SHARE

RESEARCH CORNER

Unconventional Natural Gas Development: Epidemiologic Studies and Public Health Implications

Sara G. Rasmussen, MHS, and Brian S. Schwartz, MD, MS

Ms. Rasmussen (srasmus7@jhu.edu) is a Ph.D. candidate in the Department of Environmental Health and Engineering at the Johns Hopkins Bloomberg School of Public Health. Dr. Schwartz (bschwar1@jhu.edu) is a professor of environmental health and engineering, epidemiology, and medicine at the Johns Hopkins Bloomberg School of Public Health and School of Medicine. He is also a professor in the Department of Epidemiology and Health Services Research at the Geisinger Health System.

Unconventional natural gas is natural gas in shale rock layers deep underground that generally require vertical and horizontal drilling with hydraulic fracturing ("fracking") to bring to the surface. Over the last decade, unconventional natural gas development (UNGD) has rapidly become a major energy source in the United States, growing from 5 to 46% of the country's natural gas production between 2005 and 2015.[1] Pennsylvania, Texas, and Louisiana lead the United States in UNGD. Although UNGD has environmental and social impacts, research on the health effects of UNGD is in its infancy. Here, we describe the UNGD process and its environmental and community impacts, and summarize our epidemiology studies on UNGD and health outcomes. Finally, we provide recommendations, both on the clinical and public health levels, to protect the health of residents in communities undergoing UNGD.

During the first step of UNGD, the land (about seven acres) for the well pad is cleared and materials are brought to the site.[2] This process requires more than 1,000 diesel truck trips per well.[3] The well is then drilled vertically and horizontally. After drilling is completed, the horizontal portion of the well is perforated. Hydraulic fracturing follows, and requires three to seven million gallons of fluids, which is comprised of 90-95% water, 5-10% sand proppant (to keep the rock fractures open), and 0.1-1% chemical additives (including friction reducers, biocides, acids, and gelling agents). Although the term *fracking* is often used to describe the entire process, the hydraulic fracturing phase only lasts less than a month out of the multi-year lifetime of the well. After hydraulic fracturing, gas production begins. The gas is compressed, and then distributed or stored.[4]

The impacts of this rapid industrial development can vary in spatial scale and over the different phases of well development. Nearby residents can experience physical exposures including noise, light, and vibration.[5] Chemical exposures from air, water, and soil pollution are also possible.[2-11] Community and social impacts have included changes in home prices, increased truck traffic on local roads, and changes to the built environment and neighborhood aesthetics.[12-15] Together, these changes can contribute to stress and anxiety.[16] While much media attention has been paid to potential water impacts, we think that air pollution and social impacts may be of more immediate concern for public health. Whereas cancer and other conditions resulting from potential water contamination could take years to develop, air pollution and stress can lead to health effects within days.

To date, we have conducted three epidemiologic studies of UNGD that evaluated the association of UNGD with birth and pregnancy outcomes, asthma exacerbations, and nasal and sinus, migraine, and fatigue symptoms.[17-19] We selected these outcomes because we hypothesized it was biologically plausible for UNGD to affect the outcome through air pollution and/or stress pathways. Several methods were common across the three studies. We conducted these studies in partnership with the Geisinger Clinic, located in 40 counties in central and northeastern Pennsylvania that cover a range of UNGD. The clinic has had an electronic health record (EHR) system since the early 2000s, and the EHR provides a rich source of longitudinal data on patients. In the birth and pregnancy outcomes and asthma exacerbations studies, we identified cases and control events in the EHR, and in the nasal and sinus, migraine, and fatigue symptoms study, we identified cases and controls through a questionnaire on these conditions. In all three studies, we created covariates (*e.g.*, age, sex, race/ethnicity, co-morbid conditions, body mass index, and tobacco use) using EHR data for the study population. We categorized patients into very low, low, medium, and high UNGD groups using a metric that incorporated the distance from the patients' home to active wells, the density of wells, and the size of the wells (defined as the well depth and natural gas production). In our analyses, we controlled for other potential causes of the outcome (for example, smoking in the asthma exacerbation study). We compared patients with higher UNGD activity to those in the lowest UNGD activity group.

In the birth outcome study, we found increased odds of preterm birth and suggestive evidence for reduced birth weight among women with higher UNGD activity (those living closer to more and bigger unconventional wells), compared to lower UNGD activity during pregnancy. In the asthma study, we found increased odds of asthma

continued on page 2

continued from page 1

hospitalizations, emergency department visits, and use of a medication for asthma attacks among asthma patients with higher UNGD activity, compared to those with lower UNGD activity. Finally, in our study of symptoms, we found that patients with higher UNGD activity had higher odds of nasal and sinus, migraine headache, and fatigue symptoms, compared to those with lower UNGD activity. In each study, we conducted sensitivity analyses to evaluate the robustness of our findings. For example, we repeated the studies with a different outcome, gastrointestinal illness, which we would not expect to be associated with UNGD. Had we seen an association between UNGD and gastrointestinal illness, we would have been concerned that a factor other than UNGD was responsible for our results, but we did not see an association between UNGD and gastrointestinal illness. As these studies are observational, they cannot prove that an exposure caused an adverse health outcome. However, these studies contribute to a growing literature on UNGD and health outcomes. Other research groups have also found associations of UNGD with pregnancy outcomes and symptoms; together these suggest that UNGD is associated with health impacts.[20-22]

While our studies have several strengths, including large, population-based samples, they also had limitations: importantly, our UNGD metrics cannot determine if our associations are due to air pollution, stress, or another pathway. Future studies are needed to take environmental measurements and establish pathways, but in the meantime, what can be done to protect the health of people who live near UNGD?

At the individual level, the Southwest Pennsylvania Environmental Health Project (environmentalhealthproject.org), a nonprofit organization working on health impacts of UNGD in Pennsylvania, provides several recommendations for secondary and tertiary prevention for nearby residents.[23] These include frequently vacuuming with a HEPA filter vacuum and taking notes of health symptoms over time. They also recommend residents stop drinking water from the tap if it causes rash or pain for someone in the household.

At the public health level, best practices and regulations can prevent populations from exposure to potentially harmful impacts of UNGD. Some states, like Maryland and New York, have taken this path—they established moratoriums on UNGD at a time when few health studies had been published because of possible uncharacterized environmental and health impacts. Currently, several studies have found associations between UNGD and health outcomes. Maryland's moratorium ends in 2017. As the state evaluates what to do next, we urge it to take these now published studies into consideration. These states can learn from the experiences of states like Pennsylvania, which has rapidly moved forward with UNGD.

Specific recommendations on what people should do to protect their health if they live nearby UNGD, whether at the individual or public health level, is not something we nor any other epidemiologic researchers have evaluated to date. Therefore, health studies with detailed exposure measurements (*e.g.*, noise and air pollution levels) are needed so that we can understand why we are seeing associations between UNGD and health. With these studies, we can better inform doctors and patients. Until then, we hope that policy makers adopt the precautionary principle and make the decision to protect public health in the absence of complete data.

References

1. U.S. Energy Information Administration. Energy in Brief Web site. Shale in the United States. https://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm#shaledata. Updated 2016. Accessed November 27, 2016.
2. Olmstead SM, Muehlenbachs LA, Shih J, et al. Shale gas development impacts on surface water quality in Pennsylvania. *Proc Natl Acad Sci* 2013; 110(13):4962-67.
3. Litovitz A, Curtright A, Abramzon S, et al. Estimation of regional air-quality damages from Marcellus shale natural gas extraction in Pennsylvania. *Environ Res Lett* 2013; 8(1):014017.
4. Maloney KO, Yoxtheimer DA. Production and disposal of waste materials from gas and oil extraction from the Marcellus shale play in Pennsylvania. *Env Prac* 2012; 14(04):278-287.
5. Adgate JL, Goldstein BD, McKenzie LM. Potential public

continued on page 3

continued from page 2

health hazards, exposures and health effects from unconventional natural gas development. *Environ Sci Technol* 2014; 48(15):8307-8320.
6. Roy AA, Adams PJ, Robinson AL. Air pollutant emissions from the development, production, and processing of Marcellus shale natural gas. *J Air Waste Manage Assoc* 2013; 64(1): 19-37.
7. McKenzie LM, Witter RZ, Newman LS, et al. Human health risk assessment of air emissions from development of unconventional natural gas resources. *Sci Total Environ* 2012; 424:79-87.
8. Kemball-Cook S, Bar-Ilan A, Grant J, et al. Ozone impacts of natural gas development in the Haynesville shale. *Environ Sci Technol* 2010; 44(24):9357-9363.
9. Pacsi AP, Alhajeri NS, Zavala-Araiza D, et al. Regional air quality impacts of increased natural gas production and use in Texas. *Environ Sci Technol* 2013; 47(7):3521-3527.
10. Pacsi AP, Kimura Y, McGaughey G, et al. Regional ozone impacts of increased natural gas use in the Texas power sector and development in the eagle ford shale. *Environ Sci Technol* 2015; 49(6):3966-3973.
11. Vinciguerra T, Yao S, Dadzie J, et al. Regional air quality impacts of hydraulic fracturing and shale natural gas activity: Evidence from ambient VOC observations. *Atmos Environ* 2015; 110: 144-150.
12. Graham J, Irving J, Tang X, et al. Increased traffic accident rates associated with shale gas drilling in Pennsylvania. *Accident Analysis & Prev* 2015; 74:203-209.
13. Sangaramoorthy T, Jamison AM, Boyle MD, et al. Place-based perceptions of the impacts of fracking along the Marcellus shale. *Soc Sci Med* 2016.
14. Gopalakrishnan S, Klaiber HA. Is the shale energy boom a bust for nearby residents? Evidence from housing values in Pennsylvania. *Am J Agric Econ* 2014; 96(1): 43-66.
15. Muehlenbachs L, Spiller E, Timmins C. The housing market impacts of shale gas development. *Am Econ Rev* 2015; 105(12):3633-59.
16. Powers M, Saberi P, Pepino R, et al. Popular epidemiology and "Fracking": Citizens' concerns regarding the economic, environmental, health and social impacts of unconventional natural gas drilling operations. *J Community Health* 2015; 40(3):534-541.
17. Casey JA, Savitz DA, Rasmussen SG, et al. Unconventional natural gas development and birth outcomes in Pennsylvania, USA. *Epidemiol* 2015.
18. Rasmussen SG, Ogburn EL, McCormack M, et al. Association between unconventional natural gas development in the Marcellus shale and asthma exacerbations. *JAMA Intern Med* 2016; 176(9):1334-1343.
19. Tustin AW, Hirsch AG, Rasmussen SG, et al. Associations between unconventional natural gas development and nasal and sinus, migraine headache, and fatigue symptoms in Pennsylvania. *Environ Health Perspect* 2016.
20. Rabinowitz PM, Slizovskiy IB, Lamers V, et al. Proximity to natural gas wells and reported health status: Results of a household survey in Washington County, Pennsylvania. *Environ Health Perspect* 2014.
21. Stacy SL, Brink LL, Larkin JC, et al. Perinatal outcomes and unconventional natural gas operations in southwest Pennsylvania. *PLOS ONE* 2015; 10(6):e0126425.
22. McKenzie LM, Guo R, Witter RZ, et al. Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. *Environ Health Perspect* 2014.
23. Southwest Pennsylvania environmental health project. Three good things you can do to protect your health from gas drilling. http://environmentalhealthproject.org/files/3%20steps%20if%20you%20live%20near%20drilling%2002.15.12%20%E2%80%93%20FINAL.pdf. Accessed November 29, 2016.

SGIM