

# [Hydrofracking and human health effects review of current literature research pape...](https://assignbuster.com/hydrofracking-and-human-health-effects-review-of-current-literature-research-paper/)

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The decrease in world’s petroleum and oil supply has led the nations to look for alternate sources of energy. As a result of this short-supply, unconventional gas reserves are gaining importance as alternative source of crude oil, where the unconventional gas reserves are estimated to contribute to 45% of the US gas production by the year 2035. Large-scale extraction of unconventional natural gas has resulted in the development of new and untested extraction technology such as hydraulic fracturing or hydrofracking, which is expected to develop rapidly in the next few decades near human settlements and pose a health hazard (Adgate, Goldstein & McKenzie, 2014). The attention on hydraulic fracturing is intense due to the use of fluid additives, the release of unwanted methane into water that has potential for groundwater contamination, soil erosion, sedimentation, enrichment of surface water and spills into streams causing damage to aquatic life. Such activities could pose direct and indirect risks to human health through exposure via various pathways (Burton Jr. et al., 2014). Currently, the health and environmental hazards of hydrocracking are uncertain with sparse data. There is a requirement of large-scale, good quality research for the assessment of long term and short-term risks of hydraulic fracturing (Adgate et al., 2014).

## Background

Process of hydraulic fracturing
The process of hydrofracking commences with injection of large volumes of water (90%) mixed with fluid additives (0. 5 to 2%) and sand (9%, approximately) into deep wells (150 m to 4000 m in depth) at high pressure. The sand acts as a proppant that helps to break open the natural gas layers and helps them stay open for harvesting. The gas or oil then flows through the fractures into the pipeline and to the surface. 10 to 70% of the water that helps build the pressure comes back to the surface and can be reused. This used water, which is a mix of sand, fluid additives and other chemicals, is called produced water (Goldstein et al., 2014). The produced water may contain naturally occurring radioactive material that are found underground along with the added chemicals. Each well has a production life of 20 to 30 years during which the primary product and the produced water are collected, treated and disposed. During these processes, chemical and nonchemical stressors affect the workers as well as the communities surrounding the site of extraction (Adgate et al., 2014).
Some of the chemicals used in hydrofracking are diluted acids, clay stabilizers, breaker, biocides, solvents, buffer, foamers, defoamers, gel and surfactant. These chemicals help improve the flow of the water, chemicals and the proppant through the pipelines, help thicken the sand to hold the fractures for better retrieval of the fossil fuels, prevent rust in the pipes, reduce friction by reducing surface tension and in general, make hydrofracking a smooth affair (Burton Jr et al., 2014). While these additives make up very little of the fracturing fluid, over the 20-30 years, they may add up to hundreds of thousands of gallons. Some of the additives are considered harmless while others among them such as silica, lead, benzene, methanol and boric acid are toxic to humans (Korfmacher et al., 2013).

## Potential exposure pathways and toxicological effects

Occupational and community exposure via air pollution. Hydrofracking causes release of air pollutants such as hydrogen sulfide, benzene, toluene, ethylbenzene, and xylene, formaldehyde, nitrogen oxides and volatile compounds. Hydrogen sulfide is an explosive gas and has the risk of acute toxicity to humans (Shonkoff, Hays & Finkel, 2014). Silica is another chemical that is used frequently in drilling and is associated with lung cancer, chronic obstructive pulmonary disease, kidney disease and silicosis. Hydrofracking uses silica as a proppant that causes formation of large clouds of silica during use, thereby increasing the respirable silica (Esswein, Breitenstein, Snawder, Kiefer & Sieber, 2013). Exposure to aliphatic and aromatic hydrocarbons is possible during drilling of the oil wells, which have been associated with various forms of leukemia, lymphoma, myeloma and many other blood disorders (Adgate et al., 2014).
Community exposure via water pollution. Produced water is often recycled for further hydrofracking purposes; however, some of the water that is heavy in total dissolved solids (TDS) is treated and disposed at an offsite location (Shonkoff et al., 2014). One form of containing disposed produced water is to inject the water into deep containment wells. Such an unlined deep well could allow some of the produced water to be absorbed into the rocks and lead to contamination of the water table. Studies have shown that the produced water contains chemical levels that exceed the standard drinking water concentration. In recent times, the high level of bromide in domestic water supply near hydrofracking sites has led to the use of chloramines for water purification instead of chlorine due to the possibility of formation of brominated compounds during chlorine-mediate disinfection of water. Loose sand from the drilling site often form landslides and lead to chemical runoff, thereby contaminating the surface waters (Goldstein et al., 2014).

## Study summary

Hydrofracking air emissions exposure and potential health hazard
A study was conducted in Garfield County, Colorado in persuasion of a health impact assessment of the air exposure to hydraulic drilling and directional drilling upon the residents living near the hydrofracking sites. The authors used Environmental Protection Agency’s (EPA) guidelines to assess the impact of chronic and sub-chronic cancer hazard and non-cancer hazard to hydrocarbon exposure. Two populations were taken for study where one group of residents lived less than or equal to half a mile from the fracking site while the other group of residents lived more than half a mile from the site. Sub-chronic exposure was assumed to be twenty months and chronic exposure was assumed to be 30-years (a typical lifetime of a well). The researchers found that the greatest risk of sub-chronic exposure was posed by the well completion phase, which the authors assumed would be 5 years. The residents living ≤ half a mile from the site were found to be at greater risk of sub-chronic exposure to non-cancer hazard chemicals such as trimethylbenzenes (45%), aliphatic hydrocarbons (32%) and xylene (17%). Residents living > half a mile from the well had risk of chronic non-cancer exposure from aliphatic hydrocarbons (51%), trimethylbenzenes (22%) and benzene (14%). The sub-chronic non-cancer exposure hazard indices (HI) that were calculated from the hazard quotient (HQ) were higher for the residents living nearer to the wells (5) and much lower for those living further away (0. 2). The chronic non-cancer exposure HI was found to be 0. 4 for residents > half a mile from the well and 1 for residents living ≤ half a mile from the site (McKenzie, Witter, Newman & Adgate, 2012). Non-cancer health hazard from the chronic exposure pointed towards neurological risk while sub-chronic exposure pointed towards neurological, respiratory and blood disorders. The statistically significant possibility on cancer risk was 6 in a million for residents living > half mile from the site and 10 in a million for residents living ≤ half a mile from the site. The highest cancer causing agents for residents further from the well were identified as benzene (84%) and 1, 3-butadiene (9%). For resident living nearer to the site, benzene (67%) and ethylbenzene (27%) were the primary carcinogenic risks. Descriptive statistics were used for quantitative assessment of risk of hydrocarbon exposure, which showed that nearly 2/3rd of the hydrocarbons (n= 38) were detected at 100% during the well completion phase when compared to n= 23 hydrocarbons during extraction phase. Median concentrations of benzene were found to be 2. 7 times higher during well completion than the extraction phase. Similarly, toluene and xylene were found to be 4. 3 and 9 times higher during well completion. These findings reinforce the hypothesis and findings of other similar studies (McKenzie et al., 2012).
Another study on the volatile organic compound emission during shale gas exploration in the Barnett Shale revealed that none of the VOCs released during hydrofracking activities exceeded the stipulated limit set by the state and federal governments. These data were collected over 13 years from monitors that were located in the areas that were drilling-intense. The data was not exclusive to hydraulic fracturing but included data for all types of oil drilling activities. The monitors were tested for 105 unique VOCs using GC-MS. The autoGC monitors detected potentially relevant VOCs in the range of 70 and 98% while the manual canisters detected potential VOCs between 63 and 100%. Toluene and n-hexane were detected at 98% by autoGC monitors. The manual canisters recorded detection of benzene at 99% and toluene at 100%. The results were analyzed quantitatively, similar to the study by McKenzie et al. (2012). The annual average measurement of the large amount of raw data set with non-detect measurement was calculated using Kaplan Meier (KM) method. The deterministic and probabilistic risk assessment showed that none of the VOCs were a health concern due to chronic exposure, even in the drilling intense areas (Bunch et al., 2013).

## Hydrofracking and endocrine disrupting chemicals

As mentioned earlier, some of the chemical additives used in hydrofracking are a potential risk to humans. One such risk is the endocrine disrupting activity of the chemicals. Exposure to estrogenic chemicals have been associated with sterility, cancer and underdeveloped gonads. Antiestrogenic chemicals could decrease bone density while antiandrogenic chemicals are suspected to cause many reproductive structural and qualitative problems. A group of scientists conducted a study in Garfield County, Colorado to examine the estrogen and androgen receptor activity and the amount of water contamination caused by such endocrine disrupting chemicals (EDC). 39 water samples were collected from surface, ground and artesian water sources from drilling-intense sites, drilling –sparse and no drilling sites. The chemicals from the samples exhibited antiestrogenic (24-65% suppression of estrogen), antiandrogenic (0 to 63% suppression of testosterone), and limited estrogenic activity. None of chemicals exhibited androgenic activity. Antiestrogenic activity was observed in 2-ethyl-1-hexanol and ethylene glycol while antiandrogenic activity was observed in ethylene glycol, n, n-dimethyl-formamide and cumene. Bisphenol-A exhibited estrogenic activity. 89% of the samples exhibited estrogenic activities, 41% exhibited anti-estrogenic, 12% exhibited androgenic and 46% antiandrogenic activities (Kassotis, Tillitt, Davis, Hormann & Nagel, 2013). Statistical analysis was conducted using linear mixed models (hierarchical linear model) for the results obtained from all three assays. The study showed a statistically significant association between the EDC and drilling activities by comparing the concentration of EDCs in the water sources of drilling sites (which were higher) with water sources of no-drilling sites (which showed low EDC concentration). However, these results need to be corroborated through multiple studies (Kassotis et al., 2013).

## Hydrofracking and drinking water contamination by methane

The contamination of groundwater by produced water is most likely by the process of high-pressure injection in the gas well that causes flow of the produced water into shallow groundwater. Produced water contains dissolved gases and radioactive compounds that when mixed with drinking water supply could pose potential health hazard for humans. A study on the contamination of drinking water well by methane in Pennsylvania showed that 85% of the well sampled for the study were polluted with methane that were 17 times higher in concentration than the allowed limit. Methane could be naturally occurring biogenic (and shallow) or drilling-associated thermogenic (and deep) in origin. In this case, the authors confirmed that the source of contamination was the thermogenic methane by calculating the ratio of 13C isotope to the 2H-CH4. These values were found to be statistically correlated (P < 0. 0001). The methane concentration of non-active sites were concluded as biogenic in origin. The study also indicated that there were no fracturing chemical fluids in the drinking water (Osborn, Vengosh, Warner & Jackson, 2011).
A study on the water wells near Marcellus shale gas site has revealed that water wells of homes located approximately 1 km from the hydrofracking site had dissolved methane and ethane in them, both of which are harmful to humans. Of the 141 drinking water wells sampled for the study, 82% (n= 115) contained six times higher concentration of methane when compared to control water well samples. Similarly, ethane was found to be 23 times higher in concentration while some wells had propane. 13C isotope was found in the houses less than 1 km from the drilling sites. The data were analyzed using multiple regression, Pearson correlation and Spearman analyses. The concentration of methane in the wells and the distance of the wells from the fracking site had a high correlation (P= 0. 0003 and P= 0. 001 for Pearson and Spearman coefficients, respectively). The authors proposed that the reason behind the high dissolved methane could be due to one of two reasons, namely, faulty casing leaks and improper cement sealing. The researchers concluded that some of the homeowners had their water wells contaminated by hydrofracking activities due to improper well construction (Jackson et al., 2013).

## Hydrofracking and occupational exposure to silica during

Crystalline silica is a commonly used proppant and is often called as fracsand in hydrofracking lingo. During well development phase, each individual site requires hundreds of thousands of pounds of quartz sand to keep the cracks open for gas and oil extraction. The workers have to mechanically handle the fracsand, which has a high possibility of turning into respirable silica dust. As mentioned earlier, silica dust has been associated with silicosis and lung cancer. In this study, the authors conducted experiments for three consecutive days at eleven hydrofracking sites to detect the amount of respirable silica taken in by the workers. The assessment was done across various job titles to obtain a randomized sample. The results revealed that workers with the job title pump truck operator, quality control technician and wireline operators had respirable quartz below the detection level. Since there were multiple samples from the same job title, a one-way analysis of variance (one-way ANOVA) was conducted to assess the statistical difference. To assess the statistical differences among the different job titles, least significant difference (LSD) multiple comparison test was used. The authors identified that T-belt operators and sand movers were the most affected by breathable silica (53%) while water tank operators were least affected. The authors also discovered seven possible sources of silica dust generation, namely, thief hatches, sand mover belt, blender hopper, T-belts, dragon tail, fill ports and site traffic (Esswein et al., 2013).

## Hydrofracking and teratogenic effects

There have been studies associating low birth weight, VOCs, nitrogen oxides, benzene and particulate matter. Since benzene is one of the highly emitted pollutants during the well developmental stage, the authors in this study examined the correlation between birth outcomes and maternal proximity to hydrofracking sites. Live birth data were analyzed and maternal locations at the time of pregnancy and birth geocoded and linked to existing active well locations. Data from 1996 to 2009 were sampled for this purpose. Five possible teratogenic birth defects and birth outcomes were identified, namely, cleft lip and/or left palate, neural tube defects, coronary heart disease (CHD), preterm birth and full term low birth weight. Exposure assessment was carried out by analyzing the distance between maternal residence during pregnancy and time of birth and the fracking site using the inverse distance weighted (IDW) approach. A 10-mile radius was used for narrowing down the number of hydrofracking sites. The results were analyzed using logistic regression to find the statistical correlation between birth outcomes and maternal proximity to hydrofracking sites. The authors found a positive but modest correlation between the density of hydrofracking wells and maternal proximity to the negative birth outcomes such as CHD and neural tube defects. The authors found a low positive correlation between occurrence of oral cleft and no correlation between maternal proximity to hydrofracking site. A negative correlation was observed between low birth weight and maternal proximity to hydrofracking sites (McKenzie et al., 2014).

## Hydrofracking and childhood cancer

As an explorative study, researchers in Pennsylvania counties evaluated the correlation between hydrofracking and the occurrence of childhood cancer. Data from Pennsylvania drilling well and cancer centers were obtained. The data from 1990 to 2009 regarding leukemia and central nervous system (CNS) tumors were collected (Fryzek, Pastula, Jiang & Garabrant, 2013) as hydrofracking fluid additives have been often correlated with blood disorders and nervous system disorders (Adgate et al., 2014). The statistical method of standardized incidence ratios (SIRs) was used to correlate the number of cancers on record with the expected number of cancer for the population. The data for observed and expected counts were determined by analyzing the cancer occurrence before the drilling activities began and after the first well was drilled, respectively. The observed childhood cancer cases before drilling were 1894 and after drilling were 1996. The researchers found a negative correlation between the number of wells and the number of leukemia cases, although the numbers of CNS tumor cases were statistically higher after the drilling began. Even so, the numbers of tumor cases did not increase with an increase in the numbers of wells drilled. The analysis was restricted to gas wells and did not include oil wells (Fryzek et al., 2013).

## Conclusion

The information from the recent studies is not clear on the direct impact of hydrofracking on human health due to lack of strong association and evidence. McKenzie et al. (2012) mentioned that their default assumption for exposure values, use of 95% confidence interval of exposure concentrations and use of upper limit values of cancer and non-cancer risk in their study as their limitations. The hazard index is a sound evidence but requires clinical correlation to actual cases. The strength of evidence from the study by Kassotis et al. (2013) is statistically strong due to the use of goodness of fit model, linear mixed models, Kenward-Roger method and corrected Akaike information. However, these findings need to be corroborated by clinical studies. The hydrofracking activities have been positively correlated to methane contamination of the drinking water wells using statistically sound evidence that were backed by multiple regression analysis, Pearson and Spearman analysis (Jackson et al., 2013) but the studies also proved that no hydrofracking fluid additives contaminants were found (Osborn t al, 2011). Research has shown a positive correlation between hydrofracking activities and occupational silica exposure. The multiple samples were analyzed using one way ANOVA to arrive at statistically significant evidence (Esswein et al., 2013). Some of the studies reviewed here also presented negative or statistically weak correlation between hydrofracking and childhood cancer (Fryzek et al., 2013), VOCs and health hazard (Bunch et al., 2013) and maternal proximity to hydrofracking sites and birth outcomes (McKenzie et al., 2014). These studies have revealed some potential hazards that need to be investigated but also have shed light on some concerns that are baseless.

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