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Original Research

Shale gas development and cancer incidence in southwest Pennsylvania

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ABSTRACT

Objective: To what extent does unconventional gas development lead to an increase in cancer incidence in heavily drilled Southwest Pennsylvania?
Study design: Ecological study.
Methods: Data for urinary bladder, thyroid and leukaemia were abstracted from the Pennsylvania Cancer Registry (PCR). Cancer incidence among counties with high, moderate and minimal number of producing wells is compared before drilling activity and thereafter. Observed vs expected cases, standardized incidence ratio and 95% confidence intervals are presented. Data are presented by county, diagnosis and sex for the years 2000–2004, 2004–2008 and 2008–2012. The percent difference between the observed cases from 2000 to 2004 and 2008–2012 was calculated.
Results: The observed number of urinary bladder cases was higher than expected in both sexes in counties with shale gas activity. In counties with the fewest number of producing wells, the increase was essentially non-existent. The number of observed cases of thyroid cancer increased substantially among both sexes over the time period in all counties regardless of the number of wells drilled. The pattern for leukaemia was mixed among males and females and among the counties regardless of the extent of shale gas development activities.
Conclusion: Potential risk factors other than shale gas development must be taken into account to explain the higher than expected cancer cases in counties with and without shale gas wells before and during unconventional shale gas activity.

Introduction

Unconventional oil and gas development has enhanced the ability to extract trapped gas from tight shale formations. The process, using hydraulic fracturing, requires injecting millions of gallons of water combined with a mixture of chemicals (many of which are toxic) and proppants (usually sand or silica) into the drilled well under high pressure. With unconventional natural gas extraction, trapped gas is released along with flowback fluids consisting of the water and the chemicals used in hydraulic fracturing. In the USA, over the decades,

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38,000 oil and gas production wells in at least 25 states were hydraulically fractured, the majority of which are in Texas, Colorado, Pennsylvania and North Dakota.[1]

Studies conducted in the USA have linked shale gas development to surface and ground water contamination,[2–6] and a landmark 2015 Environmental Protection Agency (EPA) report on the impact of hydraulic fracturing estimated that almost 10 million people live within one mile of a fracked well and that hydraulic fracturing and associated activities not only have the potential to contaminate drinking water, ground water and other water resources but actually did in a number of places.[7]

Further, air pollutants, such as hydrogen sulphide, nitrogen oxides, volatile organic compounds (e.g. benzene and formaldehyde), particulate matter and ground level ozone are emitted or produced, are released during all phases of the drilling and extracting phases.[8–11] Well venting, flaring and burning gas on release account for a large source of air emissions.[12] Truck traffic and diesel truck exhaust also contribute to airborne emissions of fugitive dust, fine particulate matter and high-benzene concentrations. Werner et al.[13] comprehensively reviewed the strength of evidence focussing on the environmental health impacts of unconventional natural gas development (UGD), including the potential for harm to air, water, soil and climate change.

Finkel and Law[14] and later Shonkoff et al.[15] were the first to raise the issue of a paucity of well-designed epidemiologic studies on the public health impact of hydraulic fracturing. Anecdotal reports from areas with UGD found that adults and children living near drilling sites were presenting with symptoms such as skin rashes, dizziness, headaches, nausea, respiratory problems, eye and throat irritations, nosebleeds, anxiety. Other health conditions, many potentially serious, will take more time to develop (e.g. cancers; endocrine and reproduction systems disruptions). Hydraulic fracturing fluids contain endocrine disrupting chemicals that may adversely impact organs in the body years or decades after exposure.[16]

The byproducts of hydraulic fracturing, including benzene, fine particulate matter, and other nitrogen oxides, sulphur dioxide and ozone, have been shown to increase the risk of adverse birth outcomes and a variety of health problems among those living in near proximity to hydraulic fracturing activities.[17] Recent empirical evidence shows an increase in adverse birth outcomes (e.g. preterm birth, low-birth weight) in areas with active drilling, especially among women living close to gas wells.[18–20] Also documented is an increase in hospital utilization rates (admissions for cardiac and neurological conditions in particular) among those living in proximity to wells,[21] and mental health problems have been shown to be associated with proximity to drilling sites.[22,23]

While the accumulation of reports enumerating the potential for harm in the short-term are a matter of concern, the long-term effects of living in near proximity to unconventional drilling sites are not known as of this writing. Certainly, the potential for harm will vary by proximity to wells, length of time of exposure and route of exposure. Confounding factors would need to be taken into account as well to understand the extent of the relationship between health outcomes and UGD.

Purpose of study

Many states actively support unconventional natural gas development (e.g. Colorado, Louisiana, North Dakota, Pennsylvania, Texas, Wyoming). Pennsylvania, in particular, has embraced an aggressive policy of drilling and extracting natural gas from the Marcellus Shale, one of the largest shale plays in the USA. Drilling commenced in 2008, and as of May 1, 2015, 9134 unconventional wells have been drilled in Pennsylvania, notably in several counties in the southwest part of the State.[24]

Anecdotal reports of elevated cancer rates in the heavily drilled southwest region of the state provided the impetus to investigate whether exposure to UGD activities impacts the development of cancers that are known to be associated with environmental exposure (e.g. bladder, leukaemia and thyroid cancers). To what extent were the observed number of cancer cases higher than expected in counties with the highest number of producing wells (Washington and Greene) compared to counties with little or no UGD (Fayette and Westmoreland) and to counties with a moderate amount of producing wells (Allegheny and Beaver). Data before UGD commenced (2000–2008) are compared to years during UGD (2009–2012). Key questions that we sought to answer include: to what extent was cancer incidence elevated prior to UGD? To what extent does UGD contribute to cancer development?

Methods

While genetics and lifestyle factors account for many cancers, occupational and environmental exposures also can be major risk factors. Three specific cancers were selected for inclusion in this study: bladder, leukaemia and thyroid. Bladder cancer, for example, is associated with exposure to arsenic in drinking water, and exposure to benzene, cadmium, aromatic amines, tricholoroethylene solvants, silica and lead. Benzene, pesticides, reactive chemicals, dioxin solvents and non-ionizing radiation are linked to leukaemia. Radiation, pesticides and genetics are linked to thyroid cancer. However, cancer causation is complex and multi-factorial. UGD requires hundreds of different chemicals in the fracturing process, many of which have been shown to be carcinogenic.

Cancer incidence and mortality were abstracted from the Pennsylvania Department of Health (DOH) Bureau of Health Statistics and Research's Pennsylvania Cancer Registry (PCR).[25] The PCR includes the annual number of invasive cancer cases and cancer deaths by age, sex, race, primary site, as well as observed and expected cases by diagnosis. The observed number of cases is based on the number of primary tumours, not the number of individuals diagnosed with cancer. The PCR follows the SEER ICD-0 coding structure used to identify primary sites of cancers. Expected cases represent the total number of primary malignant tumours that would have been reported to the PCR if Pennsylvania's male and female populations had experienced the same age-specific rates of cancer incidence as those reported by the SEER program during the same time period.