VIEWPOINT

# Potential Health Implications Related to Fracking

**Russell A. Wilke, MD, PhD**
Department of Internal Medicine, University of South Dakota Sanford School of Medicine, Sioux Falls.

**Jerome W. Freeman, MD**
Department of Neurosciences, University of South Dakota Sanford School of Medicine, Sioux Falls.

**Corresponding Author:** Russell A. Wilke, MD, PhD, Department of Internal Medicine, University of South Dakota Sanford School of Medicine, 1400 W 22nd St, Sioux Falls, SD 57105 (russell.wilke@usd.edu).

**Society depends on fossil fuels** as an important energy source. Although global availability of alternative fuel sources (eg, wind power) continues to slowly increase, the majority of daily energy demand is met by coal, oil, and natural gas. Prior to the availability of hydraulic fracturing (fracking), tremendous volumes of natural gas and oil were inaccessible by conventional drilling methods; it was difficult to extract fuel reserves from the oil-laden shale known to underlie many of the more porous geologic formations used historically.

Within the last decade, however, fracking and horizontal well drilling have provided access to deeper less-porous rock strata (often called source rock), containing even larger volumes of fossil fuel. By injecting large volumes of water into shale (along with acid, surfactant, and sand), the petroleum industry is able to generate sufficient pressures within this previously inaccessible source rock to liberate unconventional fuel reserves at unprecedented rates. Because the process of fracking these shales has increased the relative role of the continental United States in the worldwide production of oil and natural gas, it is increasingly important to understand the potential implications of this technology on the health of individuals and the US population.

## Fracking in the United States

The availability of fracking technology has allowed the US petroleum industry to markedly increase domestic production of natural gas and crude oil over the past decade.[1] More than half of all domestic oil and natural gas now comes from wells that have been fracked. At least 10 states overlie shales that are currently being leveraged to produce oil and natural gas through fracking. Pennsylvania, New York, Ohio, Maryland, Virginia, West Virginia, and Kentucky overlie the Marcellus shale along the western edge of the Allegheny Mountains and the Appalachian Mountains. Along the eastern edge of the Rocky Mountains, North Dakota and Montana overlie the Bakken shale. Texas overlies the Barnett shale in the north and the Eagle Ford formation in the south. In the Williston Basin of North Dakota, the Three Forks formation, located beneath the Bakken shale, extends the potential reach of this huge resource to Wyoming and South Dakota as well (**Figure**).

More than 100 000 domestic wells have been fracked in the last decade. By 2014, nearly 30 000 new domestic wells were being drilled and fracked each year, and many existing wells were being fracked to optimize production.[1] Even with a decline in the price of oil and gas in recent years, the United States currently drills and fracks approximately 20 000 new wells annually.[1] Before a new well can begin production, each site undergoes months of preparation. Steps include preparation of the drilling pad, vertical drilling operations (often >1 mile deep), horizontal extension of the well (often >1 mile laterally), and fracking. Preparation of each well can therefore take months, and care must be taken to monitor local air quality and ground water quality. Each step has the potential to influence the health of local residents.

> Cross-contamination between fracking flowback and drinking water must be avoided.

## Fracking and Air Quality

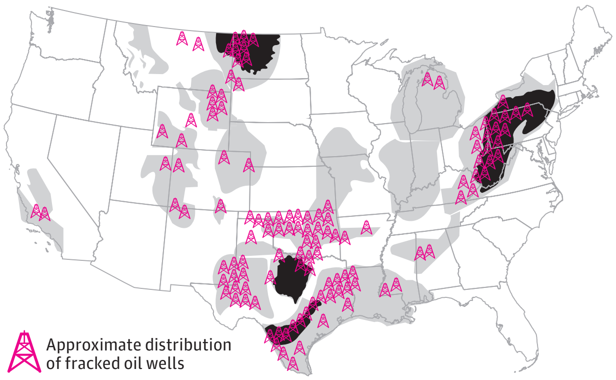
The relationship between fracking and air quality is important to understand because of the influence of air quality on acute and chronic respiratory illness.[2,3] Asthma exacerbations can be triggered by small changes in air quality (eg, airborne particulates, ozone, and exhaust from equipment used for drilling and transport). In communities overlying the Marcellus shale, well production rates have recently been associated with the frequency of asthma exacerbations. Using data from a large electronic medical record representing more than 400 000 primary care patients in Pennsylvania, investigators observed that 5935 patients with asthma who lived near low-production wells were more likely to initiate a new oral corticosteroid than 5713 frequency-matched nonasthmatic controls living in the same region (odds ratio [OR], 1.28 [95% CI, 1.13-1.46]), and patients with asthma who resided near high-production wells were even more likely to initiate a new oral corticosteroid (OR, 4.43 [95% CI, 3.75-5.22]).[2]

The US Occupational Safety and Health Administration has also raised concern about the long-term respiratory effects of occupational exposure to airborne silica at fracking sites.[4] Because silicosis can be associated with systemic autoimmune processes, workers exposed to crystalline silica from the high quantities of sand used during fracking will need to be monitored longitudinally for lung disease as well as adverse effects on multiple organ systems.

## Fracking Fluid and Potential Toxic Exposures

Fracking fluid contains water, sand (silicates), and a proprietary mixture of chemicals that vary by company and site. Silicates are added as a proppant to keep fractures in the shale open. Acids are added to solubilize some of the common minerals in the shale, and surfactants are added to aid in fracture penetration. Millions of gallons of this fluid are injected into each well at high pressures sufficient to fracture rock, and millions of gallons of wastewater (ie, flowback) return to the surface and contain heavy metals (eg, barium, manganese, and iron), radioactive materials (eg, radium), and organic compounds

Figure. Locations of Major US Fracking Sites




More than 100 000 wells have been hydraulically fractured in the continental United States.

(eg, benzene, toluene, xylenes, oil, and grease).[1] This flowback is then either reused (recycled for additional fracking), evaporated in surface pools, or transported and injected into deeper disposal wells. At present, as much as 95% of the wastewater generated by fracking is injected into disposal wells.[5] Due to the potential toxicity of this wastewater, monitoring the depth and geological location of these disposal wells is important.

Acids are routinely added to the fracking mix, and low pH mobilizes heavy metals from the rock into which the fracking mix is injected.[6] Environmental heavy metals are nephrotoxic, and changes in renal function associated with human exposure to fracking flowback will need to be studied longitudinally. A recent series of intentional ingestions of fracking fluid[7] associated with acute methanol intoxication highlights the need for studying the health effects of unintentional ingestion, such as may occur through the inadvertent contamination of drinking water. Heavy metals are also potentially neurotoxic. In the central nervous system, manganese has a high affinity for the basal ganglia where it increases risk of parkinsonism. In the peripheral nervous system, mercury has a high affinity for the dorsal root ganglia, and elevated blood mercury levels have been documented in patients with idiopathic neuropathy.[8] Because methyl mercury is a more potent neurotoxin than inorganic mercury, the effect of fracking activity on biodiversity and mercury organification (conversion to methyl mercury by aquatic microorganisms) is being quantified in watersheds overlying some large shale formations.[9]

Given the large volume of flowback generated by fracking, water quality requires ongoing monitoring. Cross-contamination between fracking flowback and drinking water must be avoided. More than 10% of the US population obtains drinking water from nonpublic water supplies, including private water wells that supply drinking water to a residence.[1] In 2016, the US Environmental Protection Agency published a report outlining factors that are more likely than others to result in more frequent or severe adverse effects.[1] Use of drinking water for fracking should be minimized in times or areas of low water availability, and the following also should be avoided: spills during management of fracking fluid, injection of fracking fluid into wells with inadequate mechanical integrity, injection of fracking fluid directly into groundwater, discharge of inadequately treated wastewater into surface water, and disposal or storage of wastewater in unlined pits that have not been lined with an impermeable base.[1] Close attention to these safeguards could help to reduce health risks among individuals during expansion of this key energy resource.

## Future Outlook

Safeguards (eg, cement well casings and deep re-injection wells) exist to keep fracking flowback separate from the surface and groundwater sources that provide drinking water. Ongoing oversight by the petroleum industry and regulatory agencies should help mitigate potential health problems (such as parkinsonism, neuropathy, and kidney disease) that could occur with cross-contamination of drinking water and subsequent exposure to toxic substances from fracking fluids. With the widespread implementation of electronic medical records, health systems are in a position to prospectively monitor toxicity end points in observational cohorts.

ARTICLE INFORMATION

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