

Community Perceptions of Health Risks Associated With a Petrochemical Plant in Beaver County, Pennsylvania

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Abstract We surveyed residents in Beaver County, Pennsylvania, to explore their perceptions on health in the months leading up to the November 2022 opening of a petrochemical plant (specifically, an ethylene cracker plant) in the county. An online survey collecting demographics, self-reported health habits, perceived community and personal health status, and attitudes toward environmental health was distributed from July 2022 through August 2023. Descriptive statistics were generated and chi-square tests of independence were calculated. A total of 436 adult residents of Beaver County completed the survey. Respondents indicated concerns about their current exposure to air pollution (76%) and unsafe drinking water (65%). Approximately 36% and 25% of survey respondents indicated that they felt their health had been harmed by air pollution or unsafe drinking water, respectively. Perceived health and specific health habits were associated with agreeing or disagreeing with the statements “My health has been harmed by unsafe drinking water” and “My health has been harmed by air pollution.” These data illustrate that there is high concern about current and future exposure to pollution in Beaver County. These findings can assist community leaders in addressing and advocating for participant concerns about exposure to air and water pollution. A follow-up survey will be conducted to determine if there have been changes in perceptions since plant operations began.

Keywords: air pollution, water pollution, environmental health risk, self-reported health status, community perceptions

Introduction

Since 2010, the petrochemical industry and its related infrastructure have expanded. Ethylene cracker plants expose ethane derived from natural gas to high heat, resulting in ethane splitting or cracking to form ethylene to produce plastic “nurdles,” tiny plastic pellets approximately 3–5 mm in size that are the building blocks for all plastic products and are shipped globally for manufacturing (Jiang et al., 2022; Murtazashvili et

al., 2023). Despite progress toward reducing single-use plastics and increasing recycling, plastic consumption and waste production increased an estimated 60–99 million metric tons in 2015 and is projected to reach 155–265 million metric tons by 2060 (Lebreton & Andrady, 2019).

Plastic production generates air pollution that contains a variety of emissions (Ragothaman & Anderson, 2017). As a result, in 2019 plastic production generated 850 metric tons

of greenhouse gas emissions. The production and disposal of plastics also play a role in the exacerbation of water pollution, including the degradation of plastics into plastic debris and chemicals such as polystyrene and persistent organic pollutants (e.g., polychlorinated biphenyls) (Alabi et al., 2019). Nurdles can enter waterways through unintentional spillage during production and transportation; nurdles are found in bodies of freshwater and saltwater throughout the world (Jiang et al., 2022).

Although surveys have been used to measure perceived environmental health risk (Carlton & Jacobson, 2013; Rundmo, 2002; Zeng et al., 2020), little research has been conducted to measure how proximity to a facility such as an ethylene cracker plant influences change in perceptions by community members regarding risk. Moreover, data are scarce on perceptions prior to a facility beginning operations. The objective of our study was

to collect baseline demographics and health and environment perceptions of residents at the time the plant began operations. We focus here on associations with the environmental health risk perception statements: “My health has been harmed by exposure to air pollution” and “My health has been harmed by exposure to unsafe drinking water.”

Methods

Study Setting

This study was conducted in Beaver County, approximately 20 miles northwest of Pittsburgh, Pennsylvania. Beaver County, particularly along the Ohio River Valley, has a history of industrial manufacturing, including glass and steel production, and is home to the Shell Polymers Monaca plant. The current site of the Shell plant was once home to the Horsehead Corporation zinc smelter, which at the time was one of the largest zinc refineries in the U.S.

Since the opening of the ethylene cracker plant in November 2022, the Pennsylvania Department of Environmental Protection has filed 15 violations against Shell due to their lack of adherence to state air quality guidelines (Glabicki, 2023). Within 6 months of operation, the ethylene cracker plant already had reached its 12-month volatile organic compound (VOC) emission limit. Since then, Shell has been mandated to submit monthly emission levels, was issued a \$10-million fine, and was shut down for repairs for 2 months (Frazier, 2023).

Survey

The self-administered online survey was developed in collaboration with members of a community advisory board and approved by the University of Pittsburgh (UPitt) Institutional Review Board (Study 19080112). The survey was disseminated via Pitt+Me, an initiative of the UPitt Clinical and Translational Science Institute, and via community organizations. Participants received a \$10 gift card after completion of the survey. Before enrolling, participants were screened for study eligibility criteria: being a current resident of Beaver County and at least 18 years of age.

The survey collected demographic information. Participants were asked their age (≤ 25 , 26–39, 40–54, 55–64, ≥ 65 years), race and ethnicity (American Indian or Alaska Native, Asian, Black or African American,

Native Hawaiian or Other Pacific Islander, other, White), sex, marital status (married/domestic partnership, not married/single, other), education level (less than high school, high school diploma/GED, college or higher, other), employment status (disabled/unable to work, full-time employment, not employed, part-time employment, retired, stay-at-home parent/caregiver, student), income level ($< \$20,000$, $\$20,000$ – $\$29,999$, $\$30,000$ – $\$49,999$, $\geq \$50,000$, prefer not to answer), and health insurance coverage (private health insurance, Medicare, Medicaid, Veterans Administration, self-pay/no insurance, other).

Participants self-reported tobacco use and history of asthma, cancer, chronic obstructive pulmonary disease (COPD), depression, diabetes, heart attack, and stroke. A single-item self-related health statement was assessed by agreement with the statement: “My overall health is very good or excellent” (Bowling, 2005). Additionally, 12 health habits and perspectives were measured, including:

- Eating products from local hunting, fishing, or gardening
- Using well water as their primary water source
- Using a home water filtration system
- Changing their furnace filter regularly (2–3 times/year)

Environmental health risk perception was assessed by 13 statements. Responses to each statement were measured using a 5-point Likert scale and subsequently collapsed to “agree,” “neutral,” or “disagree.” Environmental health risk statements included:

- Individual attitudes toward current exposure to air pollution
- Individual attitudes toward current exposure to water pollution
- Experiences of adverse health effects attributed to exposure to air pollution
- Experiences of adverse health effects attributed to exposure to unsafe drinking water
- Existing and future industrial environmental practices
- Local government role and performance in addressing community concerns

Statistical Analysis

Submitted surveys that contained an invalid or missing ZIP Code were excluded. Categorical variables were dichotomized as yes or no (the latter category included no and not

sure). We calculated chi-square tests of independence to assess the associations between the sentences “My health has been harmed by exposure to unsafe drinking water” and “My health has been harmed by exposure to air pollution” with the questions about environmental health risk perception. Statistical analyses were performed using RStudio version 4.2.3 (RStudio Team, 2023).

Results

From July 2022 through August 2023, the survey was distributed to 677 individuals. Of residents who received the survey, 74% (498/677) started it, and out of that group, 93% (465/498) completed the survey. Respondents without a valid ZIP Code (26) were excluded. In total, 439 responses were included in our analysis.

Survey respondents self-reported as female (54%), college-educated (82%), married/in a domestic partnership (79%), having an income $> \$50,000$ (64%), employed full-time (60%), and having health insurance (96%). The largest age group was 25–39 years (36%). A total of 81% of respondents reported that their health was very good or excellent. Depression was reported as the most common diagnosis among participants (30%), followed by asthma (16%).

Most respondents agreed with the statement “My health can be harmed by exposure to air and water pollution” (92%) and with the statements about concern for current levels of exposure to air pollution and unsafe drinking water (77% and 66%, respectively). More than one third (39%) of all survey respondents, however, agreed with the statement “Overall, I am satisfied with the environmental practices of local industry.”

More than one half (56%) of respondents agreed with the statement: “Fossil fuel sources, such as coal or natural gas, are economically important to the future of Beaver County.” Three out of four respondents (77%) agreed with the statement: “Alternative energy sources, such as solar or wind, are economically important to the future of Beaver County.” Approximately one third (32%) of respondents indicated that they rely on well water as their primary drinking source, and 52% of respondents reported never having had their well water tested. Many respondents reported taking preventive measures against exposures to pollutants, such as using

a home water filtration system (53%) and regularly changing their furnace air filter (75%).

Table 1 shows counts, percent agreement, and statistical significance between the statement “My health has been harmed by exposure to air pollution” and the environmental risk perception questions. Respondents who hunted or fished locally and spent more than 1 hr outside each day were more likely to disagree with the statement than respondents who did not. Respondents who grew their own produce and filtered their drinking water were also more likely to agree with the statement: “My health has been harmed by exposure to air pollution.”

Table 2 shows counts, percent agreement, and statistical significance between the statement “My health has been harmed by unsafe drinking water” and the environmental risk perception questions. In contrast to the previous question, respondents who hunted or fished locally were more likely to agree, as were respondents who grew their own produce and filtered their drinking water. Respondents who spent more than 1 hr outside, however, were more likely to disagree with the statement: “My health has been harmed by unsafe drinking water.”

Discussion

We developed and implemented our survey to gather baseline demographic, health information, and risk perceptions among adult residents of Beaver County. While we found widespread concern among survey respondents regarding exposure to unsafe drinking water (65%) and air pollution (76%), we also found support for fossil fuels (56%) and moderate satisfaction with local industry’s environmental practices (39%). Similar to a study in Southwest Detroit by Warner et al. (2023), our study highlights the importance of understanding community perceptions toward environmental hazards such as air and water pollution, which are exacerbated by industrial activities.

Perception of one’s health being harmed by specific pollution sources is based on a continuum of evidence ranging from clinical findings to subjective impressions. Nonetheless, it appears that as many as 25% of Beaver County residents felt they were directly affected by current levels of water pollution, and 33% of residents felt they were directly affected by current levels of air pollution.

TABLE 1

Agreement Between Environmental Risk Perception Questions and the Statement “My Health Has Been Harmed by Air Pollution”

Question		Agreement With “My Health Has Been Harmed by Air Pollution”		
		Agree # (%)	Neutral # (%)	Disagree # (%)
I eat meat from local hunting *	Total	158 (36.4)	139 (32.0)	137 (31.6)
	Yes	82 (39.6)	45 (21.7)	80 (38.6)
	No/not sure	76 (33.5)	94 (41.4)	57 (25.1)
I eat fish from local fishing *	Total	157 (36.3)	139 (32.1)	137 (31.6)
	Yes	78 (41.7)	38 (20.3)	71 (38.0)
	No/not sure	79 (32.1)	101 (41.1)	66 (26.8)
I grow my own fruits and/or vegetables *	Total	159 (36.6)	139 (32.0)	137 (31.5)
	Yes	96 (41.7)	70 (30.4)	64 (27.8)
	No/not sure	63 (30.7)	69 (33.7)	73 (35.6)
I filter my drinking water with a pitcher *	Total	157 (36.3)	139 (32.2)	136 (31.5)
	Yes	90 (46.4)	52 (26.8)	52 (26.8)
	No/not sure	67 (28.2)	87 (36.6)	84 (35.3)
I have a home water filtration system *	Total	159 (36.6)	139 (32.0)	137 (31.5)
	Yes	81 (35.4)	63 (27.5)	85 (37.1)
	No/not sure	78 (37.9)	76 (36.9)	52 (25.2)
I spend more than 1 hour a day outside *	Total	158 (36.5)	138 (31.9)	137 (31.6)
	Yes	117 (34.6)	101 (29.9)	120 (35.5)
	No/not sure	41 (43.2)	37 (38.9)	17 (17.9)
I feel well-informed about healthy indoor air practices *	Total	159 (36.7)	137 (31.6)	137 (31.6)
	Yes	101 (35.8)	80 (28.4)	101 (35.8)
	No/not sure	58 (38.4)	57 (37.7)	36 (23.8)
I use well water as my primary drinking source *	Total	159 (36.6)	139 (32.0)	137 (31.5)
	Yes	75 (53.6)	30 (21.4)	35 (25.0)
	No/not sure	84 (28.5)	109 (36.9)	102 (34.6)

*Statistically significant comparison at $p < .05$.

Many more felt current levels had the potential to affect their health. These responses were associated with specific risk-related behaviors; however, at this point we cannot determine if practicing specific actions such as filtering drinking water alters an individual’s overall perception of risk or if a preexisting overall perception of risk leads someone to adopt these specific behaviors.

While the full impact of the Shell Polymers Monaca plant is not yet known, the number of Beaver County residents who consume locally sourced foods is notable. This find-

ing can help justify soil and water monitoring because a large proportion of residents are at an increased risk of exposure to contaminants through their eating habits.

The application of the “exposome” concept, as explored in a study around the Vasilikos Energy Center in Cyprus (Kleovoulou et al., 2021), offers an innovative framework for comprehensively assessing environmental exposures. This approach, which seeks to explain an individual’s environmental exposures over an entire lifetime, could greatly enhance our understanding of the cumula-

TABLE 2

Agreement Between Environmental Risk Perception Questions and the Statement “My Health Has Been Harmed by Unsafe Drinking Water”

Question		Agreement With “My Health Has Been Harmed by Unsafe Drinking Water”		
		Agree # (%)	Neutral # (%)	Disagree # (%)
I eat meat from local hunting *	Total	106 (24.4)	115 (26.5)	213 (49.1)
	Yes	62 (30.0)	39 (18.8)	106 (51.2)
	No/not sure	44 (19.4)	76 (33.5)	107 (47.1)
I eat fish from local fishing *	Total	106 (24.5)	115 (26.6)	212 (49.0)
	Yes	63 (33.7)	36 (19.3)	88 (47.1)
	No/not sure	43 (17.5)	79 (32.1)	124 (50.4)
I grow my own fruits and/or vegetables	Total	106 (24.4)	115 (26.4)	214 (49.2)
	Yes	61 (26.5)	68 (29.6)	101 (43.9)
	No/not sure	45 (22.0)	47 (22.9)	113 (55.1)
I filter my drinking water with a pitcher *	Total	105 (24.3)	114 (26.4)	213 (49.3)
	Yes	67 (34.5)	49 (25.3)	78 (40.2)
	No/not sure	38 (16.0)	65 (27.3)	135 (56.7)
I have a home water filtration system *	Total	106 (24.4)	115 (26.4)	214 (49.2)
	Yes	69 (30.1)	47 (20.5)	113 (49.3)
	No/not sure	37 (18.0)	68 (33.0)	101 (49.0)
I spend more than 1 hour a day outside	Total	106 (24.5)	115 (26.6)	212 (49.0)
	Yes	77 (22.8)	86 (25.4)	175 (51.8)
	No/not sure	29 (30.5)	29 (30.5)	37 (38.9)
I feel well-informed about healthy indoor air practices	Total	105 (24.2)	115 (26.6)	213 (49.2)
	Yes	66 (23.4)	68 (24.1)	148 (52.5)
	No/not sure	39 (25.8)	47 (31.1)	65 (43.0)
I use well water as my primary drinking source *	Total	106 (24.4)	115 (26.4)	214 (49.2)
	Yes	59 (42.1)	27 (19.3)	54 (38.6)
	No/not sure	47 (15.9)	88 (29.8)	160 (54.2)

*Statistically significant comparison at $p < .05$.

tive health risks associated with petrochemical industry expansion. By engaging a broad spectrum of interested parties, including local authorities, industries, and communities, the authors demonstrated the necessity of collaborative efforts in addressing environmental and public health concerns effectively. Engagement with interested parties emphasizes the importance of transparent and inclusive communication strategies (Kleovoulou et al., 2021; Warner et al., 2023).

This approach fosters trust and facilitates a more accurate understanding of health risks

and mitigation measures. Perceptions—particularly those related to health monitoring and the dissemination of risk-related information—resonate with our findings, suggesting that Beaver County could benefit from adopting a more inclusive approach to risk communication and management.

Limitations of our study include reliance on self-reporting and potential selection bias among individuals who chose to participate. A strength is that there were few missing responses, suggesting that the survey was an appropriate length. Another strength is that

the demographic characteristics of respondents were similar to the population of Beaver County, although survey respondents were more likely to be married and more likely to have completed a college degree than the general population of the county (U.S. Census Bureau, 2022).

Future research should aim to address community concerns, strengthen collaborations among interested parties, and enhance environmental health literacy within the community to increase community engagement in these types of studies. From a policy perspective, it is important to determine if current regulations are adequate to prevent adverse health outcomes from ethylene cracker plants and other industry-related pollution. In terms of public health practice, tailored interventions (e.g., environmental monitoring systems) should be implemented.

Conclusion

Our baseline survey of Beaver County residents reveals varying perceptions about current and future energy sources. This study emphasized the importance of engaging the community as soon as possible to assess environmental health concerns and perceptions that could help enlighten community needs. These data can guide advocates, policymakers, and health professionals, in collaboration with community members, to implement meaningful interventions that address perceived health and environmental risks. These interventions are instrumental in enhancing public health. 🌸

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