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Public Health Dimensions of Shale Gas Development

Shale gas is developed using high-volume, horizontal, hydraulic fracturing (HVHF). HVHF includes the drilling and hydraulic fracturing events as well as the ancillary infrastructure required for the entire process. Data suggest that this process poses substantial risk to public health. However, the science and epidemiology is incomplete and more research is needed to adequately understand the public health dimensions of shale gas development and HVHF.

The Science in Short . . .

- ***Water and air contamination can occur throughout the lifecycle of shale gas development*** - drilling, collecting, compressing, processing, storing, and sending to the gas market;
- ***Health impacts of air pollutants*** associated with shale gas development, such as benzene, trimethylbenzenes, xylenes, aliphatic hydrocarbons, diesel particulate matter, and ground-level ozone, are well documented;
- The majority of the identifiable chemicals used in HVHF activities are associated with both ***immediate health impacts and long-term damage to organs and body systems due to chronic exposure***;
- There is ***scientific documentation of water contamination*** associated with shale gas development;
- ***Children and low-income families*** are especially vulnerable to pollutants from shale gas development.

Vulnerable Populations

Children are at particular risk given behaviors that often put them in closer contact with environmental contaminants. They eat, drink, and breath more per unit of body weight and lack the same ability to metabolize and excrete chemicals as adults (Landrigan 2010). Further, given their age children have a longer shelf life for many diseases that have a long latency period.

This also applies to ***prenatal*** exposure to environmental toxins. For example, known consequences of prenatal exposure to airborne benzene include neural tube defects, cognitive impairment, and childhood leukemia (Whitworth 2008; Lupo 2010; Slama 2009).

Moreover, **low-income households** have a decreased financial ability to mitigate exposures (i.e. purchasing alternative water sources, such as "water buffalos") and to treat health concerns (e.g. doctor visits, etc.).

What goes into the ground?

Frac fluids - water based fluids used in HVHF:

Water + proppant (usually **silica sand**) + and a variety of chemicals:

ethylene glycol
monobutyl ether
isopropanol
glutaraldehyde
methanol
xylene
naphthalene.

What comes back up?

Flowback and Produced waters:

chlorides
salts
lead
arsenic
bromide
radionuclides/radon
BTEX
other contaminants
frac fluid.

The majority of flowback and produced water is too costly to clean and wastewater disposal is a problem (Alley 2011).

Air Quality

Emissions of air pollutants from shale gas occur over the full life cycle of shale development.

A health assessment of exposure to air emissions from shale gas development in Colorado found that residents that live ≤1/2 mile from well pads are at a greater risk of developing cancer and non-cancer health effects due to exposure than those living further away. Exposure to Trimethyl-benzenes, xylenes, and aliphatic hydro-carbons contributed most to the cumulative non-cancer, and benzene to the cumulative cancer risks (McKenzie 2012).

Nitrogen oxides (NOx), volatile organic compounds (VOCs), and methane interact with sunlight to produce tropospheric, or **ground-level ozone** (O_3), a hazardous respiratory irritant that increases risks of morbidity and mortality (Jerrett 2009). Studies have determined that shale gas production is associated with elevated atmospheric concentrations of tropospheric O_3 concentrations in rural areas at levels found most often in heavily polluted areas of downtown Los Angeles, California (Schnell, et al. 2009; Kemball-Cook, et al. 2010; Olaguer 2012; Pétron, et al. 2012).

Diesel trucks emit **diesel particulate matter (DPM)**, a health damaging air pollutant that contributes to cardiovascular and respiratory diseases, atherosclerosis, and premature death (Pope 2002, 2004, CARB 2008). More than 1,000 diesel trucks are required to transport the water for one typical hydraulic fracturing event (EPA 2011). Multiple frac jobs per well and high well densities increases the cumulative health impact of fine diesel particulate .

The CDC identified **crystalline silica** in the form of "frac sand" as a significant hazard for workers and other populations in close geographic proximity. Humans exposed to crystalline silica dust are at a higher risk of developing silicosis, lung cancer, chronic obstructive pulmonary disease (COPD), chronic kidney diseases and a variety of autoimmune diseases (NIOSH/CDC 2002; Davis 1996; NTP 2012).

Groundwater Quality

As with air, risks to water quality can occur over the full life-cycle (Rozell, 2011).

Cases of water contamination by subsurface fluid migration remain largely anecdotal and difficult to document given the absence of baseline data and the existence of regulatory exemptions for HVHF that make chemical detection difficult. Although more studies are needed, there is scientific documentation of water contamination.

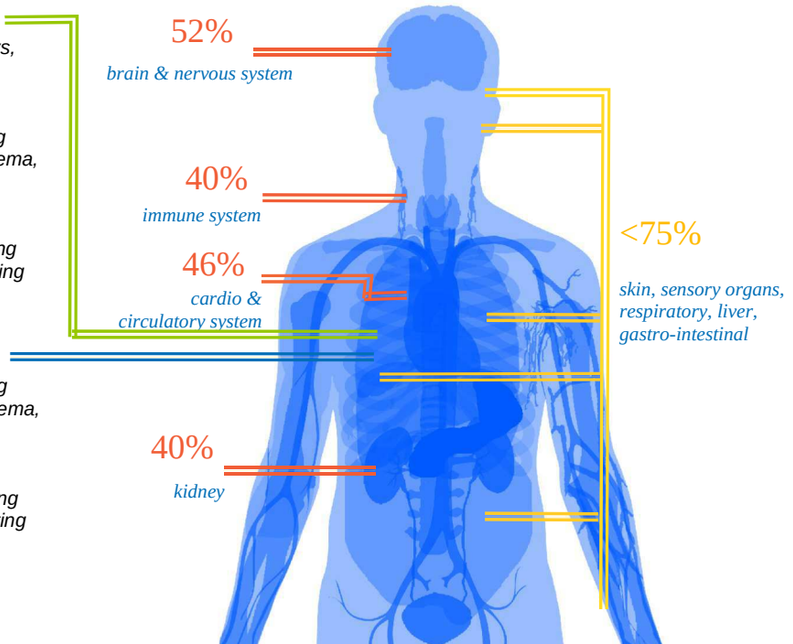
- The EPA analysis of groundwater in Pavillion, WY detected **benzene concentrations above federal standards, high methane levels, and synthetic chemicals** such as glycols and alcohols consistent with gas production and hydraulic fracturing fluids (EPA 2011).
- Osborn et al. (2011) tested 69 water wells & found groundwater near drilling areas contained **methane concentrations 17 times higher** than wells where drilling was not taking place.
- **Evidence of fluid/gas migrations pathways** to drinking water aquifers have also been modeled (Myers 2012) and found in field

+ ground-level ozone

- *Coughing, irritation of the airways, discomfort in the chest or when breathing*
- *Premature aging of the lungs*
- *Faster or more shallow breathing*
- *Aggravation of asthma, emphysema, and other respiratory diseases*
- *Increased risk of respiratory infections*
- *Premature death (primarily among older adults and those with existing heart and lung disease)*

+ DPM

- *Faster or more shallow breathing*
- *Aggravation of asthma, emphysema, and other respiratory diseases*
- *Increased risk of respiratory infections*
- *Premature death (primarily among older adults and those with existing heart and lung disease)*



Colborn et. al. (2011) identified chemical information on 353 of 632 additives reported in natural gas operations and profiled a number of possible health effects of the soluble and volatile chemicals used.

Chronic Exposure/Long-term System Damage

Acute Exposure

Left & Center: % of identified chemicals used in HVHF with immediate or chronic/long-term damage to organs and body systems (*Adapted from Colborn et al. 2011).* **> 25%** of the chemicals are **carcinogens/ mutagens**
Right: health impacts of ground-level ozone and diesel particulate matter