

# FRACKING AND PUBLIC HEALTH: FINDING THE BEST BALANCE

By Mark Wolverton



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The experts in Penn's Center of Excellence in Environmental Toxicology seek the facts that are essential for decisions that affect our environment.

Just a few years ago, the term *fracking* might have drawn a perplexed stare from most of the general population. But today, particularly in large parts of the United States such as rural Pennsylvania, the word isn't just a figure of speech but a real and immediate curse word. Although fracking in common parlance has come to represent the entire range of unconventional gas and oil drilling activities, technically it refers only to

the technique of hydraulic fracturing or hydrofracturing: extracting natural gas from deep within the Earth by cracking open rock layers with high pressure liquids.

It's become one of the most contentious political and environmental issues of the past decade. It is a focus of bitter controversy, from the national news all the way down to the grassroots community level, as the lives and perhaps the health of residents in previously sleepy rural communities are disrupted and threatened. Meanwhile, gas well drilling in states such as Pennsylvania and North Dakota continues to expand and accelerate at so fast a pace that the concerns of residents, environmentalists, and other involved parties seem almost an afterthought.

That's certainly true from a scientific and public health standpoint, particularly in Pennsylvania, where the proliferation of well drilling seems to be inversely proportional to the available data on its environmental and health effects. At Penn Medicine, studying those effects falls under the aegis of the Center of Excellence in Environmental Toxicology (CEET). Part of the Perelman School of Medicine, CEET is also one of only twenty Environmental Health Sciences Core Centers

(EHSCCs) in the United States, as designated by the National Institute of Environmental Health Sciences (NIEHS). In collaboration with the Mailman School of Public Health at Columbia University, Penn's center recently published a major study identifying an association between fracking and increased hospitalization rates. Their work is already having a major impact on the fracking controversy, introducing some sorely needed facts into an issue too often muddled by passionate but ill-informed rhetoric on all sides.

As the only EHSCC in the Environmental Protection Agency's Region III (Pennsylvania, Delaware, Maryland, Washington DC, Virginia, and West Virginia), Penn's center could be expected to take a particular interest in the fracking controversy. Most of those states lie firmly atop the Marcellus Shale formation, one of the major sources of natural gas to be developed and explored in recent decades. Half of Pennsylvania's land mass, in fact, rests under Marcellus Shale. At a 2012 meeting of all the EHSCCs, Trevor Penning, Ph.D., a professor in the Department of Systems Pharmacology and Translational Therapeutics and director of CEET, gave a presentation on potential public health impacts of hydraulic fracturing in Pennsylvania. "I made the point that this was such a complex issue that no single environmental sciences center could tackle this by itself. What we needed was to pool our resources so we could work collaboratively together. That led to the establishment of an inter-center working group on hydraulic fracturing."

And led as well to the recent study, published in the journal *PLOS One* in the summer of 2015. The lead author was Reynold A. Panettieri Jr., M.D. '83, G.M.E. '90, deputy director of CEET



and professor of medicine. The study, "Unconventional Gas and Oil Drilling is Associated with Increased Hospital Utilization Rates," he notes, was rated among the journal's top six viewed publications online, garnering about 14,000 views in only a month and a half. "So it's obviously a passionate area."

Trevor Penning doubts that banning hydraulic fracturing on a national scale is practical. "The best we can do is identify the potential risks and manage them by having the industry adopt safe practices."

Although the commotion and controversy over hydraulic fracturing might be fairly recent, the practice itself is not. It was first used in Kansas in 1947. As mentioned, it's only one part of an elaborate process that includes the selection of the well site, pad construction, drilling, and encasing the borehole in concrete. A mile or more deep, the drilling

changes to a horizontal direction, into and along the shale layers. Then the actual hydraulic fracturing process begins, in which the horizontal borehole is perforated by holes at various spots and millions of gallons of fracturing fluids are pumped through them at high pressures. That forces the rock layers to crack and fractures to open, releasing their coveted stores of natural gas, to be recovered and stored back on the surface.

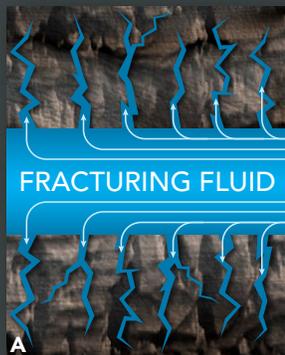
### Why Fracking, Why Now?

If fracking is nothing new, why is everyone suddenly so concerned about it? The main reason is that in the past, hydraulic fracturing tended to be done in places where oil and gas drilling were already well established. But in recent years, the economics of energy production and demand, dwindling supplies of more "conventionally" obtained gas, the desire to reduce our reliance on dirtier carbon-based fuels such as coal, and the development of improved drilling techniques that make accessing formations such as the Marcellus Shale cheaper and more practical have all come together to spur a burgeoning new enterprise. That means that drilling is now being done in

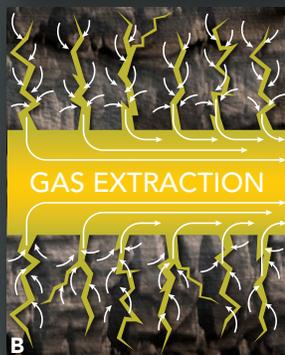


Trevor Penning: striving for scrupulous scientific objectivity.

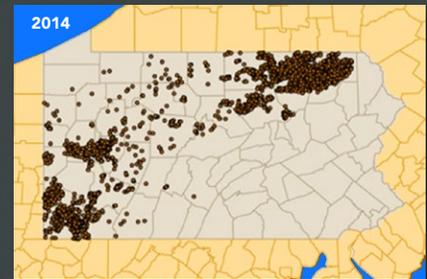
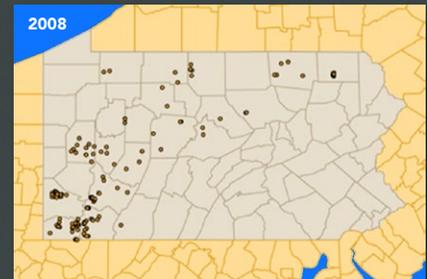
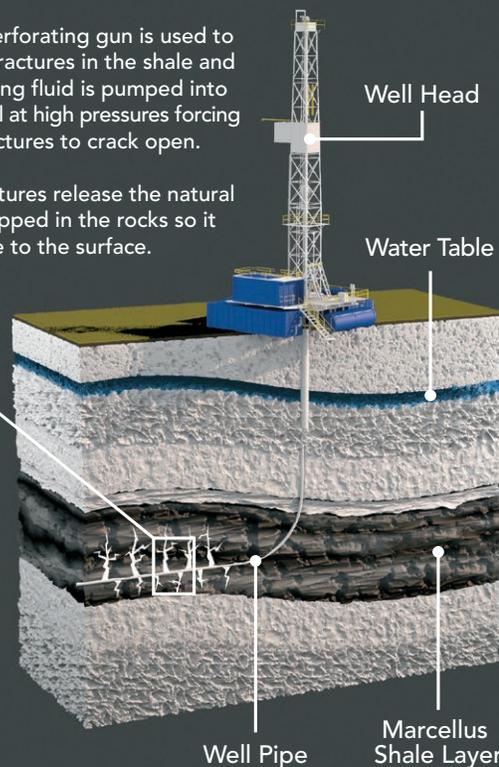
## HYDRAULIC FRACTURING PROCESS



A. A perforating gun is used to make fractures in the shale and fracturing fluid is pumped into the well at high pressures forcing the fractures to crack open.



B. Fractures release the natural gas trapped in the rocks so it can rise to the surface.



These maps illustrate the growth of gas producing wells in Pennsylvania between 2008 and 2014.

thousands of locations that have never before seen anything more industrial than a passing diesel truck. Now these communities are being invaded by hundreds of trucks, heavy equipment, and noisy and smelly activities that used to happen hundreds or thousands of miles away. All these developments have literally brought home the oil and gas industry to many people who previously would encounter it only at their local gas stations.

“While hydraulic fracturing is not new,” Panettieri explains, “the magnitude of the drilling is certainly different. So we have to take that into account and the proximity to populations which didn’t necessarily exist before. The other part of the equation obviously is, well, if we don’t use this fuel, we would simply continue to do coal burning. Isn’t this better than coal burning? That becomes a societal issue.”

Engineers and geologists prefer to use the term *fracking* (with a “k”) to mean the overall drilling process and the word *fracing* (or *frac’ing*) to refer solely to the hydraulic fracturing technique. They make that distinction because some phenomena that have been blamed on *fracking*, such as recent earthquakes in Oklahoma, are not actually the result of hydraulic fracturing but other processes, such as the injection of waste water into deep underground wells. Whatever one’s preferred terminology, it’s the possible release of toxic materials into air or water that’s of prime concern, especially for the people living near well sites. A 2013 *Wall Street Journal* report esti-

mated that more than 15 million Americans live within one mile of a well drilled since the year 2000. In the rush to find and develop resources to satisfy America’s ever-increasing thirst for energy, the people most directly affected by it have more and more questions – but definitive answers remain frustratingly elusive.

“How do we have no data on an enterprise of this magnitude?” asks Aubrey K. Miller, M.D., M.P.H., a senior medical advisor at National Institute of Environmental Health Sciences. “How do we have 15 million people living within one mile of a well, and we can’t answer their questions?” The reassurances from the oil and gas industry that well operators are scrupulously observing best practices often ring hollow to mothers whose children have developed mysterious rashes and other ailments or homeowners who have found their drinking water wells contaminated by unknown substances. Anecdotes and horror stories abound, as do confident proclamations of safety, but with a dearth of hard data, it’s virtually impossible to sift out truth from the rhetoric.

### Assessing the Risks

“There are different ways to approach the problem,” Penning says. “One is a classical risk-assessment approach,” with four components. “Risk identification, meaning what are the hazards that we have to be concerned about as it relates to human health? I think we have a good handle on what the

possible air pollutants might be. We don't have a strong handle on the pollutants that might contaminate the water supply." Although the hydraulic fracturing fluid used by well operators is about 99% water, the remainder is a mixture of other chemicals that varies among different companies, and the specific formulation of a company's "fracking fluid" is considered proprietary information – a trade secret to be protected and guarded. "Therefore," notes Penning, "we don't know what we're looking at."

A second component of risk assessment is to establish a solid baseline of data to identify what's normal and what's not. "Because of the lack of baseline data both in air and water quality, it's tough to attribute contamination or air pollution to the process itself, because there could be other sources," Penning explains. That, of course, provides a convenient out for industry representatives to discount the complaints and concerns of local residents.

Once a particular hazard has been identified, it needs to be characterized. What are its effects? How much exposure is needed to induce what kind of responses? Again, in the fracking debate, answers to these questions are few and far between. As Penning observes, "Most things follow a dose response curve, and you need to know what the margin of safety is between the exposure and the levels that would cause a health effect. And that's also obviously very difficult when you can't do the hazard identification in the first place."

The final piece of risk assessment is figuring out how to mitigate risks and how to communicate information effectively both to policy makers and to residents. "So it's a four-part approach, but it's also sequential," Penning says. "And we're stuck on one and two right now. That's what led us to actually think about designing the *PLOS One* study. We felt we needed some kind of broad-stroke approach to determine whether there was a signal worth looking at."

### What's Real and What Isn't Real?

The CEET/Columbia study looked at two counties in northeastern Pennsylvania where unconventional oil and gas drilling has blossomed and is continuing (Bradford and Susquehanna) and one in which no active wells are located (Wayne). Researchers looked for any correlation between the density of wells in each area and the inpatient admission rates from 2007 to 2011. "Our whole approach is an unbiased examination of the data," says Panettieri. "What's most important is that we look at this with glasses off, what's real and what isn't real."

Penning, Panettieri, and their collaborators were startled by what they found. Using data from 25 specific medical categories (e.g., cardiology, dermatology, gynecology, gastroenterology, neurology), they examined hospitalization rates within each category and county, noting any association with well activity. They expected to find fairly stable rates, considering that they were working with a time span that was relatively short, in epidemiological terms.

Instead, the study found significant associations between inpatient admissions and fracking activity in a number of

medical categories, particularly for cardiology and neurology. Seeing such a strong statistical signal over such a short time is considered fairly remarkable. Says Panettieri, "It was shocking to us that we saw a signal after five years. Many epidemiological studies of toxic exposure take decades. This was fast and really speaks to maybe some major issues that need to be addressed."

But just as with any other controversial public issue, people tend to hear what they want to hear, and nowhere is that more prevalent than with fracking. "Obviously when the data came out, we were embraced quickly by all of the pundits who were against fracking, while we made no friends in the oil industry," says Panettieri with a laugh.

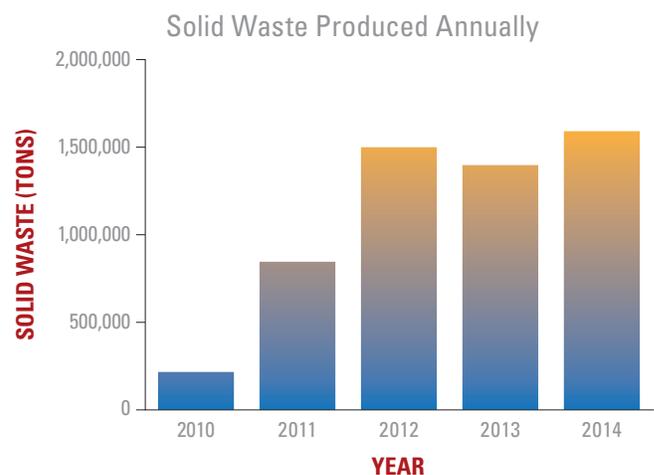
Careful scientists that they are, however, Panettieri and his colleagues emphasize the study's limitations and caution against drawing premature and unfounded conclusions. The study states that "the precise cause for the increase in inpatient prevalence rates . . . remains unknown" and that "the clinical significance of the association remains to be shown."

As Penning puts it, "This is just a drop in the ocean in terms of where we could go with this approach." He points out that there are subcategories that need to be mined to see whether certain subsets of disease show up. In addition, he says, "so far we've only looked at hospitalization rates. We need to look at outpatient data as well."

### Weighing the Impact on Wells and Springs

Aside from the CEET study, another draft report released in 2015 has caused a mighty stir: a study by the U.S. Environmental Protection Agency that examines the potential impact of hydraulic fracturing on drinking water sources. It focused specifically on Bradford and Susquehanna Counties in Pennsylvania, the same counties studied by CEET. Analyzing more than 225 water samples taken over a year and a half from about 40 different locations, the EPA found no evidence of any "widespread" impact on homeowner wells or springs from hydraulic fracturing, although it did find some evidence of fracking-associated methane and ethane in several wells.

### Unconventional Gas Drilling in the Marcellus Shale of Pennsylvania





Photos by Tommy Leonard

Reynold Panettieri, here conferring with Christie Ojiaku, led the CEET study.

It was predictable that the EPA study (which remains to be finalized after review and public comment) was interpreted differently by pro- and anti-fracking camps. While those in industry saw themselves vindicated, fracking opponents criticized the EPA for pandering to oil and gas companies. The EPA has acknowledged some definite limitations in the study, and scientists such as Penning have criticized it on that score.

As he explains, “we sent in a 22-page commentary that was actually not too pleasant.” The CEET experts identified what they considered serious gaps in knowledge that should have been taken into account in the agency’s executive summary.

Even more emphatic is Marilyn V. Howarth, M.D., an adjunct associate professor of emergency medicine and pharmacology at the Perelman School who also serves as director of CEET’s Community Outreach and Engagement Core. “The EPA’s conclusions are premature,” she says. “Their retrospective studies found impacts on drinking water such as increased sediment and problems with clarity. No one should be expected to drink water that contains debris whether or not the debris is toxic. In addition, there has been no prospec-

tive study on drinking water throughout the life of a nearby well. Water quality may significantly yet transiently change.” Howarth asserts that there is no data to determine if these changes are occurring and, if they are, what are the impacts on people’s health.

Still, Penning emphasizes that the best way to resolve such contentious issues is to strive for a scrupulous scientific objectivity, which means taking biases into account, both conscious and unconscious. Many studies are not adequately designed, or their results are exaggerated or misrepresented by the press or overzealous advocates on both sides. “We get these one-liners, but you have to look at the details,” he observes. “One thing that made the *PLOS One* study so powerful is it’s unbiased. We didn’t have any preconception of what we should be measuring. Some of the other health studies have been focused on one or more particular health point that’s been pre-selected, so you don’t know if, based on that pre-selection, other things could have been missed.”

### What Remains to Be Done?

Because so much remains unknown and uncertain, there’s much more work to be done. While many researchers are focusing on toxicological effects of air and water pollution from hydraulic fracturing, little attention has been given as yet to the psychosocial aspects, which may be even more important in the long run.

Says Penning, “If you look at the *PLOS One* study, you’ll see there was a trend but not a specific association between psychological disorders as well, but specifically issues of depression, anxiety, and so on. I think psychosocial stress is a very important component of this, along with sleep deprivation.”

As Panettieri points out, “These areas are pretty bucolic, they’re rural. And in comes a lot of industry very quickly setting up camp, disrupting that lifestyle, and it engenders a lot of stress. We know that chronic stress can cause cardiovascular disease and impair the immune system. We believe that with this short observation period and the rapidity and robustness of the data, there’s a stress response from noise, disruption of lifestyle, uncertainty, and air pollution from diesel truck exhaust. Our hypothesis is that a combination of chronic stress on top of air pollution rather than water pollution might be responsible for our findings.”

What should be done now, while we continue to debate and study and assess and define the risks of hydraulic fracturing? It’s a question that depends heavily upon the political climate, which in Pennsylvania is undergoing a shift from the unabashedly pro-industry stance of the administration of the former governor, Tom Corbett, to the apparently more cautious administration of Governor Tom Wolf. One measure that CEET and other scientific and public health experts recommend is estab-

lishing a health registry to track and monitor the health of residents living near fracking sites. But while the current Wolf budget has set aside funding for a registry, it's not nearly enough.

"It was only funded to a level of \$100,000 a year, which is basically one person at a computer," Penning notes, adding, "a registry is not really a valuable tool unless there is appropriate exposure data to go with it." That data, he says, should be based on a particular ill effect or symptom as diagnosed by a physician trained in taking exposure history. "Unfortunately, what we have in Pennsylvania – which is not unusual for the U.S. as a whole – is a lack of physicians that are actually trained in occupational environmental medicine."

### The Consensus: More Information Is Desperately Needed

Although the fervent advocates on both sides of the fracking controversy might consider the essential questions already settled, the only real scientific and public health consensus at the moment is that far more information is desperately needed. To the researchers at CEET and the other EHSCCs, it's clear that *something* is going on. Says Panettieri, whose expertise includes asthma and pulmonary disease, "I'm confident that as time goes by, you're going to see more and more studies showing health consequences rather than safety."

But at this stage, specifics are hard to come by. As Panettieri noted at a 2014 CEET symposium on fracking and public health: "We can only get the right answers with the right questions and right tool set. We don't have the tool set. We don't know necessarily what we're looking for. Mixed toxigen exposure is wildly complex. It's multiple doses from a long period of time – air and water pollution together – that we're seeing in hydrofracking. It could be synergistic, and we need to understand that."

### The Funding Dilemma

Striving for scientific objectivity in a public health issue as volatile and polarized as fracking is a continuing problem. "We've been very careful in terms of accepting any money for our research," says Trevor Penning, Ph.D., director of Penn's Center of Excellence in Environmental and Toxicology. "We have been approached by the American Petroleum Institute, and we did not take money from them or from public advocacy groups. We don't want to have our work pilloried because people feel it's biased in some way."

One way to avoid accusations of bias and undue influence is to keep funding sources independent. "We would love to be able to do a lot more," Penning emphasizes. "We've been doing it on a shoestring, really, and when we think about what needs to be done, it means a large investment of dollars."

Penn alumni who wish to contribute to the efforts of CEET to study not only hydraulic fracturing but also other pressing questions in environmental health and toxicology should contact Torren Blair, in Penn Medicine Development, at [torrenb@upenn.edu](mailto:torrenb@upenn.edu) or 215-898-7680 for more information.

Marilyn Howarth points out that even when dealing with individual communities and patients who may be affected, doctors are often working in the dark. "The secrecy that has been codified into law that prevents doctors from quickly learning the chemicals that ill patients may have been exposed to is unprecedented." She explains that although technically a pathway exists for obtaining information about exposure to

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chemicals, the delay involved precludes its usefulness in making a diagnosis. "Exemptions to environmental laws are generally reserved for processes that have been thoroughly researched and found to be safe. Hydraulic fracturing enjoys the exemption from major environmental laws without being thoroughly researched or having very many restrictions."

With natural gas and oil drilling currently part of the U.S. energy picture, Penning is doubtful that banning hydraulic fracturing on a national scale is practical, even if individual communities and states such as New York choose to do so. "The best we can do is identify the potential risks and manage them by having the industry adopt safe practices. I also believe that some in the industry would like to make sure that there are useful best practices, because they do not want the industry to become overregulated because of some bad actors. There's a middle ground, and I think by trying to reach that middle ground we end up being no one's friend."

In the meantime, Panettieri notes, "there has to be a concerted effort and resource allocation to further research." That includes facilities to better monitor air and water near fracking sites and more prospective studies that compare data before and after drilling. "If oil companies have found sites that are going to be initiated for drilling, it would be very important for a third party to do an assessment of health six months or a year before drilling, and then follow the health care consequence afterwards."

"There are severe gaps in knowledge," says Penning. "And the question becomes, who is best positioned to fill those gaps in knowledge? Is it the industry? Is it environmental advocacy groups? Or is it trusted academic institutions?"

Perhaps Aubrey Miller of the National Institute of Environmental Health Sciences best sums up the attitudes of science and public health professionals: "Let's not assume health and safety – let's *establish* health and safety." □