Environmental and health impacts of ‘fracking’: why epidemiological studies are necessary

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Over the past decade, there has been a surge in drilling for natural gas and oil in shale rock. Natural gas and oil extraction using high-volume, slickwater hydraulic fracturing from clustered multwell pads using long, directionally drilled laterals (known by its popular name ‘fracking’), is an unconventional extraction process that is currently the focus of controversy. The process involves the injection of millions of gallons of water, chemical additives, and a proppant (sand and/or silica) at high pressure into a wellbore in order to create small fractures in the rock formations to allow natural gas (or oil) to be released. But for the lack of effective technology, this source of energy would have been tapped long ago.

While there are some positive aspects of high-volume hydraulic fracturing (eg, reduction in the dependence on foreign oil and gas; becoming a net exporter of natural gas and oil; possible reduction in unemployment in areas where wells are drilled), there are serious concerns including its impact on climate change and the potential harm to the environment and human health.

The process of drilling, extracting and transporting oil and gas is a dirty, messy and polluting process if not done correctly, cleanly and carefully. Well venting, flaring and burning gas on release account for the largest sources of air emissions. Volatile organic compounds and diesel particulate matter, for example, result in elevated air pollution concentrations that exceed US Environmental Protection Agency (EPA) guidelines for both carcinogenic and non-carcinogenic health risks. Truck traffic and diesel truck exhaust contribute to airborne emissions of fugitive dust and high benzene concentrations.

The structural integrity of wells can and does fail over time; for example, cement cracks and steel casing barriers corrode. Wells have blowouts, spills are common, and methane is leaked and vented into the atmosphere at all stages of the extraction process. By far, one of the most critical issues is the management (storage, treatment and disposal) of water produced in the gas or oil extraction process. The flowback water contains thousands of gallons of toxic chemicals, the vast majority of which are not identified. Moreover, an undetermined number of the chemical compounds used in the drilling and fracturing processes lack scientifically based maximum contaminant levels, which makes it difficult to assess their public health risks. The mixture of chemicals used by drilling companies is considered to be proprietary, and in many states companies are not mandated to disclose information about the quantities, concentrations or identities of the chemicals used in the process despite calls for such action.

While many states actively support this technology (eg, Pennsylvania, Texas, Louisiana, North Dakota, Wyoming), a growing number of states and municipalities are more hesitant to embrace it. For example, whereas Pennsylvania embraced an aggressive drilling agenda, neighbouring New York took a more cautious route. Both states sit atop the Marcellus Shale.

Several years ago the governor of New York placed a de facto ban on high-volume hydraulic fracturing pending an assessment by the Department of Health (DOH) of the potential health and environmental risks of high-volume hydraulic fracturing. On the basis of the findings compiled in a comprehensive report issued by the DOH, Governor Cuomo, in mid-December 2014, announced that this procedure will be banned in New York State because of the risks to health and the environment. The report concluded that until there is sufficient scientific information to determine the level of risk to public health, and until there is a plan to adequately manage potential risks, high-volume hydraulic fracturing should not proceed in New York. To a certain degree, the governor’s decision reflects that of the majority of Americans across the country who are very concerned about high-volume hydraulic fracturing’s impact on the environment, as well as on human health.

The available science raises substantial questions about the potential for harm to health. Naturally occurring radioactive materials (NORMs), toxic flowback water, and production brine are brought to the surface during the extraction process. NORMs consist of uranium, thorium, and decay products including radium and radon. Exposure to any of these can be a public health concern if exposure occurs at sufficiently high levels.

People living near drilling sites are presenting with symptoms (eg, skin rashes, nausea, abdominal pain, respiratory difficulties, headaches, dizziness, eye irritations, throat irritations, nosebleeds, anxiety, stress) that demand further investigation. Anecdotal reports of health problems (ranging from the mild to the more serious) do not advance knowledge in a meaningful way. High-volume hydraulic fracturing is generally taking place in rural, poor areas where poor healthcare status is not uncommon. Yet, can one truly and confidently state that but for the gas or oil extraction activity an individual would be healthy? Epidemiological studies must be conducted to assess the strength of association among risk factors and health.

Without baseline morbidity and mortality data, without accounting for bias and confounding, without applying Hill’s criteria (especially taking into account dose-response relationships, temporality, consistency across a range of studies), findings may not reflect a true association of risk factors and health outcomes. Clearly, there is a need for well-designed, methodologically sound studies.

While there has been a dramatic increase in the number of peer-reviewed published studies on the topic, there are few well-designed studies to quantify the connections between risk factors and health outcomes, especially among populations living in close proximity to shale gas operations. There have been numerous small-scale health outcomes studies conducted, but these studies are limited in their ability to show that exposure to risk factors caused a health outcome. The findings are suggestive, but do not demonstrate cause and effect.

Ecological descriptive studies, while useful, only generate hypotheses, they do not test hypotheses. They can suggest a relationship between a risk factor and health outcomes; they cannot show cause and effect. Hypothesis testing studies have advantages as well as disadvantages: Prospective cohort studies are expensive...
and take a long time; case–control studies are cheaper and quicker to conduct, but care must be taken in selecting both cases and controls. Regardless of the type of study design used, drawing conclusions about causal association is not so simple from an epidemiological perspective.

That being said, a few important studies are currently underway that hopefully will add to the body of knowledge:

- The Marcellus Shale Initiative Study is a National Institute of Health-funded project focusing on asthma control and pregnancy outcomes among patients at the Geisinger Health System in Pennsylvania.
- The University of Colorado at Boulder Sustainability Research Network, a National Science Foundation funded study, is focusing on the impact of high-volume hydraulic fracturing on air and water.
- A long-awaited EPA study on hydraulic fracturing, and the potential impact on drinking water resources is underway, with the full study expected to be completed in 2016.
- The Pennsylvania Department of Environmental Protection Comprehensive Oil and Gas Development Radiation Study focuses on radioactivity levels in produced and flowback waters, wastewater recycling, levels of radon in natural gas, and potential exposures of workers and residents near drilling sites. High-volume hydraulic fracturing is relatively new (approximately 10 years), and diseases, such as cancer, can take many years to present. In the meantime, it would be instructive to examine trends in morbidity and mortality in areas with gas and oil extraction and compare the data to neighbouring areas without such activity. For example, many respiratory and reproductive conditions are known to be impacted by environmental insults as are many cancers (eg, bladder, thyroid, leukaemia). Trend data at the municipal level, or at the county level, are far more precise than that for an entire state. Such data can shed light on health in a particular area at a particular point in time. However, it is important to look at the data years before gas or oil extraction began, as it would be unusual to see any appreciable changes in morbidity and mortality in the short term. While some symptoms may appear fairly quickly, other symptoms will take more time to develop.

Certainly, the potential for harm will vary by proximity to drilling sites, the nature of the exposure, exposure pathways, route of exposure, and length of time exposed. There needs to be particular attention paid to when the drilling started, for how long individuals lived in proximity to the drilling site, and the health status of the individuals prior to drilling. There must be an understanding of potential confounding factors, especially behavioural factors, such as tobacco smoking, diet and health insurance status.

Well-designed epidemiological studies are absent, but given the available evidence from published studies looking at air and water-quality impacts, including groundwater contamination, it is prudent to proceed cautiously. There are significant uncertainties about adverse health outcomes that may be associated with high-volume hydraulic fracturing, and that should give us cause for concern.

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COMMENTARY

While the development of unconventional oil and gas resources has the potential to greatly benefit the economy, there are concerns about the environmental impacts associated with the extraction process, particularly high-volume hydraulic fracturing (fracking) with proppants and chemical additives. Published and peer-reviewed scientific research on health outcomes due to unconventional natural gas development, and particularly the consequences of chemical additives in hydraulic fluids, has been limited. There is a significant gap in the evidence from published studies looking at air and water-quality impacts, including groundwater contamination, it is prudent to proceed cautiously. There are significant uncertainties about adverse health outcomes that may be associated with high-volume hydraulic fracturing, and that should give us cause for concern.