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Comment on "Predictors of Indoor Radon Concentrations in Pennsylvania, 1989–2013"

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When dividing Pennsylvania counties into five groups, Casey et al. reported an upward trend in radon concentration between 2004 and 2012 in all groups. NBC News subsequently warned, "Rising levels of toxic gas found in homes near fracking sites" (NBC News 2015). This headline is misleading.

The county groups of most interest—high, low, and no Marcellus activity—show a difference in adjusted geometric mean indoor radon concentration of < 0.8 pCi/L during any given year. Because the counties with no drilling activity had higher indoor radon concentrations than those with low drilling activity, it is unreasonable to attach a physical meaning to the difference of < 0.4 pCi/L between high- and no-activity counties at any time during Marcellus development. This result (i.e., < 0.4 pCi/L) would not be expected if ambient radon gas was escaping in significant volume from Marcellus drill pads.

While it is fair to separate counties with high and low activity, both groups are part of the same geological province, the Appalachian Plateau. High- and low-activity counties are interspersed in a patchwork such that, prior to any Marcellus activity, the two data sets should have shown similar but not necessarily identical trends. Figure 4 of Casey et al. shows that with the exception of 1995, 1996, and 2000, they do exhibit the same up–down trends in radon, with predicted indoor radon concentrations in high-activity counties offset upward by a fraction of a pCi/L long before the arrival of drilling in Pennsylvania. The same trends carry through the years of Marcellus drilling. The no-activity counties are part of a different geological province, possibly giving rise to a different radon trend (Rodgers 1971), but even data from the no-activity counties demonstrate a similar up–down trend that carries through from before the arrival of Marcellus activity.

It is even more difficult to make the case that radon trends correlate with hydraulic fracturing, or fracking, if one considers the true arrival date of significant high-volume fracking in all but Washington County, Pennsylvania. Arguably, major drilling activities were not under way until the second half of 2008, and significant production of Marcellus gas was not under way until 2009 (PA DEP 2015). The authors state explicitly that "[o]nly unconventional wells (horizontal wells, hydraulic fracturing) were included" in their study. There was only one horizontal Marcellus well drilled in Pennsylvania in 2006 and only five by the end of 2007, all in Washington County (PA DEP 2015). Yet Figure 3A of Casey et al. indicates as many as 320 horizontal wells were drilled by the end of 2007, an obvious error in their paper. Figure 4 indicates radon concentration was trending upward in 2004 in all regions, long before fracking hit Pennsylvania. Prior to 2004, there is a clear down–up–down trend in all five study regions so that an up-trend after 2003 just mirrors a similar five-year cycle starting about 1994. Even implying a link between Marcellus activity and radon as much as 12.5 miles from the nearest drill pad unreasonably stretches any message found in the data.

The only way significant amounts of natural gas–related radon will enter homes at distances outside well-pad setbacks is through use of gas for heating or cooking. The cities on gas service should be most affected; in my experience, most rural homes are not connected with natural gas service. With heat turned off in summertime, the most common entry point for radon is, to my knowledge, through gas stoves on the first floor, which consume a small fraction of the natural gas burned in basement furnaces during the winter heating season. Yet, statistics from the Pennsylvania Department of Environmental Protection show that summertime radon concentrations are lower in both basements and first floors (Robert Lewis, personal communication, 14 May 2015), the latter with open windows being the logical entry point for direct diffusion from nearby pads. Throughout the year, first-floor radon concentration consistently remains at about half the basement concentration (Robert Lewis, personal communication, 14 May 2015). This is the behavior expected if radon enters from soil and migrates to the first floor from the basement by the stack effect.

Because up–down trends in radon were present in Pennsylvania prior to the arrival of Marcellus drilling, another explanation is necessary. Something as simple as soil moisture could account for the variation of radon with time. Trends that are similar back to 1989 suggest that the arrival of drilling activity is just a confounding factor making it more difficult to identify the real cause of the decadal-scale up–down trend in radon throughout Pennsylvania.

In sum, Casey et al. raised an alarm without justification. The literature shows that such alarms stress communities near drilling activity (Ferrar et al. 2013). Thus, it behooves health educators to be circumspect before placing statements in the peer-reviewed literature that can be manipulated by the media to cause public fear and concomitant stress-related health symptoms.

The author declares his company, Appalachian Fracture Systems (ASF), has served as a consultant to the Pennsylvania Department of Environmental Protection, the government agency that generated the radon data for the study by Casey et al. ASF has also consulted for more than three dozen organizations, corporations, and government agencies dealing with various aspects of energy production and/or regulation. Any one of these consultancies might be perceived as a conflict of interest.

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References

Ferrar KJ, Kriesky J, Christen CL, Marshall LP, Malone SL, Sharma RK, et al. 2013. Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region. Int J Occup Environ Health 19(2):104–112; doi:10.1179/2049396713Y.0000000024.

NBC News. 2015. Rising Levels of Toxic Gas Found in Homes Near Fracking Sites. Health section, Health News. Available: http://www.nbcnews.com/health/health-news/could-fracking-raise-lung-cancer-risk-n338146 [accessed 9 July 2015].

PA DEP. 2015. PA DEP Oil & Gas Reporting Website—Welcome [website]. Harrisburg, PA:Department of Environmental Protection, Commonwealth of Pennsylvania. Available: https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/Welcome/Welcome.aspx [accessed 9 July 2015].

Rodgers J. 1971. The Tectonics of the Appalachians (Regional Geology Series). Hoboken, NJ:John Wiley & Sons, Inc.

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We thank Engelder for his interest in our recent publication on indoor radon concentrations in Pennsylvania. We agree that some press coverage about our article was misleading, perhaps due to various interest groups' concern about radon and shale gas development. Therefore, shortly after publication in *EHP* we used The Conversation, an independent research news website, to clarify our findings (Casey and Schwartz 2015). Our main messages regarding radon

have been that geology is the most important contributor, unconventional natural gas development (UNGD) may make a small contribution, and there is a need for continued radon monitoring in states with rapid and continuing UNGD.

Engelder focused his letter on just one of our analyses that related UNGD to building radon levels, the one that categorized counties into five groups. We note that there are two additional analyses that provided parallel evidence, which he did not address.

As Engelder noted, county-category average radon differences were small, but aggregation to the county level may mask larger UNGD-associated differences in smaller geographies or in individual buildings—a question for future research. While we agree that a difference of 0.4 piC/L between two individual measurements may be of little importance, what we observed was a mean difference of approximately 0.4 piC/L among hundreds of thousands of measurements. Aggregated, these small average differences directly translate into more lung cancer.

We also agree with Engelder that Pennsylvania counties contain different geologies, which is why we adjusted for geologic unit in all analyses. Because geology, not UNGD, is the primary driver of indoor radon concentrations, it is not surprising that when we grouped counties the average radon concentrations were not ordered by level of Marcellus activity. Nevertheless, it is not absolute radon levels but rather relative changes over time that might provide insight about impacts from recent UNGD. In our analysis, which accounted for many factors, including geology, we found that after significant UNGD began in 2009, counties with high drilling activity had statistically significantly higher radon levels than counties with no drilling, a divergence from the earlier trends presented in our article. Although an upward trend was evident prior to UNGD, both our county category and overall analysis suggest larger increases after 2009, when UNGD accelerated.

Engelder correctly identified an error in our description of the wells included in our analysis. We stated that we only included horizontally drilled wells, but we included all unconventional wells (both vertical and horizontal) in all analyses. Our data indicate that more than 200 unconventional wells were drilled by 2007, but counts do differ by source.

Engelder suggested that the only pathway for radon from UNGD to enter buildings is through use of natural gas for heating or cooking. With recent studies demonstrating the importance of ambient air and groundwater, we believe these pathways also could play a role. Fugitive emissions can travel long distances, and radioactive ingrowth can lead to increases in radiation from an original emission over many years (Nelson et al. 2015; Tait et al. 2013; Vinciguerra et al. 2015).

Engelder next asserted that statistics from the Pennsylvania Department of Environmental Protection (PADEP) show that summertime radon concentrations "are lower in both basements and first floors," but our analysis using PADEP data indicated neither basement nor first-floor levels were lower in the summer than in other seasons (Table S2), consistent with our other findings. So, contrary to Engelder's claim, we did observe elevated first-floor radon concentrations during summer months.

In a second analysis related to UNGD, we also found higher summertime first-floor radon levels in buildings located near a higher density of drilled unconventional wells. There was an attenuated association for basement concentrations, as would be expected if radon associated with UNGD entered on the first floor.

We agree with Engelder that it is possible another factor could explain our findings. However, contrary to Engelder's suggestion, it is unlikely that soil moisture is one of them, because we adjusted for monthly rainfall in our models. In a third analysis related to UNGD, which Engelder did not address, we observed that buildings with more exposure to producing Marcellus wells had higher concentrations of indoor radon. Since the amount of natural gas produced increased dramatically from 2005 to 2013, we noted that the finding could be explained by another factor that also discernably changed during that time and was associated with UNGD. However, we have no knowledge of other such factors, and certainly none that have changed as dramatically over the past decade as has UNGD in Pennsylvania.

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References

Casey JA, Schwartz BS. 2015. Small increases in radon track natural gas development with fracking in Pennsylvania. The Conversation, Environment + Energy section (10 April 2015). Available: https://theconversation.com/small-increases-in-radon-track-natural-gas-development-with-fracking-in-pennsylvania-39991 [accessed 15 June 2015].

Nelson AW, Eitrheim ES, Knight AW, May D, Mehrhoff MA, Shannon R, et al. 2015. Understanding the radioactive ingrowth and decay of naturally occurring radioactive materials in the environment: an analysis of produced fluids from the Marcellus Shale. Environ Health Perspect 123(7):689–696; doi:10.1289/ehp.1408855.

Tait DR, Santos IR, Maher DT, Cyronak TJ, Davis RJ. 2013. Enrichment of radon and carbon dioxide in the open atmosphere of an Australian coal seam gas field. Environ Sci Technol 47(7):3099–3104; doi:10.1021/es304538g.

Vinciguerra T, Yao S, Dadzie J, Chittams A, Deskins T, Ehrman S, et al. 2015. Regional air quality impacts of hydraulic fracturing and shale natural gas activity: evidence from ambient VOC observations. Atmos Environ 110:144–150; doi:10.1016/j.atmosenv.2015.03.056.