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The League of Women Voters of Pennsylvania

SHALE GAS EXTRACTION AND PUBLIC HEALTH

A Resource Guide

Marcellus Shale Natural Gas Extraction Study
2013 Addendum

Shale and Public Health Committee
Lead Writer, Vera Bonnet

Acknowledgments

This Resource Guide on Shale Gas Extraction and Public Health is an Addendum to the original Marcellus Shale Study Guides developed in 2009-2010 by the League of Women Voters of Indiana County. The Shale Gas Extraction and Public Health Resource Guide was developed and researched over months in 2012-2013, written and edited in 2013 by Indiana County League member Vera Bonnet, who served as Lead Writer and Editor. Members of the Shale and Public Health Committee of the League of Women Voters of Pennsylvania, and additional members of the Indiana County League, contributed to the research and study, development, writing and review of the guide.

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There have been many studies and articles written and data collected relevant to the study of the public health impact of shale gas development. While the committee has reviewed many studies and articles in the course of writing this guide, their review – and what is covered in this resource guide - is by no means exhaustive. Furthermore, this is a rapidly developing field with change occurring constantly. The reader is advised to follow this issue to keep up with the changes.

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SHALE GAS EXTRACTION and PUBLIC HEALTH

INTRODUCTION

In the United States, the practice of drilling before consultation with public health officials is standard procedure. Unconventional drilling for natural gas is no exception. Public health safety measures provided by laws governing the environmental impact of industry are currently lessened for the oil and gas industry. This is because of partial exemptions from several federal environmental laws since 2005. The most frequently mentioned concerns involve the quality of water and air in the vicinity of the wells where the actual horizontal hydraulic fracturing (also referred to as "fracking' or unconventional gas extraction) takes place. However, a more systematic approach to the subject requires inclusion of the entire cycle of extraction, processing, transmission, transportation, storage and distribution.

The public health impact is multifaceted. Worker health and safety issues range from truck drivers subcontracted by the gas producers to sand miners who supply the huge quantities of fine-grained silica particles needed for fracking. Less direct impacts involve the deterioration of community health resulting from the boom-and-bust cycle that can occur with extractive industries. Potential short- and long-term impacts on the environment, such as seismic activity and climate change, also have a bearing on public health.

The scope of the research has grown as the industry has developed. As a result, federal and state agencies are finding new strategies for examining the evolving questions. In the first ten years during which slick-water horizontal hydraulic fracturing technology was first used, starting in Texas in 1998, there was little research on the impact of unconventional gas extraction on human health. Although hydraulic fracturing is not new, dating back through the 1940's, the technologies used now, depth of drilling, pressure, and volume of chemicals and water is new, as is the extent of use of these technologies. According to Howarth (2012), "over half of all the shale gas that has ever been developed in the world has been produced in the last 3 years... (thus)… almost all peer-reviewed scientific publications on the environmental health and public health consequences of shale gas have been published since April 2011." The pace and scope of public health research is increasing.

Many government entities involved with public health are under the umbrella of the Department of Health and Human Services. These include: NCEH, the principal federal public health agency responsible for hazardous waste and public health; the National Institute for Occupational Safety and Health (NIOSH) dealing with worker safety; and the National Institute for Environmental Health Sciences (NIEHS) which is responsible for evaluation of water and air quality, among other mandates.

Other research has originated in the Department of Energy, and the Environmental Protection Agency, with additional input from the Science Advisory Board, the Government Accounting Office and the U.S. Geological Survey. Multi-agency projects include senior leadership from the U.S. Geological Survey, the Occupational Safety and Health Administration, and the Centers for Disease Control and Prevention (CDC). Among the non-governmental agencies doing research on health and fracking is the National Science Foundation which has conducted several health-related studies.

On April 2012, President Obama issued an executive order authorizing a multi-agency task force to "support safe and responsible development of unconventional domestic natural gas resources." The 13-agency working group is tasked with creating "sensible, cost-effective public health and environmental standards to implement federal laws and augment state safeguards." The agencies designated to take part in the new monitoring and regulatory group include the departments of Defense, Interior, Agriculture, Commerce, Health and Human Services, Transportation, Energy, Homeland Security, the Environmental Protection Agency, the Council on Environmental Quality, the Office of Science and Technology Policy, the Office of Management and Budget, and the National Economic Council (ICIS, 2012).

The most significant exception to the practice of drilling before consultation is found in the state of New York. There, Governor Cuomo has imposed a moratorium on fracking, which has delayed a long-awaited decision on whether to allow slick water horizontal hydraulic fracturing for natural gas drilling in the state. Before allowing industry to move forward in the state, New York's Department of Environmental Conservation must conduct a review of a health impact analysis and advise the governor on its findings (Esch, 2012).

Unlike New York, Pennsylvania has allowed unconventional gas extraction since 2005. Thus Pennsylvanians rely on federal and state regulations and the industry's best practices as the primary means of protecting public health. The state's willingness to accept the risks associated with drilling is in stark contrast with the caution of Pennsylvania's northern neighbor. Bamberger (2012) has described this choice as "an uncontrolled health experiment on an enormous scale."

TWO PERSPECTIVES

Before discussing the results of research, an understanding of the roles of the major players is in order. The ultimate aim of both the environmental health researcher and the public health practitioner is to protect human health, but the emphasis of their respective work is different.

Environmental scientists approach health impacts using a variety of research techniques and disciplines. These researchers aim for the highest standards of scientific accuracy which, among other things, depend on replication of results by other scientists. This practice requires future researchers to reproduce every aspect of the investigation in order to reliably compare results. However, this kind of rigorous scientific proof is not always possible when working on the highly complex system that is the environment.

The mandate of the public health practitioner is to act to alleviate illness in individuals who present symptoms. While health care workers do not conduct research per se, they collect daily evidence from their contacts with residents of the affected areas. In their role as humanitarians, doctors and nurses are concerned about the source of the problem and the extent to which it can be identified and eliminated. Their collective data about individual symptoms can provide invaluable evidence of impacts on humans from environmental causes.

The distinctions between researchers and health care practitioners are elaborated in the following discussion.

THE SCIENCE OF ENVIRONMENTAL HEALTH

Environmental health is a relatively new field, defined by the World Health Organization as the study of "all the physical, chemical, and biological factors external to a person . . . It encompasses the assessment and control of those environmental factors that can potentially affect health." Other observers have included psychosocial factors as well (Pope, 1995).

The following major methods of investigation are designed to explore different aspects of the problem. Each approach has its strong points and limitations, and each contributes information towards understanding the situation under investigation, with evidence that can answer different questions. The evidence is collected by various methods and is subjected to more or less rigorous testing. The most rigorous research includes old-fashioned lab work with individual chemicals. Epidemiological studies use statistical methods that have been greatly aided by the use of computers which can digest large data sets. The fields of study, from least to most rigorous, include:

- **Surveys and self-reports.** Research on health impacts includes surveys of residents in the affected areas who report on various changes in their health which have occurred after the installation of a gas well. These "self-reports" can also be found on the Internet and they are frequently cited as evidence of the danger of fracking. While the reliability of self-reports is compromised, these reports are useful as indicators of possible problems and open up areas for further research. As discussed below, public health officials and physicians have a responsibility to help those who report symptoms and to attempt to eliminate the cause(s) of the problem even if those symptoms do not meet the highest standards of scientific proof.

- **Exposure assessment and analysis.** These fields involve an examination of how contaminants in the environment affect a living being. The assessment is the final step of the process which begins with the contaminant's release. An assessment measures the amount of the contaminant which can be absorbed, and at what rate the organism will be affected. Because exposure assessments deal primarily with humans, they are good tools for public health practitioners. **Analysis** is used to identify and quantify exposures. While this research methodology does not directly study health impacts, it provides a link in the understanding of the overall problem by

  1) describing environmental exposures that may lead to a particular health outcome;
  2) providing information about exposures that can be further clarified in a toxicology study, or
  3) assessing risk if a substance appears to exceed recommended levels.

  NOTE: Exposure analysis requires baseline measures to be taken before the event has taken place, so that these measures can be compared to impacts after the event has taken place. This requirement has been difficult to meet in many rural areas where monitoring water contamination and air pollution has not been a routine practice. As baseline measurements become more common as an industry practice, this research technique becomes more viable.

- **Toxicology** can be based on experiments humans or with animals. The studies involve trials using exact dosages of a toxin to discover the health impact following the rule that 'dose makes the poison.' While such a study incorporates the elements of experimental research (i.e., identical treatments, a control group for comparison, statistically significant results), there are obvious limits to applying the results of animal studies to human subjects. This is not a reason to ignore animal studies. Animals can provide critical epidemiological insights in their capacity as "sentinels" for human exposure. Like canaries in the coal mines, they indicate dangers ahead.

- **Environmental epidemiology** often deals with entire communities, including humans and animals. Because the toxins are in the environment, dosages are unclear, and the researcher has no control over the source. The epidemiologist cannot predict that a particular individual will suffer an adverse consequence due to a particular event. The best an epidemiologist can say is, "if a particular chemical . . . [was] not in the environment, some number out of every hundred people who got sick would have remained healthy, and some number of those who died might still be alive" (Davis, 2002). These results are not the "smoking gun" that can make or break a court case, but they are nonetheless based on sound statistical principles drawn from a wide array of available evidence and as such, the most rigorous conclusions can be drawn.

Despite the increasing pace of research and the resources applied to improving methods, NIEHS Senior Advisor John Balbus, M.D. stated as recently as last year, that "the health system finds itself lacking critical information about environmental health impacts" (Loose, 2012).

LIMITATIONS OF RESEARCH

Surveys and "self-reports" are the least reliable sources of information. Surveys can be done by mail, or face-to-face and each method has its pros and cons. Not only is the wording of the survey questions critical; so is the size of the sample. Generally speaking, the larger the sample size, the more accurate the results will be. Results can be skewed, if only because people are suggestible and simply by focusing attention on the problem, the researcher can prompt an answer. Even when the problem is verified by a physician or other health professional, the research does not meet a rigorous standard of proof because surveys cannot provide evidence of a direct cause-and-effect relationship between the health of the person and the drilling activity. Nevertheless, people's perceptions of their own health are a useful place to begin to understand the general nature of the problem.

In the specific case of unconventional gas extraction studies, toxicology research is limited by the fact that the industry is exempt from disclosing the complete chemical composition of fracking fluids. The composition of these fluids is protected as "trade secret" information, although more companies are now voluntarily disclosing the information, primarily via FracFocus, the national hydraulic fracturing chemical registry, which maintains the website fracfocus.org. Currently ten states, including Pennsylvania, designate fracfocus.org as their official chemical disclosure website. However, companies who disclose may not list all the chemicals, describing some as "proprietary." Also, the site is designed to provide information on wells fractured prior to January 2011, or to the time the company registered to participate in the website; earlier information may not be made available to the public. If the complete composition of the site-specific fracking fluid were made available to researchers, the accuracy of research would be considerably enhanced.

Certain chemicals known to be used in fracking (such as methyl alcohol, hydrochloric acid, and boric acid, to name a few) have been proven to be hazardous to humans. But, as stated by former Pennsylvania State Representative Bud George, who chaired the Environmental Resources and Energy Committee, "without knowing the specific concentrations ... the level of harm ... cannot be predicted" (George, n.d.).

Even if the exact chemical breakdown of the horizontal hydraulic fracturing fluids were known, the complexity of the environmental processes throws a wrench into even the best-designed studies. After all, what matters to our health is what comes OUT of the well -- which is somewhat different from what goes INTO the well. For example, the FracFocus website states that "issues unrelated to chemical use in hydraulic fracturing such as Naturally Occurring Radioactive Material... (are) beyond the current scope of the site." Gas wells and water wells sit on geologic formations which differ from one site to the next. Depending on the composition of the strata through which the fluid must pass, as well as the chemicals that are injected, the results of an assessment may differ from well to well.

To further complicate matters, although certain health impacts seem to present themselves immediately, others, such as cancer, may not be evident for years. Even if evidence of illness is presented, the relationship between that finding and shale gas extraction may be inconclusive. For instance, epidemiologic measures of women's health have shown higher levels of breast cancer in Texas counties where fracking was first used fifteen years ago, relative to other counties in that state. Meanwhile, nationally, breast cancer rates have been dropping. Although the higher invasive breast cancer rates occurred in the same Texas counties which saw the most intensive gas drilling development and points of emissions in the Texas Commission on Environmental Quality's 2010 inventory (according to Heinkel-Wolfe, 2011), researchers are reluctant to attribute the phenomenon to the gas industry. Correlation does not necessarily indicate causation, and the incidence of breast cancer in these counties could be attributable to other factors (Begos, 2012). Well-designed longitudinal studies, collecting data over a period of years or even decades, are needed.

In addition to these obstacles, environmental assessments for entire communities may face political hurdles. One major health impact assessment designed for Garfield County, CO by the University of Colorado School of Public Health was halted after the first year of a three-year study, when local officials decided to withdraw funding (Scofield, 2011; Shogren, 2012). The study was critiqued by the industry for measuring air samples close to Interstate 70 (Mickley and Blake, 2012)

Given the many variables that may influence a particular event, it is difficult "to draw good, solid conclusions about whether [unconventional drilling] is a public health risk as a whole." (Lustgarten, 2011). Uncertainty has a ripple effect, creating anxiety in lay people who live within the area of potential exposure. Ultimately, the question is, how much illness is required before "anecdotal evidence" adds up to "plausible evidence" that, in turn, mandates that humanitarian action be taken. This question is the purview of the public health professional.

THE USES OF RESEARCH

Christopher J. Portier, director of the National Center for Environmental Health (NCEH) and the Agency for Toxic Substances and Disease Registry (ATSDR) stressed the importance of research in a recent NPR interview saying that a "well-conducted study ... could help us better understand if there's an impact, what its magnitude [is], how we should avoid having that impact if there is one" (Stein, 2012).

As investigators seek to refine their methods, public health concerns tend to be delegitimized. Confronted with a paucity of hard scientific evidence for establishing a clear path between fracking and various negative health impacts, scientists are playing catch-up with a well-funded and fast-moving industry. While studies proliferate and governments and individuals wait for conclusive findings which meet our culture's faith in the scientific process, there is continued tension between public health and industry objectives.

Corporate responsibility has increasingly become part of the business ethic, but it is undeniable that industry has a clear stake in downplaying risks and justifying current extraction methods. The corporate practice of exploiting uncertainty created by inconclusive experimental findings has been well-documented; see, for example, writings on the tobacco industry campaign to deny the lethal effects of cigarette smoking by Devra Davis *(The Secret History of the War on Cancer, 2007).*

Furthermore, research can be used to obfuscate as well as to clarify a problem. In a recent case, a University of Texas study which purported to show that fracking had no effect on water quality, the lead researcher was found to have been paid several million dollars by gas industry sponsors (Wogan, 2012). Similar allegations in the same year forced the University of Buffalo to close a seven-month-old shale gas research institute when it was shown to be tied to industry (Thompson, 2012).

A study by the American Petroleum Institute (API) showing low levels of methane gas release was challenged by a group of researchers known as Physicians, Scientists and Engineers for Healthy Energy (PSE). The PSE accused the API of failing to use a systemic approach, using a biased survey instrument, suggesting the desired answers, and cherry-picking results, among other things (Howarth, 2012).

The industry has also critiqued some of the scientific research to date, accusing researchers of having insufficient data to support their conclusions, and using imperfect methodologies (see for example, Steve Everley's and other blogs on the Independent Petroleum Association of America's Energy In Depth website).

"No matter who backs which study, the studies with the most valid, replicable data will win out. That's how science works" (Nocera, 2013). In the meantime, as unconventional drilling continues, public acceptance can be wooed with well-funded PR campaigns, emphasizing issues of national security and job creation. To protect public health, Pennsylvanians can prompt public deliberation and responsible decision-making by advocating for more research and better funding to improve monitoring and promote preventative best practices during all phases of natural gas operations.

THE PUBLIC HEALTH APPROACH

Unlike clinical professionals (doctors and nurses) who treat individuals after they've become sick or injured, public health professionals are primarily concerned with prevention. They are tasked with implementing educational programs, developing policy, providing services, regulating health systems and conducting research. Public health practitioners are heavily involved with issues of social justice, such as health care equity, quality, and accessibility (Association of Schools of Public Health, n.d.).

For these professionals, the existence of a plausible relationship between observable health problems and the proximity of a likely source is sufficient cause for instituting preventative measures and policies to protect the public. Inaction is a form of action. On the other hand, industry is reluctant to support additional government intervention without conclusive evidence showing negative health impacts, even though taking precautionary measures is a common practice in this country. (As an example, the U.S. Food and Drug Administration (FDA) subjects all new drugs to testing before allowing them to be sold to consumers.)

In 1998, the Science and Environmental Health Network (SEHN) adopted a "precautionary principle," stating that health professionals must take "anticipatory action" even in the absence of scientific certainty. By shifting the burden of proof to those responsible for the potentially harmful activity, this standard parallels the FDA's operating procedures, by requiring responsible parties to "vouch for its harmlessness and be held responsible if damage occurs" (SEHN, n.d.).

In the past ten years, the **precautionary principle** has slowly gained traction in the US. In 2003 the Board of Directors of the American Nurses Association adopted it, re-stating the principle in the following terms: "if it is within one's power, there is an ethical imperative to prevent rather than merely treat disease, even in the face of scientific uncertainty"(McDermott-Levy, 2012).

This is a significant endorsement since nurses are often the initial, and sometimes the only point of contact for people seeking medical care. A workforce of 2.2 million trained professionals, they are the largest group of health care providers in the United States, many of whom visit patients in their homes. With first-hand knowledge about potential problems in the community, including those related to possible environmental exposure, on-site visits provide opportunities to both detect problems and to initiate interventions (Institute of Medicine Report, 1995).

While the clinicians' primary job is to treat the sick, the accumulated knowledge of physicians does have a place in public health research. However, without an organized effort to gather and interpret the evidence collected from individual cases, this information can be lost. New research initiatives will take on this task. For instance, the Geisinger Hospital System, located in the northern tier of Pennsylvania, plans to mine years' worth of data to determine if asthma rates among patients had changed after the gas industry began operating in the region. The New York Times' Drilling Down series described a hospital system in Texas reporting high incidence of asthma in young children in counties with some of the heaviest drilling (Urbina, 2011). With their large store of electronic health records, Geisinger is in an ideal position to conduct research on asthma in Pennsylvania and other health topics. In February, 2013 Geisinger received a $1 million grant from the Degenstein Foundation to work on the planning and execution of the study in collaboration with two other health systems (Socha, 2013).

Since February 2012, the Southwest Pennsylvania Environmental Health Project (SWPA-EHP), a private non-profit environmental health organization, has been operating in Washington County for the specific purpose of providing advice and referrals to residents in this heavily drilled county as well as to serve as a resource center for physicians and researchers. Staff of the project performed a comprehensive literature review (available on request). They concluded that research (from animal models, human clinical observations, and epidemiological studies) converged to implicate the practice of unconventional hydraulic fracturing as a significant concern to public health, even if the evidence would not be sufficient to prove legal liability (Brown, 2012).

HEALTH IMPACTS

A study of the materials known to be used in natural gas extraction resulted in a list of 353 chemicals (Colborn, 2011). By searching through existing literature on the lethality of these chemicals, the researchers came to the following conclusions:

75% of the chemicals have been known to affect the skin, eyes and other sensory organs, and the respiratory and gastrointestinal systems
40% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys
37% have been known to affect the endocrine system
25% could cause cancer and mutations

The following chart, compiled by the Medical Society of the State of New York (Bushkin-Bedient, n.d., used by permission), provides some specific effects of a dozen commonly used fracking chemicals.

Selected Toxins Associated with Hydraulic Fracturing

Chemicals	Exposure Route	Effects in Humans	Effects in Animals
Acetic Anhydride	Inhalation Ingestion Eye/skin contact Highly volatile	Severe irritation of eyes, upperrespiratory mucous membranesand skin to very low concentrations - permanent corneal scarring - explosion related injuries	Highly corrosive to eyes, upper respiratory mucous membranes and skin Direct mortality
Arsenic	Oral – drinking contaminated water Inhalation	*IARC Group 1 Carcinogen:* - Adenocarcinoma of the lung - Cancers of skin, digestive tract, liver, urinary bladder, kidney, lymphatic and hematopoietic, meningioma *Noncancer chronic effects:* - Severe peripheral vascular disease, - "blackfoot disease" - arsenicosis: arsenic poisoning	Carcinogen: - Adenocarcinoma of lung - Lymphocytic leukemia - Lymphoma
Benzene	Inhalation Oral – drinking contaminated water	*IARC Group 1 Carcinogen:* -Leukemia (acute myelogenous) *Noncancer acute effects:* Neurological: - drowsiness - headaches - unconsciousness - convulsions - skin - eyes and upper respiratory tract irritation GI: Nausea, vomiting *Noncancer chronic effects:* -blood dyscrasias - aplastic anemia - excessive bleeding - leukopenia - immunosuppression Developmental: - low birth weight, - delayed bone formation	Carcinogen in experimental animals In rodents: - Oral cavity - Malignant lymphoma - Lung Cancer - Mammary gland *Noncancer acute effects:* - Neurologic, immunologic, hematologic - Low toxicity from inhalation - Moderate toxicity from ingestion *Noncancer chronic effects:* Similar to human findings

Chemicals	**Exposure Route**	**Effects in Humans**	**Effects in Animals**
Chlorine dioxide	Inhalation	Severe respiratory and eye irritant, Congestion of lungs, chronic bronchitis Mortality at 19 ppm	Severe respiratory and eye irritant Purulent bronchitis Mortality at 150-200 ppm
Ethylene glycol (commonly known as antifreeze)	Ingestion of contaminated water	Acute: - Neurotoxicity - Cardiopulmonary effects - Renal Low dose effects: eyes, nose and throat	Hepatic and renal damage Fetotoxicity in rodents
Formaldehyde	Inhalation Ingestion in contaminated water or food	*IARC Group 1 Carcinogen:* - nasopharyngeal and sinonasal cancer - lymphohematopoietic cancer *Noncancer acute effects:* Respiratory - Eye, nose and throat irritation *Noncancer chronic effects:* - Respiratory - Eye, nose, throat - Skin irritation; contact dermatitis - Menstrual disorders	Carcinogenic in experimental animals: In rodents: - Nasal squamous cell carcinoma - Leiomyosarcoma of stomach, intestines - Lung cancer *Noncancer acute and chronic effects:* - Lesions on nasal epithelium and lower respiratory system - Weight loss
Lead	Inhalation Ingestion Dermal contact	*IARC Group 2B Carcinogen:* Associated with cancer of: - Lung - Stomach - Urinary bladder *Noncancer effects:* - Neurotoxicity (especially fetal and childhood development) - Kidney damage - Anemia - Immune system - Cardiovascular system - Male infertility (decreased sperm count)	Carcinogenic to experimental animals: Adenocarcinoma of the kidney Tumors of brain Hematopoietic system Lung Noncancer effects: Birth defects
Phenol	Inhalation Ingestion Eye/skin contact Absorption through skin	*IARC Group 3 Carcinogen:* (not classifiable in humans) *Non cancer acute effects:* Severe irritation to eyes, skin, mucous membranes - CNS impairment - Damage to liver and kidneys - Mortality following high dose exposure (1 gram oral ingestion is lethal; death associated with respiratory failure) *Noncancer chronic effects:* Systemic disorders including Gastrointestinal, neurological, dermatological	Carcinogenic to experimental animals: Leukemia and lymphoma Non cancer acute effects: Severe irritant of eyes (immediate corneal opacification in rabbits) Irritant of upper respiratory mucous membranes; Neurotoxic to motor centers in CNS (twitching, convulsions) Tachy/bradycardia, hypotension Dyspnea Noncancer chronic effects: Damage to lung, liver, kidneys

Chemicals	Exposure Route	Effects in Humans	Effects in Animals
Toluene	Inhalation Ingestion	*IARC Group 3 Carcinogen* *Noncancer acute effects:* Neurotoxic; fatigue, drowsiness, headaches, nausea, unconsciousness Cardiac arrhythmia Oral ingestion, high dose=lethal (associated with severe CNS depression, pulmonary hemorrhage, myocardial necrosis, and acute tubular renal necrosis) *Noncancer chronic effects:* CNS depression, ataxia, tremors, cerebral atrophy, impaired speech, hearing and vision, Inflammation and degeneration of nasal epithelium, pulmonary lesions Maternal Reproductive : - increased spontaneous abortions Developmental: - neurotoxicant, - attention deficit - cranial-facial and limb anomalies	Acute: Central nervous system depression Immunosuppressed (increased risk of pulmonary infection) Chronic: Hepatic Renal Pulmonary Impaired hearing Developmental toxicant
Uranium-238	Ingestion (food, water) Inhalation	No information on acute effects. *Chronic effects:* Renal toxicity	No information on acute effects. Chronic effects: -Inflammation of nasal mucosa -Renal toxicity
Radium-226	Ingestion (drinking water)	*IARC Group 1 Carcinogen* No information on acute effects. *Noncancer chronic effects:* - anemia - necrosis of the jaw - brain abscess - bronchopneumonia and death (from oral ingestion) - acute leukopenia (from inhalation)	
Radon-222	Inhalation	*IARC Group 1 Carcinogen* No information on acute effects. *Non-cancer chronic effects:* - chronic lung disease - pneumonia - pulmonary fibrosis	Weight loss, hematologic disorders

IARC : International Agency for Research on Cancer: **Group 1**= known to cause cancer in humans and animals; **Group 2A**= probably carcinogenic to humans; **Group 2B**= possibly carcinogenic to humans; **Group 3**= not classifiable as to its carcinogenicity in humans

ppm = parts per million

Using completely different methods, a recent community survey conducted in 14 Pennsylvania counties investigated the extent and types of symptoms most frequently reported by residents in areas of gas extraction (Steinzor, 2013). The 108 respondents lived in 55 households, which were no further than five miles away from a gas production facility. The top 25 symptoms reported were:

1. increased fatigue (62%),
2. nasal irritation (61%),
3. throat irritation (60%)
4. sinus problems (58%),
5. eyes burning (53%),
6. shortness of breath (52%),
7. joint pain (52%),
8. feeling weak and tired (52%),
9. severe headaches (51%),
10. sleep disturbance (51%),
11. lumbar pain (49%),
12. forgetfulness (48%),
13. muscle aches and pains (44%),
14. difficulty breathing (41%),
15. sleep disorders (41%)
16. frequent irritation (39%),
17. weakness (39%),
18. frequent nausea (39%),
19. skin irritation (38%),
20. skin rashes (37%),
21. depression (37%),
22. memory problems (36%),
23. severe anxiety (35%),
24. tension (35%)
25. dizziness (34%).

The Steinzor study does not attempt to measure levels of exposure, nor to assess long-term health effects. Nevertheless, the correspondence between the symptoms described in the Steinzor study and the known health impacts of various chemicals makes a prima facie case for caution in the development of unconventional drilling.

CONSIDERATIONS RELATING TO EXPOSURES TO TOXIC SUBSTANCES

We know that certain chemicals that are either used in horizontal hydraulic fracturing or are by-products of fracking are hazardous to human health. The extent to which these chemicals are involved in air and water pollution as a result of fracking is still to be determined. Before discussing the specifics of different forms of pollution in air and water, there are some general precepts to keep in mind when assessing the current state of knowledge.

1) The potential for health disorders resulting from gas extraction is not limited to the immediate vicinity of the well. Polluted air can be carried up to 200 miles from its source by prevailing winds (TEDX). Furthermore, although any one small engine or even a single drilling site may not emit significant amounts of pollutants, the cumulative effects of air pollutants from many gas wells located in the same general vicinity can be significant enough to meet and exceed regulatory limits. Nonetheless, natural gas pollutant sources are currently regulated as individual point sources in Pennsylvania (Reber, 2012). More obvious, but equally important, contaminated waters could affect large watersheds. In the past there have been limited baseline measurements for air and water quality prior to drilling. While many companies and property owners now routinely test well water prior to drilling and at intervals thereafter, it is often difficult to trace pollution sources over time. This is especially true in areas far from the drilling site or source of accidental release, making it very challenging to know to what extent downstream health impacts can be attributed to shale gas production.

2) We know that health effects may be different for different populations, and vary by duration of the exposure. Acute effects are usually an immediate result of exposure and are generally reversible when exposure ends. Chronic effects tend to appear later, sometimes years later, and are not reversible. People with chronic diseases may experience aggravation of the disease when exposed to certain pollutants. Young children and the elderly are at greater risk, as are pregnant women (EPA, 2010).

For instance, children and pregnant women are particularly susceptible to “endocrine disruptors,” a class of chemicals that mimic hormones and thus derail normal developmental functions. Very small amounts of these chemicals can have an effect on pregnant women, their children and their unborn babies, depending on developmental stage (Colborn, 1993).

Furthermore, although many times chemicals are found to be well below federal limits, these standards are usually designed for healthy adult males who are exposed intermittently during work hours. Risks will be different -- and often higher -- for people who are exposed 24 hours per day, even though the exposure may be at lower levels (Colborn, 2010).

3) Air and water monitors are only effective if they are placed in affected areas for long enough periods to be able to detect the full impact of the pollutant, the fluctuation of the pollutants, and any relationship of weather to pollution concentrations (Colborn, 2010). Furthermore, certain gases (like methane) can travel through water, and under the appropriate conditions, may become airborne. Whether traveling through water or air, many of the chemicals are eventually deposited in the soil where they can accumulate over time and potentially contaminate our foodsheds, especially in areas like Pennsylvania which is primarily agricultural (see section on “Hydraulic Fracturing And Our Food Supply”).

4) Because of the known effects of chemical contamination, air and water are normally regulated by the federal Clean Air, Clean Water and Safe Drinking Water Acts. However the oil and gas industry have been exempted from meeting some of the standards set by these three acts. The so-called Halliburton Loophole, exempting the industry from the Safe Drinking Water Act of 1974 was embedded in the Energy Policy Act in 2005. Other at least partial exemptions for the industry are written into the following legislation (see more detail in LWVIC Study Guide V, 2009-2010):

- National Environmental Policy Act (requiring impact statements for major industrial projects. Because drilling is carried out in scattered sites, the individual sites are exempted.)
- Resource Conservation and Recovery Act (for “cradle to grave” tracking of industrial wastes)
- Comprehensive Environmental Response, Compensation, and Liability Act (“Superfund” tax)
- Toxic Release Inventory of the Emergency Planning and Community Right-to-Know Act

These exemptions from federal oversight do not prevent individual states from passing regulations. Under this system, the states are solely responsible for monitoring and enforcing the regulations (Phillips, 2011).

WHAT WE KNOW ABOUT ENVIRONMENTAL HAZARDS - AIR

A study with three years of air sampling conducted by the University of Colorado concluded that the greatest potential for health impacts from airborne chemicals occurs during the well completion period, when condensate tanks are vented during filling, and methane is flared off. The estimated potential for health risks, based on exposures to air pollutants, was found to be greater for people living closest (within one half mile) to the site (McKenzie, 2012).While the practice of flaring has been banned by the EPA, the rule will not go into effect until 2015. However, some companies have already begun to upgrade their facilities to avoid these problems (Hopey, 2012).

Flaring is not the only time that air pollutants are released during normal operations. Non-methane hydrocarbons are at their highest concentrations during the initial drilling phase. These included 30 chemicals, including several polycyclic aromatic hydrocarbons (PAHs), known to impact the human endocrine system. These can be dangerous at very low concentrations (see above) and have been known to be correlated to lower developmental and IQ scores in prenatally exposed children in urban areas (Colborn, 2012).

Nitrogen oxide and Ozone Precursors - Despite the many exemptions made to federal laws for the gas industry, diesel exhaust, the source of nitrogen oxides, is still on the federal watch list. Diesel fumes have long been known for their lethal impact in urban areas. In the gas extraction process, these fumes are emitted by banks of machinery on the well pad and by vehicles transporting water, chemicals, sand and equipment (Katkins, n.d.). According to John Hanger, former Secretary of the Pennsylvania DEP, “gas drilling is the second largest source of nitrogen oxide pollution on the state (second to coal-fired power plants)” (Phillips, 2011).

These oxides are particularly dangerous when they combine with toxic Volatile Organic Compounds (VOCs) and hydrocarbons to form ozone. Ground level ozone produces harmful smog which causes irreversible damage to the lungs. Chronic exposure can lead to asthma and chronic lung disease. Depending on the duration of the exposure and the concentration of the chemicals, chronic effects can include decreased lung capacity and less commonly, lung cancer, damage to the immune system and neurological, reproductive and developmental problems (TEDX). Respiratory problems and lung disease caused by ozone have been extensively documented by the American Lung Association long before the gas boom, and are a routine part of the EPA Air Pollution Control Orientation Course (EPA, 2010).

In addition to causing respiratory tract infections and asthma, airborne chemicals can also affect the skin, and can cause eye irritation, sore throats and headaches. Other substances of concern are sulfur dioxide (SO2), particulate matter, and hydrogen sulfide (H2S) that are also found in the vicinity of wells (See LWVPA Study Guide #2).

WHAT WE KNOW ABOUT ENVIRONMENTAL HAZARDS - WATER

In the process of drilling and fracking a well for unconventional natural gas extraction, wastewater of varying composition returns to the surface at different rates. Brine is the result of drilling a deep well and boring horizontally into the shale. It is highly salty and can contain rock cuttings. Even when highly diluted, salt levels in brine remain above drinking water levels (*Science Daily*, 2012). Salts found in the brine as well as other chemicals such as barium, strontium, arsenic and naturally occurring radioactive material (NORMS) would normally remain trapped in the deep underground rocks. However, they can become dissolved or mixed with the fluids used during drilling and extraction processes and return to the surface. Once a well is fracked, about a third of injected fluids return as “flowback” after a few days or weeks. Over the life of the well, the remaining wastewater that emerges from the well can be termed “produced” water. It gradually diminishes in quantity over time.

Disposal of wastewater from natural gas extraction is a complex issue that has not yet been fully resolved. In recent years, technological advances have allowed some of the wastewater to be treated and reused in future fracking. In the past, the handling of wastewater has created difficulties for municipal treatment plants that were generally not equipped to remove radioactive or other materials (Hopey, 2011). As a result the water discharged into the rivers was only partially treated.

Compounding other problems that can occur at water treatment plants are bromides. This non-toxic salt compound is converted to brominated trihalomethanes (THMs) when exposed to chlorine used by municipal water treatment plants. THMs are linked with birth defects, bladder cancer and other cancers (Hopey, 2011). According to TEDX, the Superfund Act classifies many of the chemicals found in fracturing fluids and degradation products as hazardous waste.

Certain chemicals found in wastewater are known to disrupt the endocrine system with potential health consequences such as spontaneous abortions, fetal death and irregular fertility cycles. These chemicals can interfere with both human and animal reproduction and may have long-term consequences for agriculture and food production (see section on the food supply).

Released contaminants may be absorbed through the skin, inhaled during daily activities like bathing or showering, or simply by breathing vapors from wastewater stored in pits or tanks. While efforts are made to keep the fracking fluids from entering homes and watersheds, toxic events occur. Casings fail, storage pond liners tear, wastewater trucks overturn -- just to name a few of the problems (Legere, 2010). And these events can have consequences for both humans and animals. The EPA Study on the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, authorized and funded by Congress in 2010, is still underway. Its final report may prove instructive for further research on related risks to public health.

Methane migration - One question that has provoked a lot of interest and has yet to be answered satisfactorily is when, and to what extent does methane gas migrate into ground water. Although there is no peer-reviewed research on the health impacts of methane, the gas is not considered harmful if ingested. However, this colorless, odorless, tasteless gas that is released during drilling, can cause asphyxiation when it enters confined living spaces. In high enough concentrations, it creates a risk of explosion.

A 2011 study of 60 private wells in northeastern Pennsylvania and New York found methane in 85% of the wells, nine of which were above levels where action is recommended. The researchers matched the chemistry of the methane found in the water wells to the methane from the fracked well. This study also indicated that methane levels in private water wells were, on average, 17 times higher when they were within 1,000 yards of a natural gas well (Bauers, 2011).

Gas migration has been a problem for decades in Pennsylvania, and the documentary *Gasland* has made the world aware of the phenomenon. Antics aside, the explosion of a water well in 2009 in Dimock, PA has had ongoing repercussions for residents. On New Year’s Day, 2009 a water well blew up with such force that it tossed a slab of concrete weighing several thousand pounds into the yard of the homeowner. Though no one was hurt in the explosion, subsequently 15 families filed a federal law suit against the drilling company claiming that that the water was undrinkable. The gas company was told by DEP to shut down three wells for contaminating 18 water wells. A moratorium was placed on further drilling and the company agreed to pay for water for the residents, without however accepting responsibility. Since that time both the

DEP and the EPA have become involved in testing the water until the EPA study in Dimock was halted and drinking water deliveries ceased. However, in the course of its investigation the EPA found elevated levels of barium, arsenic or manganese in the water supply of several households (State Impact Topics, n.d.). Hazardous levels of methane were also found in some water wells, which had to be vented as a precautionary measure to prevent explosion.

Most drillers test private water wells within 1,000 feet of a drill site to protect themselves against the presumption that the operator is responsible for problems within that zone. However, these test results are not often shared with the property owners, and these individuals often cannot afford to pay thousands of dollars to get their own certified laboratory test results. Residents who suspect that methane has entered their home through the water lines or other entry pathways, are advised to use fans and ventilation when showering or washing clothes.

Radioactive and Residual Waste – The disposal of residual solids is also problematic given potential for contamination of water and soil. These wastes can include drill cuttings, debris, and materials that settle out from wastewater or remain following evaporation of fluids in open pits. Because these residual solids can contain heavy metals, NORMS, and other contaminants, the trucking of these substances to landfills allows them to accumulate indefinitely (Urbina, 2011). According to the *Observer-Reporter*, a truckload of waste triggered a radioactivity alarm at a disposal site in Yukon, Greene County. Testing revealed it contained nine times the Pennsylvania standard for radium 226 (Kinsell, 2013). The risk of radioactivity in shale operations is the subject of further investigation, including recently announced plans for a study by the Marcellus Shale Coalition and the Pennsylvania Independent Oil and Gas Association (PIOGA) (2013).

According to a *New York Times* report, the level of radioactivity in wastewater produced in Pennsylvania, has on occasion been "hundred or even thousands of times the maximum allowed by the federal standard for drinking water" (Urbina, 2011). Another recently published study, by scientists from Duke University, documented high levels of radium in stream sediments of Blacklick Creek, a tributary to the Allegheny River (Warner, 2013). Radium can lead to cancer because it mimics calcium and as a result is deposited in bones where it causes cancerous mutations. It can also interfere with the bone marrow's ability to create blood cells, causing a condition named "aplastic" anemia.

The use of impoundments or reserve pits to store contaminated water was the subject of a recent study. A soil analysis was conducted on two sites, one which had been drained and the other still in use. It showed varying levels of radioactive contamination in the soil, including alpha, beta, and gamma radiation. The presence of certain radioactive elements was found to exceed regulatory standards by more than 800% (Rich, 2013).

Radioactivity has also entered the environment when the brine itself or salts retrieved from the brine through aeration are used for de-icing roads. This run-off can endanger pets, animals living in the wild, or livestock drinking from a ditch near the side of a treated road. Eventually, the salts and radioactive elements are apt to enter surface waters. With this comes the risk that radioactive matter will eventually accumulate on surrounding lands and be absorbed into the food chain (White, 2012).

SEISMIC ACTIVITY

One method of disposing of frack water involves the use of injection wells. The practice has been used for many waste materials over time. This is especially the case in Ohio, where deep sandstone formations are deemed suitable for injection. There has been a spate of relatively weak earthquakes in the areas where injection wells are being used, which has lead to speculation that the injection of large amounts of frack water has caused these tremors. There are currently eight deep injection wells in Pennsylvania and three more wells planned in Elk, Clearfield and Warren Counties (Phillips, 2011 and 2012).

A study finds a possible link between fluid injection and a 5.7 earthquake in Oklahoma which appears to have produced a series of aftershocks felt in 17 states. The study calculated that during the past four years, the number of earthquakes in central U.S. was 11 times higher than the average rate over the previous 30 years. Researchers hypothesize that there may be a decades-long lag time between injection and the onset of an earthquake and that the first earthquake may have triggered the successive ones (Keranen, 2013).

An outbreak of nearly 800 minor earthquakes over a six-month period occurred in the Greenbriar area of Arkansas, leading to a magnitude 4.7 earthquake on February 27, 2011 (Arkansas Online, 2011). Subsequently, the Arkansas State Oil and Gas Commission placed a six-month moratorium on this type of wastewater disposal. A decline in the number and strength on earthquakes during that period has been recorded. However, researchers say that it is too early to attribute the decline to the shutdown of the wells (Eddington, 2011).

A recent study of earthquakes occurring in the Barnett Shale in Texas showed that injection-triggered earthquakes are "more common than is generally recognized" (Frohlich, 2012). According to the study, the amount of water injected is not likely to be the sole cause of the seismic activity. The earthquakes seem to be linked to existing weaknesses in the earth's crust, such as a fault line which is already in a stressed state. A knowledge of the subsurface geology might help determine when and whether to use deep-well injection for disposal purposes.

HYDRAULIC FRACTURING AND OUR FOOD SUPPLY

The primary stakeholders in our foodsheds are farmers, who must cope with changes in water levels, soil contamination, farmland fragmentation, impacts on crop yields, livestock poisoning and falling reproductive rates. On the other end of the food chain is the public which must rely on food safety inspectors who are not trained to look for microscopic changes in animal organs (Royte, 2012).

Several studies of agricultural impacts have been done. Janna Palliser reports [Science Scope, March 2012] that a study of animals exposed to fracking wastewater describes health effects including sudden death experienced by cows, goats, chickens, dogs, cats and koi. These findings were supported by a recent peer-reviewed study, reported in *The Nation* (Royte, 2012), that also suggested a link between fracking and illness in food animals.

The research was conducted by Michelle Bamberger, a veterinarian, and Robert Oswald (2012), a professor of molecular medicine at Cornell University. Based on case studies of twenty-four farms in six shale gas states, they found that accidental or incidental exposure to fracking chemicals resulted in the death of 17 cows (Louisiana), 70 cows (Pennsylvania), and smaller numbers in other states. Other animals experienced neurological, reproductive and serious gastrointestinal problems.

Bamberger and Oswald's study of exposures in farm animals includes a case in which a herd of 40 cows was exposed to contaminated water, resulting in the death of half the herd, and an unusually high number of stillborn and stunted calves. This case is of special interest, because the same farmer pastured another 60 head separately, with no access to the contaminated water. This "control group" showed no adverse effects during the same time period (Bamberger, 2012). The authors state a concern that meat products from animals that survive chemical exposures will end up in the food supply.

Finally, the U.S. Forest Service reported that hydrofracturing fluid applied to the soil of West Virginia's Monongahela National Forest killed more than half the trees in the area exposed and drastically changed the soil chemistry. The study showed that the fracking fluid also caused severe damage and death to ground vegetation. Surface soil concentration of sodium and chloride increased 50-fold but declined over time (Adams, 2011). These results illustrate what could potentially happen to fruit trees and vegetables in the foodsheds (Cernansky, 2011).

NOISE LEVELS AND NATURAL GAS DRILLING/PRODUCTION

For the duration of the drilling phase, noise emitted from drilling Marcellus Shale natural gas wells is very intense (80-94 dBA). Construction noise can be intermittent or fairly constant and typically lasts for several weeks, 24 hours per day (Sutter County, nd). On or near these sites, OSHA requires workers to wear hearing protection devices to prevent permanent hearing loss, as it is well established that noise levels at and above 80 dBspl can harm human hearing.

Noise attenuates with distance, barriers, weather conditions, and surfaces that reflect sound. However, with noise levels on drilling pads reaching 50 dBA within 900 yards of the drilling pads, people who live, learn or work in the vicinity may find that the noise interferes with speech, understanding, learning, health, sleep and sense of well-being. Typical ambient noise levels in rural, non-commercial areas are reported at 35-45 dBA. Suburban areas measure like rural areas. In urban areas, noise levels vary with the type of neighborhood, with busy commercial areas measuring at 60 dBA or higher.

The World Health Organization (1999) states that with continuous noise, sleep starts to be affected at 30 dBA. Other health effects of noise are increased blood pressure, increased cholesterol levels, and cardiovascular disease. People seem to vary in what types of noises are most annoying. Some research suggests that very low frequencies can lead to restlessness and irritability. Generally, during the day, most people do not have a problem with the sound of 50 dBA, although constant noise is worse than intermittent noise. For shale drilling, intermittent sources of noise include trucks and fracking rigs.

Noise from compressor stations, which is present 24 hours per day, 7 days per week, is very intense (90 dBA). Great annoyance from compressor noise is the topic of numerous anecdotal reports. Indeed, a specialist in environmental law at Pittsburgh's Duquesne University law school predicts that noise created by pipelines and compression stations is likely to become the most litigated energy issue in the coming decades (Bombatch, 2013).

An interesting distinction should be made between noise level, i.e., **intensity** (in dB), and the individual's perception of noise, or **loudness**. In a person with normal hearing, an increase of 10 dB in noise level generally *doubles* the individual's perception of loudness. Therefore, a resident of a quiet residential neighborhood or rural area, would experience the noise as being significantly louder when the level increases by only 10 dB (Earthworks, n.d.; Sutter County, n.d.).

Effect on Understanding of Speech

We also know that noise affects the ability to understand speech, with greater decreases among people with hearing loss, those who use hearing aids, or in aging populations. The World Health Organization states that sound levels of 35 dBA or less are required for clear speech perception. We know that children learn less efficiently in noisy classrooms especially if they have pre-existing conditions (Center for Hearing and Communication, 2013). Thus, if drilling or compressor noise increases ambient noise levels above 35 dBA, a person's ability to understand speech and to learn efficiently may be affected.

Thus, noise produced by Marcellus Shale natural gas production could interfere with daily living activities of our citizens living or attending school in close proximity, particularly to compressor stations. It is an issue worthy of more study and thought.

BEST PRACTICES FOR PHYSICIANS

As knowledge increases about shale gas development and public health, professionals are developing best practice recommendations for physicians, community health centers and patients. One of the main recommendations for health professionals working in shale country is to incorporate questions about shale into patient intake forms and into doctor-patient discussions. Questions about exposure to shale gas operations have not previously been included as part of patient intake questionnaires, but doing so can provide clues to explaining symptoms whose possible etiology might otherwise be missed by the doctor or patient. Collecting such information can also help provide research data on the prevalence -- or absence -- of shale gas-related health symptoms among those living or working in areas of shale gas operations.

The Southwestern Pennsylvania Environmental Health Project (SWPA – EHP) has developed a patient intake questionnaire, a question prompt for health providers to use in discussion with their patients, and an occupational history question protocol for patients who work in the shale gas industry. These may be found on the SWPA-EHP website at http://www.environmentalhealthproject.org/resources/medical-resources/

The questions focus on surveying proximity to shale gas operations, determining dates of beginning of operations in relation to symptom onset, and identifying potential pathways of exposure to toxic by-products of shale gas operations (e.g. through air or water). The patient intake form lists a variety of symptoms that have been reported in conjunction with exposure to shale gas, including burning throat, skin rashes, nosebleeds, nausea, abdominal pain, breathing difficulties, and other symptoms. Such symptoms may appear in isolation, or as a constellation of symptoms.

Public health experts such as Dr. David Brown recommend taking precautionary and preventative measures to limit one's exposure to air and water if one lives in close proximity to shale gas operations. These measures include removing one's shoes upon entering the house, using bottled water for drinking, and keeping a health diary to share with one's doctor. A list of recommendations developed by SWPA-EHP and entitled "Good Things To Do If You Live Near Gas Drilling" may be found on the SWPA-EHP website: http://www.environmentalhealthproject.org/wp-content/uploads/2012/03/3-Steps-02.15.12-FINAL.pdf

THE PSYCHO-SOCIAL TOLL OF THE BOOM AND BUST CYCLE

The boom and bust cycle is typical of extractive industries, from Gold Rush days until the present. Because of its long history, the phenomenon has been well-documented. The Marcellus Shale boom has followed the same general pattern that previous cycles have demonstrated, most recently in the American west which first experienced a gas boom during the 1970's and 80's (Jacquet, 2009).

The "boomtown model" describes how the rapid development of the natural gas industry uncovers and exacerbates existing social pressures, especially in thinly populated rural areas where services are limited. These problems are compounded by lack of planning for the numerous changes that occur as a result of the industrial intervention. The current gas boom, though somewhat attenuated due to market forces, has replicated the historic pattern.

While the average person might expect the “boom” to be mostly prosperous and upbeat, and the “bust” to be a period of decline, the facts paint a much more complicated picture.

The boom is a period of higher employment, with some landowners clearly benefitting from leasing arrangements with the industry. Also, businesses benefit from the new or expanded opportunities such as sub-contracting industry-related services like trucking, water purification, drilling, etc. Secondary impacts on hotels, restaurants, clothiers, and other businesses are also felt and a multiplier effect further spreads the benefits across the area.

However, there is a downside to all this. When the demand for workers, particularly for qualified workers, outstrips the local supply, a large influx of transient workers gathers in the community. These new arrivals have their own needs and lifestyle preferences, which may be out of sync with the family-oriented permanent community. Medical facilities must adapt to a higher number of emergency room visits, higher rates of STDs and patients who may be uninsured. While many of the new arrivals are single men, some bring their wives and children, who add to the local school population. All of these changes can create a financial strain on the facilities which are forced to assume a greater debt burden (Eligon, 2013).

The boom period is also often characterized by an increase in rentals and a decrease in available housing. Law enforcement also must adjust to the new realities which may include a spike in the crime rate. Infra-structure maintenance becomes a major issue as large trucks and vehicles tear up roads that are designed for infrequent traffic. Back roads become congested with trucks, and noise levels go up.

Furthermore, as is evident from the list of symptoms earlier in this resource guide, some of the symptoms reported by residents in gas-producing areas are psychological. Severe anxiety, tension, irritability and depression are all on the list. These may have any number of sources, but a pilot study shows that concern over health problems believed to be caused by natural gas operations is not insignificant and worthy of further study (Penn Medicine, 2013).

In another study, University of Pittsburgh researchers found that some of the leading causes of stress were ‘feelings of being taken advantage of, having their concerns and complaints ignored, and being denied information or misled” (Science Daily, 2013). One respondent summed it up this way, “We are not in control of our lives . . . I feel like I’m stuck in a bad dream” (Resick & Knestrick, 2013).

Humans don’t adapt to change easily, at least in the short term, especially when a long-established, slow-paced rural life is disrupted and replaced by a barrage of unfamiliar inputs: the 24-hour cycle of modern industry, environmental degradation, medical uncertainties, and potential tensions between neighbors who have chosen different strategies for dealing with the changes. The toll may sometimes appear greater than the benefits to some of those affected.

The above paragraphs describe the boom. A period of decline may follow, when some of the extra income for local businesses, and some local jobs also disappear. We have learned from previous cycles of the necessity of mitigating the effects of a “boom” industry on our landscapes and our lives. Precautionary measures include diversifying the economy so as to not become over-reliant on one industry, and planning to address future impacts (Stares, 2013). Today’s largest gas companies have a stake in being socially responsible, and increasingly, they are aware of this. As the industry expands and impacts more individual landowners and more communities, companies face the challenge of responding appropriately and responsibly to the psycho-social impacts of shale gas development.

OCCUPATIONAL HAZARDS

According to occupational safety scientists, fatality rates in the oil and gas industry have risen dramatically with the growth of the industry. The current number of fatalities stands at seven times the national average for all industries. Fatalities are most likely to occur in operations run by small subcontractors (those with less than 19 employees), whether they are engaged in drilling or well servicing (Urbina, 2012).

Interestingly, the largest cause of fatalities in the industry is highway accidents, with almost a third of the total fatalities occurring among truck drivers. Accidents are in part due to the condition of the trucks, and also to clauses in regulations that exempt the drivers in the oil and gas industry from certain protocols. According to Urbina, in 2009 the PA State Police reported that 40% of the trucks inspected had to be taken off the road because they did not meet vehicle safety standards. Furthermore, in a pattern that is typical for this industry, drivers are exempt from occupational safety regulations. Working longer hours, the drivers make more money, but with some shifts lasting up to 20 hours, they are also risking their lives. Exemptions for the oil and gas industry have been in place for almost 50 years (Urbina, 2012).

For those who are injured on the rig site, complications also arise due to the rural locations of the wells, posing challenges to EMTs who are unfamiliar with new roads hacked out of forests and fields. Also in rural areas, where doctors generally specialize in family medicine, the physicians are at a further disadvantage in treating workers due to policies in Act 13, § 3222.1, regulating access to and sharing information about the complete list of chemical components of fracking fluids, in order to protect trade secrets (University of Pittsburgh, 2013).

Aside from the hazards of working with heavy equipment, one serious side effect of the job is exposure to radioactivity. Like the people who live in the vicinity of unconventional gas wells, workers are also exposed to radioactivity. However, workers are more likely to actually come into direct contact with the radioactive material during normal operations, such as cleaning equipment containing residual materials. The DEP belatedly recognized these dangers in 2013 (Phillips, 2013), when it reversed its previous position and announced that it will undertake a study of radioactivity associated with drilling in the Marcellus Shale. The study will examine drill cuttings and residual sludge as well as pipes, well casings, storage tanks, and tanker trucks used to transport wastewater.

Silicosis

In a Center For Disease Control National Institute of Occupational Safety and Health [NIOSH] blog (5/23/12), it was stated that most of the attention, to date, on safety and health implications of hydraulic fracturing have been related to the environment, particularly ground water. There is very little data regarding occupational health hazards during fracturing operations. NIOSH initiated The Field Effort to Assess Chemical Exposures in Oil and Gas Extraction Workers. The initial hazard assessment identified exposure to crystalline silica during hydraulic fracturing as the most significant known health hazard to workers. The first peer-reviewed study documenting exposures at harmful levels was published in 2013 (Esswein et al, NIOSH).

NIOSH explains that crystalline silica, in the form of sand (frack sand) plays a major role in the fracturing process. Each stage involves hundreds of thousands of pounds of frack sand. Moving, transporting and refilling this much sand generates considerable dust, including respirable crystalline silica, to which workers can be exposed.

Inhalation of this fine dust can cause silicosis, an incurable but preventable lung disease. The disease typically develops after a long period of exposure and progresses gradually. However, rapidly fatal cases resulting from very intense exposures over a few months or a few years are documented, according to NIOSH. Crystalline silica has been determined to be a lung carcinogen and there is evidence that it causes chronic obstructive pulmonary disease and some autoimmune diseases. Individuals with silicosis are known to be at higher risk of tuberculosis and other respiratory infections.

NIOSH reports that respiratory protection is not sufficient to adequately protect against exposure. A combination of product substitution, engineering, administrative and personal protective controls, along with worker training, is needed to control workplace exposure to silica during fracturing. NIOSH worked with their researchers and industry partners to come up with controls, simple and complex, that can be implemented.

Workers at the sites where the sand mining takes place are also at risk for silicosis and the other health conditions mentioned above. According to a News Brief of American Planning Association the Cambrian quartz sandstone underlying Minnesota, Northern Illinois and Wisconsin is ideal for the fracturing process. Sand mines in these areas are the primary source of the sand. Skyrocketing demand has exposed more workers to the tiny airborne silica particles that can cause silicosis, cancer and autoimmune diseases (conditions which may not become obvious for 10 or 15 years after exposure), as well as the noise, light of round the clock operations, truck traffic, ground water pollution and diesel pollution.

The *Engineering News-Record* (2012) reported that new OSHA research, in which 116 air samples were taken at 11 fracturing sites in 5 states, found that sites consistently exceeded current OSHA standards in addition to far tighter voluntary industry standards. The article also reports that the silica hazards on one-third of the sites were at least 10 times higher than current NIOSH exposure recommendations as well. Experts say that OSHA has out-of-date silica standards which allow workers to breathe 2.5 to 5 times more dust than will be allowed by its forthcoming standard. The new rules have been in the works for years. The delay is not just due to new scientific findings. Lobbyists opposing the new regulations argue that current limits are good enough and that it would cost employers billions of dollars to implement changes.

Although the potential of the threat of silicosis to workers is being evaluated, the risk to residents who may live in close proximity to well pad operations where sand is being used, or to sand storage areas, is yet to be determined.

RESPONSE AT THE STATE LEVEL

Marcellus Shale Advisory Commission

The Constitution of the Commonwealth of Pennsylvania states: "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" (Article I, Section 27).

With the advent of large-scale unconventional gas extraction, the rights guaranteed in the Constitution are relevant to new legislation governing shale gas extraction in Pennsylvania. In 2012, Governor Corbett signed Act 13, a bill which imposed an impact fee and set forth safety standards. In addition, the bill also contained language that impacts the role of municipalities to regulate natural gas operations through local zoning and ordinances. The Pennsylvania Supreme Court is yet to decide the fate of this provision. However, because public health decisions depend on local monitoring and often require local action, these limitations may, if enacted, restrict the ability of local public officials, including public health professionals, to respond to community concerns.

In 2011, the Governor established a 31-member Marcellus Shale Advisory Commission by Executive Order. The document states: "The Commonwealth takes seriously its responsibility to ensure the develop-ment of gas in a manner that protects the environment and safeguards the health and welfare of its citizens." Within the commission, one of the four groups was specifically tasked with "the enhancement of public health and safety." Yet, according to a published document, none of the 42 members of the Advisory Commission has recognized expertise in environmental public health. Indeed, the researcher concluded that "despite recognition of the environmental public health concerns related to drilling in the Marcellus Shale, neither state nor national advisory committees selected to respond to these concerns contained a recognizable environmental public health expert" (Goldstein, 2012).

Nevertheless, the Governor's Advisory Commission called on the Pennsylvania Department of Health to make recommendations regarding its projected role in protecting public health in affected areas. Its recommendations include: 1) routine evaluations of environmental data collected from a variety of government, industry and academic partners; 2) the establishment of a population-based health registry; 3) a system for "timely and thorough investigation of complaints;" and 4) educational programs about potential impacts on health.

Adding to these responsibilities, in October 2012, Senator Joe Scarnati (R-Jefferson) introduced Senate Bill 1616 establishing a permanent Marcellus Shale Health Advisory Panel as recommended by the Governor's Advisory Commission. As chair of the 9-member panel, the Secretary of Health would be responsible for overseeing a variety of activities, including investigating advancements in science, technology and public health data and providing information, analysis and recommendations to Pennsylvania elected officials, regulators and the general public. To date, the bill has not passed, and no funding was included in the new budget to establish a health registry.

State Agencies Responsible for Public Health

Because oversight of the gas industry has been left to the states in so many instances, it is particularly important for citizens to be informed about staffing and funding for these agencies

Pennsylvania's **Department of Health** would be the obvious key player in safeguarding the public, but even before fracking became a hot issue, the department received low grades, characterized as under-funded and understaffed. The University of Pittsburgh's Associate Dean of Public Health Practice found that while public health entities exist at every level of government, "respective sources of authority are distributed among various departments without coordinated oversight and accountability among numerous agencies" (Potter, 2008). Furthermore, Pennsylvania ranks 50th in the number of public health workers per citizen, with 37 workers per 100,000 citizens, compared to a national average of 158/100,000 (Goldstein, 2011).

Public health officials had expected to get a share of the revenue being generated by the state's new Marcellus Shale impact fee to undertake the new responsibilities. But representatives from Governor Tom Corbett's office and the state Senate cut the health appropriation to zero during final negotiations. As a result, the Department of Health is left with a new workload but no funding for it. Health clinics, a resource for many uninsured people in areas where shale gas drilling is occurring, have also been subject to financial cuts. However, the Pennsylvania Supreme Court has temporarily halted the health center closings and has asked for a speedy hearing on litigation surrounding this issue (Giammarise, 2013).

Between structural impediments and the lack of funding, the role of the Department of Health as an effective citizen advocate in regard to the Marcellus Shale industry is seriously undermined. Thus the first line of defense is left to other agencies. These include the following:

The **Pennsylvania Department of Environmental Protection** (PADEP) is the main agency responsible for enforcing regulatory standards regarding water and air quality. DEP is responsible for enforcing the state's Oil and Gas Act, as well as state regulations on drinking water quality, air quality and the environmental health of rivers and streams.

Impacts of drilling on water quality are monitored by the **Pennsylvania Fish and Boat Commission, the Susquehanna River Basin Commission (SRBC), the Delaware River Basin Commission (DRBC), and the U.S. Fish and Wildlife Service** (LWV Study Guide V).

The Pennsylvania DEP is currently funded at $135 million dollars, supplemented by $215 million in federal dollars. These funds are used to operate its 19 regional offices and eighty well inspectors employed by the DEP's Bureau of Oil and Gas Management. Funding has steadily decreased over the last few budget cycles. (State Impact Topics, n.d.) DEP recently quadrupled the size of its enforcement staff to 130 employees, 65 of whom are inspectors.

The state of Pennsylvania codified an inspections policy for oil and gas wells in 1989. Among other things, it states that a well must be inspected seven times before gas can be produced and at least once a year after the well has begun producing. An Earthworks analysis of state enforcement data claims that thousands of wells are not being inspected. The state claims these are mainly older wells (Begos, 2012).

According to the Earthworks report, citizen complaints were responsible for 2,890 oil and gas inspections between 2007 and 2011, and violations were found in over 700 cases. However these violations were not necessarily followed by enforcement action (Baizel, 2012). Auditor General Eugene DePasquale promised to rectify this when he took office in 2013. A performance audit by state auditors will examine whether citizens' complaints to the DEP have been adequately followed up. Results of the audit should be forthcoming in early 2014.

The citizens' role in enforcement would be considerably enhanced if the public had access to more information. As of January 2012, the DEP has made data on oil and gas wells more accessible by releasing an online data base. The DEP could follow the lead of other states, like Ohio and Texas, to make additional types of data accessible. These might include detailed inspections reports, copies of permits filed by operators, databases of citizen complaints and of spills, blowouts and other accidents.

U.S. EPA Clean Air Standards are monitored by the **DEP's Bureau of Air Quality.** Because the state is out of compliance with the federal standards, the Bureau prepares a "state plan" demonstrating how the state will improve air quality. Using information which anticipates increases in natural gas drilling, the Bureau can influence drilling/production activity, and the placement of air quality monitors. According to Arlene Shulman, the head of the Air Resources Management in the Bureau of Air Quality, the state essentially determines the "when, where, and how" of future drilling (Shulman, 2011).

The **Department of Economic Development** was granted a regulatory role when Governor Corbett allowed the Department Secretary to overturn permitting on the basis of economic need. The important role of economic development and its relationship to health concerns is clearly indicated in this decision.

CODA

This resource guide has discussed some of the major issues and key research studies relevant to shale gas development and public health. It is by no means exhaustive. Much of the research has been conducted only recently. As with all research, there is a critique process within the academic world. Those who conduct research try to improve upon gaps in previous studies. Research becomes even more controversial as applied to the topic of shale gas development and public health because of the economic development issues and interests involved, and because the industry is developing at a rapid pace. The pace of research is also picking up. Fortunately, research is a cumulative process, with new studies building on those previously conducted. Forthcoming research will shed more light on the health impacts of shale gas development, providing insights to help develop treatment protocols for patients, and informing the continuing refinement of shale industry practices.

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