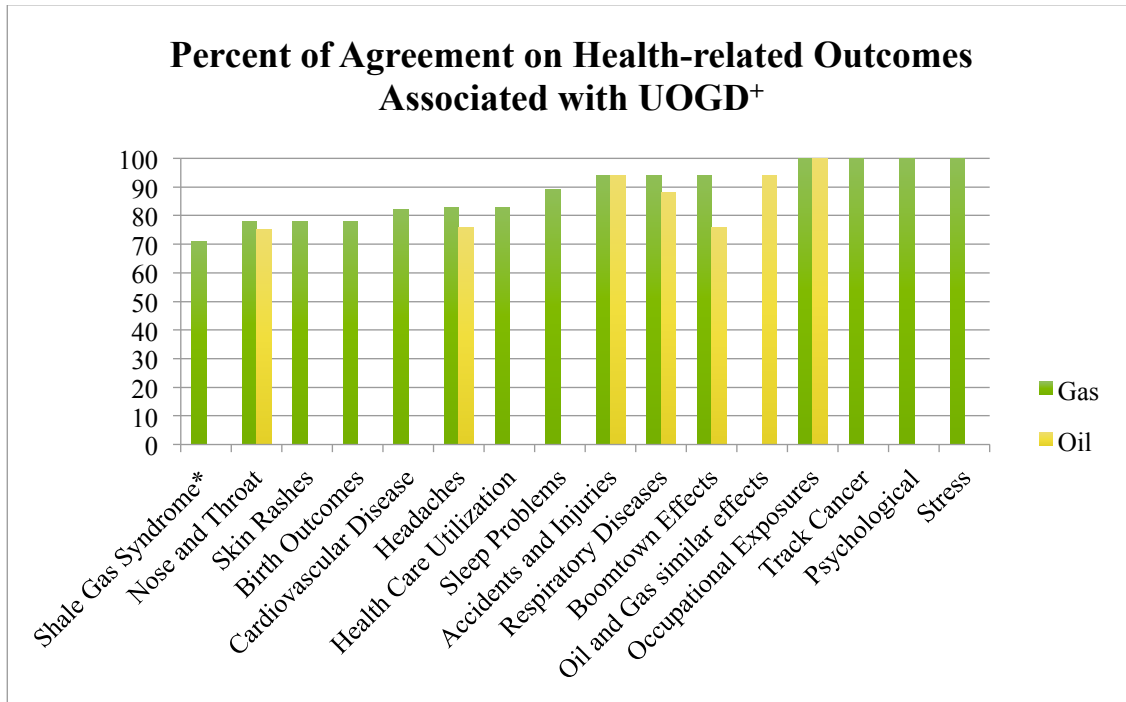
UOGD in this study is defined as oil and gas well site development that uses hydraulic fracturing, including all steps in the process from drill site construction through delivery of the product to the consumer. The use of hydraulic fracturing has increased rapidly since the 1990s. Critics have voiced concerns about potential impacts on air, water, and soil quality and there is evidence that UOGD may have a significant impact on surrounding communities because of increased traffic, light, noise, and social disruption. Evidence of adverse health outcomes is also significant.

Findings

Delphi panelists reached consensus on 22 statements: 15 associated with unconventional natural gas development and 7 associated with unconventional oil development (See Figure 1). All statements were generated by the panel. Panelists agreed that:

- Twelve specific health outcomes are associated with either gas or oil or both types of development
- Cancer is a *possible* outcome and should be tracked
- Increased health care utilization and “Boomtown” effects are associated with exposure to UOGD
- The health outcomes caused by exposure to both oil and gas appear comparable

Figure 1. Level of agreement on statements related to health outcomes associated with UOGD. Consensus is defined as $\geq 70\%$ agreement.



⁺ There are 16 outcomes shown on Figure 1. Because consensus was reached on some outcomes for both gas and oil, and for either gas or oil on other outcomes, the total number that reached consensus was 22.

* Shale Gas Syndrome was defined by panelists as “a group of symptoms that includes headaches, nosebleeds, vomiting, diarrhea, and skin rashes”.

More than 70% of panelists were uncertain about the association with UOGD for five health outcomes: reduced sperm count, neurological symptoms, gastrointestinal complaints, kidney/liver diseases, and malignant tumors.

Background

The concern for public health continues to grow as UOGD expands across the US. While early reports of problems were based on residents’ self-report of symptoms, peer-reviewed research on health impacts has increased in recent years (1). Residents’ self-reported symptoms include stress, anxiety, depression, skin rashes, headaches, shortness of breath, nausea, and sore throats. The results of several retrospective cohort studies have documented an association between proximity to and density of unconventional natural gas development and birth outcomes. A 2016 study links asthma rates in Pennsylvania to higher exposure to UOGD activity.¹ It is clear that assessment of the level and intensity of emerging health problems is needed.

This Delphi study asked an expert panel to provide their opinions in two parts. Part 1 focused on safe setback distances for residents living and working near UOGD sites, asking for opinions on appropriate set-back

¹ See Discussion section for a review of recent research.

distances for UOGD infrastructure. Those Delphi results have been described elsewhere (EHP Technical Report #2). Part 2, presented here, addresses health outcomes from UOGD.²

The Delphi Process

The Delphi is a systematic method of surveying experts (referred to as panelists) to determine their opinion regarding a complex issue. The surveys are completed in a series of rounds. In each round, the participants respond anonymously to a set of questions and in following rounds receive information about the responses of all other panelists, including their own. Panelists are encouraged to re-assess their own responses on subsequent rounds with a goal of reaching consensus. For this study there were three rounds and consensus was defined as agreement of 70% of panelists.

The Panel

All panelists met at least one of the following selection criteria:

- Researchers whose work has been published in peer-reviewed journals and/or presented at national scientific meetings;
- Scientists employed in government and regulatory agencies;
- Leaders in public policy and environmental advocacy who have been published in the grey literature.

Potential panelists included representatives of federal and state agencies, environmental advocacy groups, health care providers, public health practitioners, and researchers in a range of subject matter including health, environmental science, toxicology, and social science. Eighteen experts from across the USA agreed to be panelists and returned the completed Round 1 questionnaire and consent form. All panelists met at least one of the selection criteria. Tables 1 and 2 show panelist categories of expertise and level of participation.

Table 1. Delphi Panelist categories of expertise

Self-reported profession	Self-reported areas of expertise	Professional field of employment
Researchers/scientists	Air quality; Environmental science; Environmental health; Public health; Medicine/Health; Social science; Water quality; Toxicology	Academic research
Health care providers	Medicine/Health; Environmental health	Private practice; University health centers
Public health practitioners	Epidemiology; Environmental health	State health department; Federal government
Environmental advocates	Policy/Law; Air quality; Environmental science; Environmental health; Public health; Water quality	Environment and Public health organizations
Other	Air quality; Environmental science; Environmental health; Public health; Social science; Epidemiology; other: Risk analysis	Health policy

² UOGD refers to unconventional oil *and* gas development. The terms “natural gas” and “oil” are used in this report when referring to either resource.

Table 2. Delphi Panelist participation in Rounds 1-3

Self-reported Profession	Round 1 N=18	Round 2 N=15	Round 3 N=18
Researcher/scientist	9	6	9
Health care provider	3	3	3
Public health practitioner	2	2	2
Environmental advocate	3	3	3
Other	1	1	1
Gender			
Men	9	6	9
Women	9	9	9

The Delphi Procedure

Round 1

The first round of the Delphi began with two open-ended questions (Figure 3). Experts were asked to address, if possible, all steps in the process from drilling site construction through delivery of the product to the consumer.³ In the questions below, the steps in this process are referred to as “related activities”.

Figure 3. Open-ended questions about health and UOGD sent to all prospective panelists for their responses to initiate Round 1 of the Delphi study

1. What health outcomes do you believe are attributable to hydraulic fracturing and related activities associated with natural gas production? *Please include both direct and indirect health outcomes that you believe are attributable to hydraulic fracturing and related activities. A direct health outcome might be a disease or disorder. An indirect health outcome might be a change in the environment that leads to a disease or disorder.*

2. What health outcomes do you believe are attributable to hydraulic fracturing and related activities associated with oil production? *Please include both direct and indirect health outcomes that you believe are attributable to hydraulic fracturing and related activities. A direct health outcome might be a disease or disorder. An indirect health outcome might be a change in the environment that leads to a disease or disorder.*

³ Steps in the process include well pad construction, well drilling, hydraulic fracturing, compressor stations, pumping stations, processing plants, impoundments, pipelines, etc.

Round 1 Findings

Content analysis identified 181 statements in response to the two open-ended questions. Responses were coded for subject matter. More than twice the number of statements was generated relating health outcomes to natural gas development than for oil development. The difference between gas and oil responses can be explained by the panelists' agreement (94%) that the health outcomes associated with oil were indistinguishable from those associated with natural gas. Responses were most often provided for natural gas but not consistently repeated for oil.

Development of Round 2 Structured Questionnaire

For Round 2, a structured questionnaire was created from Round 1 responses. The questionnaire included all statements (n=181) and each panelist received the document with his/her own responses highlighted. Panelists were asked to indicate their level of agreement with each statement using a 5-point scale: strongly agree, agree, not sure, disagree, and strongly disagree. Panelists were prompted to provide a rationale for their decisions when they strongly agreed or agreed with a statement.

Round 2 Findings

Responses to Round 2 were used to revise the structured questionnaire for Round 3. Statements that were similar were combined to reflect emerging consensus. This process resulted in 39 statements of specific health outcomes, community effects, and general statements (Table 3a and b).

Round 3

The Round 3 questionnaire provided the panelists' aggregated responses for each statement and any rationales provided by the individual panelists for their responses. For this final round, panelists were asked to review the distribution of responses provided and then indicate their level of agreement with each statement. The 39 statements listed on Table 3a and b were used for the Round 3 questionnaire.

Table 3a and 3b: Panelist statements on health outcomes derived from responses to Round 2 for natural gas (3a) and oil (3b). (n=39)

Table 3a. Unconventional natural gas development: related health outcomes

Category	Statement
Specific Health Outcomes	Birth outcomes including low birth weight, premature birth, perinatal complications
	Birth outcomes: reduced sperm count
	Cancer specific tumors such as pulmonary
	Cardiovascular including cardiovascular disease, risk, hypertension
	Cardiovascular cardiac arrhythmias

Category	Statement
Specific Health Outcomes	Cognitive problems: including cognitive impairment, poor memory
	Cognitive problems: “mental spaciness”
	Headaches
	Gastrointestinal complaints including gastric pain, indigestion, weight loss
	Nausea
	Nose and throat including nose bleeds and sinus problems
	Problems related to breathing including difficulty breathing and asthma, COPD, bronchitis
	Problems related to breathing respiratory infections
	Problems related to sleep including insomnia, interrupted sleep, poor quality sleep
	Problems related to psychological wellbeing including problems with mood, anxiety, anger, irritability, fear. (NOTE: Stress is not included in this category.)
	Problems related to stress including feelings of stress and short-term (e.g., muscle tension) and long-term (e.g., inflammation) physiologic symptoms related to stress
	Problems related to skin including rashes
	Neurological symptoms including seizures, tics, tremors
	Kidney/liver diseases
	Shale Gas Syndrome: A group of symptoms that includes headaches, nosebleeds, vomiting, diarrhea, and skin rashes (defined by panelists)
	Occupational exposures including accidents--vehicular, explosions, fires-- and exposures--VOCs, silica, chemicals
	Accidents and injuries including traffic accidents, explosions, and fires
Community Effects	Boomtown Effects including increased sexually transmitted diseases and increased suicide related to economic well-being
	Increased health care utilization
General Statements	Cannot directly attribute health outcomes to unconventional natural gas development
	Cancer is a <i>possible</i> outcome/need to track

Table 3b. Unconventional oil development: related health outcomes

Category	Statement
Specific Health Outcomes	Cancer including increases in cancer rates generally and association with specific cancers such as lung, breast
	Problems with breathing including shortness of breath, asthma, bronchitis
	Reproductive health including infertility and malformations of embryos
	Headaches
	Problems related to skin including rashes, redness
	Neurological problems including dizziness, fainting, loss of consciousness, tingling in hands and feet
	Nausea and vomiting
	Eye, nose, and throat problems including irritation, burning, blurred vision
	Occupational exposures including vehicular accidents, explosions, fires, inhalation injuries
	Accidents and injuries including derailments and vehicular accidents associated with transport, and explosions
Community Effects	Boomtown Effects including increased sexually transmitted diseases and increased suicide related to economic well-being
General Statement	Problems with oil are comparable to those associated with gas
	Data are insufficient to attribute health outcomes to oil

Results

1. More than 70% of panelists agreed with 22 statements on the relationship between health and UOGD, 15 associated with unconventional natural gas and 7 associated with unconventional oil development (Table 4). These statements include 12 specific health outcomes, cancer as a possible outcome that should be tracked, increased health care utilization and “Boomtown” effects associated with exposure. There was also agreement that the health outcomes caused by exposure to both oil and gas are comparable.

2. More than 70% of the panelists ranked the relationship between five specific health outcomes and unconventional natural gas development as uncertain: reduced sperm count, neurological symptoms, gastrointestinal complaints, kidney/liver diseases, and malignant tumors (related to both natural gas and oil).

3. More than 70% of panelists *disagreed* with the statement “Cannot directly attribute health outcomes to unconventional natural gas development”.

4. Ten of the 39 statements failed to achieve the level of consensus. For natural gas, those statements addressed: nausea; cardiac arrhythmias; cognitive problems including cognitive impairment and poor memory; “mental

spaciness”; and respiratory infections. For oil extraction, those statements addressed: reproductive health; skin problems; neurological problems; nausea and vomiting; and “data are insufficient to attribute health outcomes to oil”.

Table 4: Panelists reached consensus ($\geq 70\%$) on 22 statements relating health and UOGD

Statement	Impacts Related to Gas Extraction	Impacts Related to Oil Extraction	Category
Occupational exposures including accidents (vehicular, explosions, fires) and exposures (VOCs, silica, chemicals)	100%	100%	Health Outcome
Problems related to stress including feelings of stress and short-term (e.g., muscle tension) and long-term (e.g., inflammation) physiologic symptoms related to stress.	100%		Health Outcome
Problems related to psychological wellbeing including problems with mood, anxiety, anger, irritability, fear. (NOTE: Stress is not included in this category.)	100%		Health Outcome
Cancer is a <i>possible</i> outcome/need to track	100%		General Statement
Accidents and injuries including traffic accidents, explosions, and fires (gas); including derailments and vehicular accidents associated with transport, and explosions (oil)	94%	94%	Health Outcome
Problems with oil are comparable to those associated with gas		94%	General Statement
Problems related to breathing including difficulty breathing and asthma, COPD, bronchitis (gas); including shortness of breath, asthma, bronchitis (oil)	94%	88%	Health Outcome
Boomtown Effects including increased crime, drugs, alcohol, sexually transmitted diseases (gas); including increased sexually transmitted diseases and increased suicide related to economics (oil)	94%	76%	Community Effects
Problems related to sleep including insomnia, interrupted sleep, poor quality sleep	89%		Health Outcome
Increased health care utilization including hospitalizations and visits	83%		Community Effects
Headaches	83%	76%	Health Outcome
Cardiovascular including cardiovascular disease, risk, hypertension	82%		Health Outcome
Birth outcomes including low birth weight, premature birth, perinatal complications	78%		Health Outcome
Problems related to skin including rashes	78%		Health Outcome
Eye, nose and throat problems including nose bleeds and sinus problems (gas); including irritation, burning, blurred vision (oil)	78%	75%	Health Outcome
Shale Gas Syndrome: A group of symptoms that includes headaches, nosebleeds, vomiting, diarrhea, and skin rashes (defined by panelists)	71%		Health Outcome

Discussion

This panel of experts identified 39 potential health outcomes associated with UOGD (Table 3a and 3b), reaching consensus on 22 statements (Table 4). Panelists were asked to identify health outcomes they believe are associated with unconventional natural gas extraction and, in a separate question, to identify health outcomes they believe are associated with extraction of oil. Because the panelists agreed with the statement that the health outcomes associated with oil extraction are similar to those associated with gas, results suggest that it is not possible or practical to separate outcomes from oil and gas. Yet, consensus was reached on some statements that referred to both gas and oil, or to either gas or oil. Six health outcomes were specifically associated with both:

Health outcomes related to both oil and gas

1. Occupational injuries
2. Accidents and injuries
3. Problems associated with breathing such as asthma
4. Headaches
5. Nose and throat problems such as irritation, nose bleeds, and sinus problems
6. “Boomtown” effects such as crime, drugs, alcohol, and sexually transmitted diseases (community effect/indirect health outcomes)

Seven health outcomes were associated with unconventional gas extraction. The additional results for natural gas impacts may reflect the fact that more panelists were familiar with impacts from natural gas development than with oil development.

Health outcomes specifically related to gas

1. Stress
2. Psychological wellbeing
3. Problems with sleep
4. Cardiovascular disorders
5. Adverse birth outcomes
6. Skin
7. Shale Gas Syndrome

Experts agreed that cancer was a *possible* outcome of exposure to unconventional natural gas development and that it needed to be tracked, and that health care utilization was associated with UNGD.

The panelists also reached consensus that the relationship between five health outcomes and exposure to unconventional gas and/or oil extraction was uncertain:

Health outcomes panelists were uncertain about in relation to either gas or oil

1. Reduced sperm count (gas)
2. Neurological symptoms (gas)
3. Gastrointestinal complaints (gas)
4. Kidney/liver diseases (gas)
5. Malignant tumors (gas and oil)

Reports supporting the Delphi results

The scientific evidence linking health effects and exposure to UOGD focuses primarily on the relationship between health and exposure to unconventional natural gas development. Consistent with the Delphi findings, reports in the scientific literature and media document the prevalence of occupational injuries, such as burns (2), and fatalities, in the oil and gas industry. Despite a decline in fatalities in recent years, the fatality rate of 25/100,000 workers employed in oil and gas extraction is 7 times higher than any other occupational group (3). Accidents and injuries related to vehicular traffic in communities are documented (4), as well as train derailments and industrial spills (5).

“Boomtown” effects have been well-documented in communities with UOGD that experience an influx of transient worker populations, with or without families (6,7). Increased health care utilization has also been documented in these communities; Jemielita et al. (8) demonstrated an association between increased inpatient prevalence rates of diagnoses related to cardiac, neurologic, dermatologic, oncologic, and urologic systems disorders with density of UOGD wells in three Pennsylvania counties. Birth outcomes including congenital heart defects (9), preterm birth (10), low birth weight and small for gestational age (11) have also been associated with exposure to UOGD. Scientific literature also identifies skin rashes and respiratory problems (12), and a 2016 study associates higher incidences of mild asthma exacerbation, documented in hospital records, with Pennsylvania residents who have greater exposure to UOGD wells (13).

Community-based reports

Health outcomes have also been documented by numerous media outlets (newspapers, video) and in the gray literature. The Delphi results support some but not all findings from community-based studies. Multiple community-based studies report stress and psychological problems in communities experiencing intense unconventional natural gas development (14, 15, 16). These studies also report combinations of the health outcomes endorsed by the Delphi panel: respiratory disorders such as asthma, problems with sleep, headaches, cardiovascular problems such as hypertension, skin conditions such as rashes, and nose and throat problems such as irritation or nose bleeds.

Some problems reported in community-based studies are not validated by this Delphi. The panelists did not endorse a relationship between exposure to unconventional natural gas extraction and cognitive problems or between exposure to oil extraction and reproductive problems, neurological symptoms, skin disorders,

gastrointestinal problems including nausea and vomiting, kidney diseases, or liver diseases. The panelists also did not endorse a relationship between exposure and specific cancers, although they agreed that cancer is a possible outcome and should be tracked.

EHP health survey

The Delphi results are also consistent with findings from EHP's health survey data. A review of 186 health intakes conducted by EHP shows that for residents living within 1 kilometer of shale gas activity the primary adverse health effects reported are sleep disturbance, headache, throat irritation, stress/anxiety, cough and shortness of breath. We also find that residents living in areas with higher production of shale gas report higher numbers of health impacts.

The relationship between proximity to UOGD and health risk

When paired with the results from the Delphi questions addressing setback distances (EHP Technical Report #2) a serious and growing concern for the risk to public health emerges. Panelists reached consensus that UOGD should be located at least ¼ mile from places where people live, work and play and 50% agreed that 1 - 1¼ mile may be more appropriate. Panelists further agreed that vulnerable populations need extra consideration, possibly through the implementation of additional setback distances. Health Impact Assessments were also recommended to better define public health risk near UOGD.

Limitations

The results of this Delphi should be interpreted with the understanding that, while this group of panelists is highly qualified, another group of panelists with more varied backgrounds may reach a different consensus and further research is warranted.

In the absence of comprehensive epidemiological data, the findings of the Delphi coupled with the results from recent health studies argue for caution in the expansion of UOGD. Overall, there is a need for health-focused precautions to be put in place and for closer examination of the links between UOGD and adverse health impacts. A full report on this study is currently in preparation for peer review.

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Our mission is to respond to individuals' and communities' need for access to accurate, timely and trusted public health information and health services associated with natural gas extraction.

Conclusions

A panel of experts identified 39 outcomes potentially related to UOGD exposure. Experts reached consensus on 22 statements relating health outcomes to either unconventional natural gas or unconventional oil development or both. Of these:

- 1. 12 specific health outcomes are associated with UOGD exposure.**
- 2. Cancer may be a health outcome and should be tracked in regions of UOGD.**
- 3. Increased health care utilization and “Boomtown” effects are associated with UOGD exposure.**
- 4. The health outcomes associated with exposure to both oil and gas are comparable.**
- 5. Other methods of assessing the risk to public health need to be implemented, including Health Impact Assessments (HIAs) which can be used to establish regulatory policy.**

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12 Adverse Health Outcomes

Occupational Exposures

Stress

Psychological wellbeing

Accidents and injuries

Breathing problems

Sleep problems

Headaches

Cardiovascular problems

Birth outcomes

Skin problems

Eye, nose and throat

Shale Gas Syndrome