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HEALTH RISK TO LOCAL RESIDENTS FROM THE PORTSMOUTH GASEOUS DIFFUSION PLANT

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EXECUTIVE SUMMARY

The Portsmouth Gaseous Diffusion Plant (PGDP) in Pike County, Ohio used the UF_6 gaseous diffusion process to enrich uranium from 1954 to 2001. As a result of routine plant operations, radioisotopes and toxic chemicals were regularly released to the air, water, and soil. Despite ongoing concerns about health effects of exposures to toxic radioactivity, little research on local health patterns has been conducted.

This report, using official health statistics, found the following health patterns and trends for Pike County:

1. The county's cancer incidence in 2010-2019 was 15% higher than the U.S., the highest rate of all 88 Ohio counties.

2. In the 1950s and 1960s, county cancer mortality was 12% below the U.S. The gap closed, and by 1993, the Pike rate exceeded the U.S. The largest gap (+32.8%) occurred in 2019-2020.

3. In 2009-2020, the cancer death rate in the county exceeded the U.S. by about 50% for all age groups, except for persons over age 75 (0.5% below the U.S.).

4. County age-adjusted mortality for all causes was 2-5% above the U.S. in the 1980s and early 1990s. By 2019-2020, the county rate was 42.3% greater.

5. Among persons 0-74, all-cause mortality in the county soared to 85.0% above the U.S. in 2017-2020, nearly twice that of the nation.

These unexpected findings constitute a great concern, and call for prompt and thorough review of all potential causes, including socioeconomic factors, access to medical care, health behavior, and exposures to environmental toxins, such as those from the PGDP. Any findings must be shared with the public and public officials, so that any efforts to reduce future local disease and death rates may begin promptly.

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Background– the Portsmouth Gaseous Diffusion Plant and Uranium Enrichment.
The Portsmouth Gaseous Diffusion Plant (PGDP), located just south of Piketon in Pike County, Ohio, operated from 1954 to 2001. The plant occupies about one-third of the 3,777-acre Portsmouth Site, owned and operated by the federal government.

The PGDP was one of three large gaseous diffusion plants in the United States that initially produced enriched uranium for nuclear weapons, and later for commercial nuclear reactors. After the Cold War, weapons-grade uranium enrichment at Portsmouth was suspended and production facilities were leased to the private sector. In 2001, enrichment operations were discontinued at the site (U.S. Department of Energy, 2022).

The enrichment process uses uranium compounds converted into a gaseous form (UF_6, uranium hexafluoride) having a boiling point of 57º C. The diffusion process consisted of transporting UF_6 (g) *via* a pressure differential across a porous nickel barrier; each diffusion stage produced a slight enrichment of ^{235}U in the downstream gas based upon the differing transport rates between $^{235}UF_6$ and $^{238}UF_6$. Most construction details of the separation process and nickel barrier are still maintained as classified information by the US Department of Energy (DOE).

During plant operation, radioisotopes and hazardous chemicals were routinely emitted into the air, soil, surface water, and groundwater. Besides uranium, additional, synthetic radioisotopes were present in the feed, including ^{236}U, ^{99}Tc, ^{237}Np, ^{239}Pu and ^{240}Pu, as contaminants in recycled uranium that had been recovered from Pu production reactors (Moody, 1995). The byproduct stream, which remained following extraction of all practicable quantities of ^{235}U, is referred to as depleted uranium, containing approximately 0.2% ^{235}U. Thousands of 14-ton cylinders of depleted UF_6 are currently stored on the PGDP grounds; the depleted uranium finds uses in armor, penetrators, and in nuclear weapons (World Nuclear Association, 2022).

The U.S. Department of Energy's Office of Environmental Management began its environmental cleanup program at the site in 1989, an ongoing effort coordinated with the U.S. and Ohio Environmental Protection Agencies. Decontamination and decommissioning of the plant commenced in 2011 (U.S. Department of Energy, 2022).

Introduction – Health Concerns from Portsmouth Operations Remain Unaddressed.
When ingested, all radioactive isotopes damage DNA in cells or kills them outright, leading to an elevated risk of disease and death. Several major findings are clear after decades of study:

1. All humans are affected negatively by radiation exposure, even at the lowest doses (Committee on the Biological Effects of Ionizing Radiation, 1990)

2. The most severe effects of a dose are borne by the fetus and infant, whose immune systems are immature; by the frail elderly, whose immune systems are failing; and by those who are immunocompromised

3. The lag time between exposure and onset of disease or death may take several years, or even decades

4. While some cancers are known to be especially sensitive to radioactivity, such as thyroid cancer or bone cancer, the risk of all cancers are increased after radiation exposure

Numerous articles have appeared in the medical literature, documenting the excess in cancers after relatively low-dose exposures. A recent article in the Journal of the National Cancer Institute found 21 of the 26 studies determined an excess of cancer from low-level radiation (Gonzalez, 2020).

The Radiation and Public Health Project (RPHP), a non-profit research and educational organization, has published 38 medical journal articles, mostly on health patterns and trends near nuclear plants. Unexpectedly high rates of cancer closest to nuclear plants have often been documented (Radiation and Public Health Project, 2022).

Health risks to local residents from PGDP operations have long been a concern. In 2000, a U.S. Energy Department investigation found mishandling of hazardous material, along with failure to properly monitor environmental emissions or workers' exposure to radiation. The review identified 400 accidental releases of uranium hexafluoride and fluorine gas, although the actual total was unknown due to poor record keeping (Beyerlein, 2019).

Government studies of health near PGDP (and all nuclear facilities) have been virtually non-existent. In 1990, at the request of Senator Edward M. Kennedy, the National Cancer Institute conducted a study of cancer mortality near 62 U.S. nuclear plants. The study compared the ratios of county vs. U.S. cancer mortality, before and after the plants began operating, using 1950-1984 data. The study found no consistent link between plant startup and cancer mortality.

One of the 62 plants in the study was the PGDP; the National Cancer Institute selected Pike County as the “study” (exposed) area. In each five-year period between 1950 and

1967, the Pike County cancer rate was either 12% or 13% below the U.S. (Jablon, 1990). The study is outdated, and no federal study of cancer near nuclear reactors has been conducted since.

A 2001 federal study of 8,877 persons who worked at the PGDP for at least one day found 1,088 had died by 1991, well below the 1,518 deaths expected in a general population of the same age. The report noted the young age of many workers made it difficult to fully compare death rates and work exposures (National Institute for Occupational Safety and Health, 2001).

In 2019, a middle school was closed after radioactive contaminants were detected in the school building and in the air. Two federal law suits were filed on behalf of local residents (Brookbank, 2019).

The need for more detailed health studies is crucial. The purpose of this report is to analyze historical data on local rates of cancer, and other health conditions, near the PGDP.

Methods – Ratio of Pike County vs. U.S. Rates of Cancer Incidence and Mortality.
Pike County will be the focus of this report. It is the location of the PGDP, and the 1990 National Cancer Institute study selected Pike County for analysis of cancer near the plant. The county's area is 444 square miles, meaning most of the population resides within 20 miles of the plant. Thus, the 27,000 Pike residents are most likely to have incurred any adverse health effects from exposure to toxic releases from the PGDP.

One measure of local health will be cancer incidence, or rate of cancer cases. The Ohio Department of Health makes public annual cancer incidence data, for the state and each county, from 1996 to 2019 (Ohio Department of Health, 2022).

In addition, cancer mortality will be studied. The source for mortality data is the Centers for Disease Control and Prevention's "CDC Wonder" data base. Available online, CDC Wonder includes information on every U.S. death, each year from 1968 to 2020, as of August 2022 (U.S. Centers for Disease Control and Prevention, 2022).

The 1990 National Cancer Institute study selected the U.S. cancer rate as the control, or "expected" rate for each county and calculated a county vs. national ratio for five-year periods. This report will use the same measure for incidence (beginning 1996), and mortality (beginning 2019).

The county-to-nation ratio in the 1950s and 1960s, the early years of the PGDP's operation, is the "expected" ratio for all subsequent periods. Statistical significance tests are used for any differences between the county and nation. A p-value of .05 or less means there is a 95% or greater chance that the difference between the county and national rates is not due to random chance.

Results – Cancer Incidence Trends Since 1996.

Annual incidence data are available for each of the 88 Ohio counties, for each year from 1996 to 2019. Between 2000-2004 and 2015-2019, the number of newly diagnosed cases among Pike County residents soared from 626 to 983.

The Pike County incidence rate was below the U.S. rate in the late 1990s and early 2000s, but has exceeded the U.S. ever since.

1996-1999 - 4.7% vs. U.S.
2000-2004 - 11.5% vs. U.S.
2005-2009 + 1.6% vs. U.S.
2010-2014 + 9.1% vs. U.S. (4^{th} highest of 88 counties)
2015-2019 +20.8% vs. U.S. (1^{st} highest of 88 counties)

(2019) +32.5% vs. U.S. (1^{st} highest of 88 counties)
2010-2019 +14.9% vs. U.S. (1^{st} highest of 88 counties)

The county rate was 20.8% above the U.S. for cancers diagnosed in the latest five-year period (2015-2019), and 32.5% above the U.S. in the latest year of diagnosis (2019). Pike had the highest incidence rate of any Ohio county in the latest decade (2010-2019).

Appendix 1 provides more detailed information on trends in cancer incidence.

Results – Cancer Mortality Trends Since 1950.

As mentioned, age-adjusted cancer mortality is available from 1950 to 2020. While Appendix 2 and Figure 1 include county/national ratios by five-year periods, results can be combined into four groups:

1950-1967 – 5-year county rates were 12% to 3% below the U.S. (23 annual deaths)
1968-1993 – 5-year county rates were 2% to 9% below the U.S. (42 annual deaths)
1994-2008 – 5-year county rates were 4% to 7% above the U.S. (61 annual deaths)
2009-2020 – 5-year county rates were 19% to 32% above the U.S. (73 annual deaths)

The number of cancer deaths has steadily increased, partly because the total population has increased, as well as the proportion of elderly, who have the highest rates of cancer. But age-adjusted rates account for these factors, and thus a dramatic change from a low-cancer to a high-cancer county is observed.

The county rate exceeded the U.S. by the greatest percentage in the most recent period, 2009-2020. In particular, in the years 2019-2020, the county rate was 32.8% above the U.S. based on 154 deaths. As of this writing, 2021 data is preliminary, but with 79 cancer deaths recorded for that year, this unusual excess will continue.

Results – Cancer Mortality, 2009-2020.

Exceptionally high cancer mortality in Pike County in the 12-year period 2009-2020 merits more detailed analysis. The table below (and Appendix 3) compares county and U.S. rates by age groups:

Category	Pike County Rate (Deaths)	US Rate	County Rate vs. US
All	200.0 (875)	158.6	+26.1%
Age 0-44	15.8 (28)	10.0	+58.3%
Age 45-64	263.6 (275)	172.0	+53.3%
Age 65-74	861.5 (270)	594.8	+44.8%
Age 75+	1230.6 (302)	1237.1	- 0.5%

The county's excess for all age groups ranged between +44% and +58%, except the rate for persons over age 75, which was 0.5% below the U.S. The difference between Pike County and U.S. rates is statistically significant for each age category, except for persons over age 75.

Results – Childhood Cancer Mortality.

Cancer rates in children are much lower than those in adults. However, child cancer is the most-studied type of cancer in populations exposed to radioactivity, as doses to the fetus, infant, and young child are more potent than the same doses absorbed by adults.

Historical data on child cancer mortality in Pike County, compared to the U.S., can be analyzed from two sources. The 1990 National Cancer Institute study included cancer deaths for county residents age 19 and younger for the years 1950-1967, while the

Centers for Disease Control and Prevention web site has information for all years from 1968-2021. Results are as follows (also see Appendix 4 for more detailed information):

Period	Deaths	Pike vs. U.S.
1950-1967	15	-20.1%
1968-2021	18	+20.8%

Again, the shift of Pike County from a low-cancer to a high-cancer county can be observed. However, the change is not statistically significant due to the small number of deaths in children.

Results – Mortality for All Causes Combined.

The dramatic shift in Pike County's cancer mortality relative to the U.S. suggests additional analysis of trends in all causes of death is in order. Age-adjusted mortality for all causes in Pike County vs. the U.S. by five-year period is given in the table below, and in detail in Appendix 5:

All Ages

Period	Deaths	Pike vs. U.S.
1969-1973	1158	+13.6%
1974-1978	1100	+ 6.0%
1979-1983	1157	+ 2.8%
1984-1988	1213	+ 4.6%
1989-1993	1201	+ 2.4%
1994-1998	1495	+21.3%
1999-2003	1550	+22.4%
2004-2008	1557	+23.6%
2009-2013	1650	+32.7%
2014-2018	1799	+38.5%
2019-2020	803	+42.1%

Prior to 1994, the Pike County all-cause mortality rate was slightly above the U.S. However, the gap between the county and national rates has grown steadily since then, reaching a peak of 42.1% greater most recently (2019-2020).

This report has shown that cancer mortality in Pike County is highest, relative to the U.S., for persons under age 75. Below is a table of all-cause mortality for Pike County since 1969, by five-year period (Appendix 5 contains more detailed information):

Age 0-74

Period	Deaths	Pike vs. U.S.
1969-1973	674	+13.9%
1974-1978	641	+15.4%
1979-1983	661	+16.7%
1984-1988	662	+18.5%
1989-1993	599	+ 9.9%
1994-1998	727	+32.5%
1999-2003	774	+45.9%
2004-2008	741	+39.2%
2009-2013	874	+63.9%
2014-2018	967	+72.4%
2019-2020	436	+76.8%

From the late 1960s to the early 1990s, the Pike County rate ranged from 9.9% to 18.5% above the U.S. But starting in the mid-1990s, the gap expanded, reaching a peak in the most recent period.

In the most recent four years for which final CDC data is available (2017-2020), total age-adjusted mortality for those age 0-74 in Pike County exceeded the U.S. by 85.0%. While official 2021 data will not be available until December 2022, the preliminary death total in Pike County rose 21%, compared to only 9% nationwide, between 2020 and 2021.

Thus, adding 2021 to the prior four years will mean an increase in the 85.0% excess. It is likely that 2017-2021 mortality age 0-74 will be twice as high in Pike County as in the U.S.

Discussion.

The PGDP has been continuously releasing radioactive materials into the environment since the 1950s; emissions and other radioisotopes have continued during DOE's deactivation, decommissioning, and building demolition phases. Studies of the potential health impact of exposures to the local population have been limited and are outdated.

Current (2015-2019) cancer incidence in Pike County is 20.8% above the U.S., and the gap is growing (32.5% greater in 2019, the most recent year available). In the early 2000s, the Pike County rate was below the nation. But in the past decade (2010-2019), Pike's cancer incidence was the highest of all 88 Ohio counties, with 1846 new cases.

Cancer mortality in Pike County, which had been 12% less than the U.S. for most of the 1950s and 1960s has soared to 26.3% higher since 2009, and the gap continues to grow. About 350 county residents now die of cancer every five years.

Cancer mortality in Pike County since 2009 is about 50% above the U.S. for each age group under 75 years. The county rate for those over 75 is 0.5% below the nation. Pike County's age-adjusted mortality for all causes combined was slightly above the U.S. in the 1980s and early 1990s. The gap has grown steadily, peaking at 42.1% higher in 2019-2020. For county residents under age 75, the excess was 85.0% in 2017-2020, nearly double the U.S. rate.

Analysis of rising morbidity and mortality rates of cancer and other diseases should consider multiple potential causes. These factors include socioeconomic status, access to medical care, individual health practices, and exposures to environmental pollutants.

Appendix 6 shows that Pike County ranks among the worst of the 88 Ohio counties in a number of potential factors, while ranking among the best in areas like alcohol consumption and proximity to grocery stores. While these indicators may affect morbidity and mortality, no firm conclusions can be drawn on how prominent a role they play; thus, factors such as exposures to environmental pollutants merit consideration.

Exposures to toxic chemicals released by the PGDP since it began operating in 1954 must be one factor included in attempts to identify contributors to the decline in public health in Pike County. While cancer represents the most-studied radiation-related condition, exposures to radioactive chemicals can contribute to other diseases; adverse trends in Pike County for all causes reaffirm the need to consider the PGDP as an underlying cause for the observed increases.

The process of identifying root causes of declining health requires the expertise of medical researchers. However, it is critical that the public and public leaders be informed of results and included in subsequent discussions; transparency in the process is critical if problems and solutions are to be identified.

This report is the most comprehensive analysis of local health near the PGDP to date, as well as the most current. Results call for continued efforts to understand the potential link between radiation and adverse health effects. Other available data that can be analyzed includes infant deaths, low weight births, and premature births.

Direct measurements of past internal radiation exposure are also needed. Measurement of radioactive Strontium-90 in baby teeth has been the most frequently employed means of

such measurement, as the natural loss of baby teeth makes collection of in-body samples easier than other methods. The Radiation and Public Health Project's study of Strontium-90 in 5,000 baby teeth, mostly near six U.S. nuclear plants, can be a prototype for similar human exposure studies near other plants such as the PGDP.

In addition, it appears appropriate to initiate studies of past/present human exposure of PGDP-proximity residents to uranium and other radionuclides (e.g., ^{99}Tc and ^{237}Np) *via* media such as urine, blood, teeth, hair, and post-mortem autopsy tissues.

Acknowledgement:
Michael Ketterer, PhD, Professor Emeritus of Chemistry and Biochemistry at Northern Arizona University, Flagstaff AZ, assisted in the preparation of this report.

Appendix 1
Age-Adjusted Cancer Incidence, County vs. U.S.
All Cancers Combined by Five-Year Period, 1996-2019
* County rate significantly different than U.S. at P <.05

	Cases/100,000		Pike	
Period	Pike	U.S.	Cases	% vs. U.S. (Ohio rank)
1996-1999	447.2	481.7	498	- 7.2%
2000-2004	423.8	484.9	626	- 11.6%
2005-2009	490.8	483.1	789	+ 1.6%
2010-2014	502.5	460.6	863	+ 9.1% (4^{th} of 88)
2015-2019	540.6	447.5	983	+20.8%* (1^{st} of 88)
(2019)	577.4	435.8	213	+32.5%* (1^{st} of 88)
2010-2019	522.0	454.4	1846	+14.9%* (1^{st} of 88)

Note: U.S. 1996-1999 = 1999 only; 2010-2019 excludes 2019.
Sources: Ohio Department of Health.
https://publicapps.odh.ohio.gov/EDW/DataBrowser/Browse/StateLayoutLockdownCancers (Pike County data); U.S. Centers for Disease Control and Prevention.
https://wonder.cdc.gov/cancer-v2018.HTML (U.S. data).

Appendix 2
Age-Adjusted Mortality, All Cancers Combined
Pike County OH vs. U.S., by Five-Year Periods, 1950-2020
* County rate significantly different than U.S. at P <.05

Yr of Death	Pike County Rate (Deaths)	U. S. Death Rate	% Pike vs. U.S.
1950-1952	---- (60)	----	-12.0%
1953-1957	---- (107)	----	-12.0%
1958-1962	---- (114)	----	-12.0%
1963-1967	---- (132)	----	-13.0%
1968-1972	192.3 (160)	199.1	- 3.4%
1973-1978	197.2 (231)	202.2	- 2.5%
1979-1983	195.2 (221)	207.2	- 5.8%
1984-1988	191.2 (233)	211.6	- 9.6%
1989-1993	199.4 (250)	214.5	- 7.1%
1994-1998	215.9 (298)	206.4	+ 4.6%
1999-2003	210.4 (309)	196.3	+ 7.2%
2004-2008	191.9 (307)	181.7	+ 5.6%
2009-2013	217.3 (374)	168.9	+28.7%*
2014-2018	185.9 (347)	155.3	+19.8%*
2019-2020	192.8 (154)	145.1	+32.8%*

Sources: National Cancer Institute, Cancer in Populations Living Near Nuclear Facilities (1950-1967); U.S. Centers for Disease Control and Prevention, https://wonder.cdc.gov/ (1968-2020).

Appendix 3
Cancer Mortality, Pike County vs. U.S., 2009-2020
* County rate significantly different than U.S. at P <.05

Category	Rate (Deaths)	US Rate	County vs. US
All	200.0 (875)	158.6	+26.1%*
Age 0-44	15.8 (28)	10.0	+58.3%*
Age 45-64	263.6 (275)	172.0	+53.3%*
Age 65-74	861.5 (270)	594.8	+44.8%*
Age 75+	1230.6 (302)	1237.1	- 0.5%
Female	161.1 (378)	158.6	+ 1.5%
Male	249.0 (497)	189.7	+31.3%*
W Non-Hisp	202.5 (863)	163.6	+23.8%*
Lung/bronchus	64.9 (288)	40.2	+61.2%*
(F) breast	22.6 (51)	20.6	+10.1%
(M) Prostate	13.7 (25)	19.5	- 29.7%
Colorectal	18.2 (80)	14.0	+30.2%*
Unspecified site	11.20 (49)	7.24	+54.7%*

Notes: ICD-10 codes used include Lung/bronchus (C34); breast (C50); prostate (C61); colorectal (C18-C20); unspecified (C80).

Source: U.S. Centers for Disease Control and Prevention. https://wonder.cdc.gov/Deaths-by-Underlying-Cause.html.

Appendix 4
Cancer Mortality, Age 0-19, Pike County vs. U.S.
* County rate significantly different than U.S. at P <.05

1950-1967 = 15 (observed)/18.78 (expected) = -20.1%)

1968-1978 = 5/ 87,422 = 5.72 (U.S. = 5.76)
1979-1998 = 8/157,011 = 5.10 (U.S. = 3.62)
1999-2021 = 5/180,000 = 2.78 (U.S. = 2.40)

Total 1968-2021

Pike County	18/	424,433	= 4.24 (+20.8% vs. U.S.)
U.S.	147,119/	4,186,695,510	= 3.51

Sources: National Cancer Institute, Cancer in Populations Living Near Nuclear Facilities (1950-1967); U.S. Centers for Disease Control and Prevention, https://wonder.cdc.gov (1968-2021).

Appendix 5
Age-Adjusted Mortality, All Causes
Pike County OH vs. U.S., by Five-Year Periods, 1969-2020
* County rate significantly different than U.S. at P <.05

All Ages Yr of Death	Pike County Rate (Deaths)	U.S. Rate	% Pike vs. U.S.
1969-1973	1389.6 (1158)	1223.3	+13.6%*
1974-1978	1148.6 (1100)	1083.6	+ 6.0%
1979-1983	1033.9 (1157)	1005.9	+ 2.8%
1984-1988	1023.4 (1213)	978.5	+ 4.6%
1989-1993	950.4 (1201)	927.9	+ 2.4%
1994-1998	1082.8 (1495)	892.5	+21.3%*
1999-2003	1053.2 (1550)	860.3	+22.4 %*
2004-2008	981.3 (1557)	793.7	+23.6 %*
2009-2013	982.6 (1650)	740.3	+32.7%*
2014-2018	1008.4 (1799)	728.3	+38.5%*
2019-2020	1102.7 (803)	775.8	+42.1%*
2020	(422)	(3383729)	
2021 (preliminary)	(481)	(3464026)	
% Change	+14.0%	+2.4%	

Age 0-74 Yr of Death	Pike County Rate (Deaths)	U.S. Rate	% Pike vs. U.S.
1969-1973	723.5 (674)	635.0	+13.9%*
1974-1978	644.9 (641)	559.0	+15.4%*
1979-1983	592.0 (661)	507.4	+16.7%*
1984-1988	571.2 (662)	482.1	+18.5%*
1989-1993	499.5 (599)	454.4	+ 9.9%
1994-1998	562.9 (727)	424.8	+32.5%*
1999-2003	573.5 (774)	393.1	+45.9%*
2004-2008	501.9 (741)	360.6	+39.2%*
2009-2013	549.1 (874)	335.0	+63.9%*
2014-2018	582.6 (967)	337.9	+72.4%*
2019-2020	651.7 (436)	368.6	+76.8%*
2017-2020	655.7 (878)	354.5	+85.0%*
2020	(232)	(1548724)	
2021 (preliminary)	(281)	(1693540)	
% Change	+21.1%	+9.4%	

Source: U.S. Centers for Disease Control and Prevention, https://wonder.cdc.gov (1968-2020).

Appendix 6

SELECTED HEALTH FACTORS (Pike overall 79th of 88 counties)

* = tied with other county(ies)

Indicator	Ohio Rate	Pike Rate	Pike Rank, 88 Cos.	Yr
% Adults Who Smoke	22%	27%	67*	2019
% Adults Who are Obese	35%	39%	56*	2019
Index/factors of healthy food environment	7.0	6.8	38*	2019
% >18 w leisure time physical activity	28%	36%	86*	2019
% w adequate access to physical activity	77%	28%	82	2010/2021
% Adults reporting binge/heavy drinking	21%	17%	1*	2019
% driving deaths w alcohol impairment	33%	17%	5*	2016-20
% < 65 with no medical insurance	8%	9%	63*	2019
Persons per primary care physician	1290	3470	73	2019
% >25 with high school diploma	91%	84%	81*	2016-20
% 25-44 w some post-secondary ed.	66%	48%	77*	2016-20
% >16 unemployed but seeking work	8.1%	9.4%	74*	2020
% < 18 living in poverty	17%	25%	82*	2020
% children in homes w single parent	27%	22%	45*	2016-20
% pop. w inadequate access to food	13%	19%	85*	2019
% low-income pop. not close to grocery store	7%	1%	2	2019

Source:
University of Wisconsin Population Health Institute. County Health Rankings and Roadmaps.
https://www.countyhealthrankings.org/app/ohio/2022/overview. Published 2022. Accessed July 23, 2022.

References:

Beyerlein T. Piketon: A Troubled Past. Dayton Daily News. https://www.daytondailynews.com/news/piketon-troubled-past/yVz7hjdC8z4bi9pz6MgWOJ/. Published May 15, 2019.

Brookbank S. Lawsuit: Residents Near Portsmouth Gaseous Diffusion Plant Have Been 'Sacrificial Lambs.' Cincinnati Enquirer. https://www.cincinnati.com/story/news/2019/06/30/lawsuit-residents-near-portsmouth-plant-have-been-sacrificial-lambs/1611619001/. Published June 30, 2019.

Committee on the Biological Effects of Ionizing Radiations (BEIR), National Research Council. Health Effects of Exposures to Low Levels of Ionizing Radiation: BEIR V. Washington DC: National Academy Press, 1990.

Gonzalez AB, Daniels RD, Cardis E, et al. Epidemiological studies of low-dose ionizing radiation and cancer: Rationale and framework for the monograph and overview of eligible studies. JNCI Monographs. 2020;56:97-113. https://doi.org/10.1093/jncimonographs/Igaa009.

Jablon S, Hrubec Z, Boice JD Jr., Stone BJ. Cancer in Populations Living Near Nuclear Facilities. NIH Pub. No. 90-874. National Cancer Institute, July 1990.

Moody, K.J., "Forensic Radiochemistry of PUBLIC Site Inspection Samples", Lawrence Livermore National Laboratory 1995, UCRL-ID-119658.

National Institute for Occupational Safety and Health. Mortality Patterns of Uranium Enrichment Workers at the Portsmouth Gaseous Diffusion Plant. https://www.cdc.gov/niosh/oerp/pdfs/2001-133g5-1.pdf. Published 2001.

Ohio Department of Health. Cancer Incidence Data (1996-2019). https://publicapps.odh.ohio.gov/EDW/DataBrowser/Browse/StateLayoutLockdownCancers. Accessed August 9, 2022.

Radiation and Public Health Project. https://radiation.org/category/journal-articles/. Accessed June 6, 2022.

U.S. Centers for Disease Control and Prevention. CDC Wonder; underlying cause of death or compressed mortality. https://wonder.cdc.gov/. Published 2022.

U.S. Department of Energy, Portsmouth/Paducah Project Office. Portsmouth Site. https://www.energy.gov/pppo/portsmouth-site. Published 2022. Accessed May 31, 2022.

World Nuclear Association. How is Uranium Made into Nuclear Fuel? https://www.world-nuclear.org/nuclear-essentials/how-is-uranium-made-into-nuclear-fuel.aspx#:~:text=The%20enrichment%20process%20requires%20the,gas%20at%20relatively%20low%20temperatures. Published 2022. Accessed June 6, 2022.

Figure 1
Age Adjusted Cancer Mortality, Pike County OH vs. U.S., by 5 Year Period, 1950-2020