ENVIRONMENTAL RISK FACTORS AND IOWA'S CANCER CRISIS

A 2026 REPORT

BY THE IOWA ENVIRONMENTAL COUNCIL AND THE HARKIN INSTITUTE FOR PUBLIC POLICY & CITIZEN ENGAGEMENT

Iowa Environmental Council

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ACRONYMS

AFO: Animal Feeding Operation
CAFO: Concentrated Animal Feeding Operation
CISWRA: Central Iowa Source Water Resource Assessment
EFSA: European Food Safety Authority
EPA: Environmental Protection Agency
EPC: Environmental Protection Commission
EPTC: S-Ethyl Dipropylthiocarbamate
FFDCA: Federal Food, Drug, and Cosmetic Act
FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act
GIS: Geographic Information System
IARC: International Agency for Research on Cancer
IDALS: Iowa Department of Agriculture and Land Stewardship
IDNR: Iowa Department of Natural Resources
IWQIS: Iowa Water Quality Information System
MCL: Maximum Contaminant Level
NESHAP: National Emissions Standards for Hazardous Air Pollutants
NO_x: Nitrogen Oxides
NPDES: National Pollutant Discharge Elimination System
NRS: Nutrient Reduction Strategy
OPP: Office of Pesticide Programs
OSHA: Occupational Safety and Health Administration
PFAS: Per- and Polyfluoroalkyl Substances
PFBA: Perfluorobutanoic Acid
PFOA: Perfluorooctanoic Acid
SO_x: Sulfur Oxides
TFA: Trifluoroascetic Acid
TRI: Toxic Release Inventory
USDA: U.S. Department of Agriculture
USGS: U.S. Geological Survey
VOCs: Volatile Organic Compounds
WHO: World Health Organization

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INTRODUCTION

IOWA IS AN OUTLIER FOR CANCER. People across the state are struggling with the impacts of Iowa's high and rising new cases (incidence) of cancer and what that means for their health, their families, their finances, and their lives. Since 2023, the Iowa Cancer Registry's annual Cancer in Iowa report has been highlighting Iowa's position as second in the nation for new cancer cases. Iowa is also one of the only states where cancer incidence is increasing (Iowa Cancer Registry, 2023, 2024, 2025). In 2013, Iowa was ranked 19th nationally; in 2015, it jumped to 8th; and by 2022, it reached 2nd place, where it has since remained (U.S. Cancer Statistics Working Group, 2025; U.S. Department of Health and Human Services, 2025). The Interim Findings Report of the Key Drivers of Cancer in Iowa Project found that the variation in Iowa's cancer rates is not fully explained by demographic and behavioral factors (University of Iowa College of Public Health, 2026).

Cancer develops when normal cell behavior changes as a result of genetic predispositions, lifestyle choices, certain medical conditions, environmental influences, or a combination of these factors. For more than a century, researchers have understood cancer to be a multifactorial disease. In other words, multiple DNA mutations, known as "driver mutations," are typically required to trigger cancer development. Advances in gene sequencing and molecular biology have refined this understanding, including clearer insight into how external factors can cause changes in DNA over a person's lifetime through epigenetic changes. Recent studies suggest that as few as three driver mutations may be sufficient to lead to the development of some solid tumors, while fewer may be required for leukemias and other blood cancers (Wu et al., 2018).

Experts are clear that a variety of risk factors likely contribute to cancer incidence. Those factors include smoking, exposure to ultraviolet light from the sun and tanning beds, diet and activity levels, alcohol consumption, and many others (Iowa Cancer Registry, 2024b). Factors outside an individual's control can also contribute to cancer risks and impact health outcomes such as access to screening and treatment, racial inequalities in treatment, and access to healthy food and outdoor spaces (National Cancer Institute, 2025a). Recognizing these structural factors is essential, both for accuracy and to avoid implying that individuals are to blame for their cancer risks or diagnoses when many individual choices are influenced by surrounding systems.

Cancer and Iowa's Environment: A Necessary Conversation

Academic and medical researchers, cancer organizations, oncologists, environmental scientists, healthcare professionals, public health educators, parents, caregivers, and Iowans in every part of the state are on the front lines of this fight. Groundbreaking and life-saving work is underway in the areas of cancer prevention, detection, treatment, and public education in Iowa. The Iowa Environmental Council, The Harkin Institute, and the partners involved in this report hope our voices contribute meaningfully to the evolving dialogue and help advance efforts to reverse Iowa's devastating cancer trend and save lives.

It can be challenging to discuss the ways in which pollution, naturally occurring environmental hazards, and agriculture contribute to cancer in Iowa. Farming and industry are woven throughout Iowa's history, livelihoods, and cultural identity. However, many studies have found that environmental pollution is linked to cancer through a number of pathways including inducing oxidative stress, DNA damage, inflammatory responses, endocrine disruption, and immune evasion (Rio et al., 2024).

More than 170,000 Iowans share the experience of living with a past or current cancer diagnosis, and many more have lost loved ones to cancer (Iowa Cancer Registry, 2025a). Like any disaster, it is an experience that unites us. In 2025, IEC and The Harkin Institute, in partnership with the Iowa Farmers Union, brought together hundreds of Iowans who shared their lived experiences at listening sessions across Iowa, from Iowa's biggest cities to small towns. The growing movement to address cancer in Iowa shows that Iowans are looking for real answers and serious solutions. Iowans know that what we eat, drink, breathe, and touch can potentially change our DNA, stress our immune systems, and make a cancer diagnosis more likely, especially when coupled with behavioral and genetic risk factors.

Iowans deserve to know what risks we are facing. We cannot escape what has been allowed to contaminate the environment in which we live.

People who live close to the land, especially farmers, understand that we are deeply connected to our environment. Playing outside, wading in creeks, fishing, and riding bikes are the kinds of childhood experiences that families across Iowa cherish. Access to the outdoors, public lands, nature, and recreation has the potential to boost health and wellness. Iowans who are part of vulnerable communities, including those with limited incomes and less access to healthcare services, as well as people of color, are at even greater risk for negative health outcomes (National Cancer Institute, 2025a).

All Iowans deserve to live long, healthy, and satisfying lives. Now is the time to understand, take seriously, and act on preventable environmental risk factors that threaten our health and wellbeing.

The purpose of this report is to analyze and summarize peer-reviewed research and data about environmental exposures that are present in our air, water, and soil, and their relationship to the cancer burden in Iowa.

Information is drawn from multiple sources: peer-reviewed academic and scientific research, public datasets, and lived experiences as relayed by Iowans. The research and analysis inform recommendations for policy, public health measures, further study, and preventative individual actions. The report is organized into sections based on contaminant type (i.e. pesticides, PFAS [per- and polyfluoroalkyl substances], nitrate, and radon). It also takes a high-level look at additional carcinogens pervasive in Iowa and the common sources of those carcinogens, including industrial pollution and contaminated sites.

Many of the cancer studies referenced in this report gathered detailed information on large cohorts (study groups followed over several years to decades). Such long-term research of human subjects is challenging because cancer generally takes years to develop, and scientific knowledge evolves with time and as new technology becomes available. Studies also can be subject to information bias (errors in data that arise from the approach used to collect or measure data) and confounding factors (other factors that are related to disease outcome and get in the way of determining cause and effect in a study) (Jager et al., 2008; Althubaiti, 2016). Investigators must attempt to sort out many influences when determining the cause of cancer incidence for an individual. Researchers rely on observational studies and animal models in their research because it would not be ethical to expose people to potentially harmful substances to test a hypothesis.

However, it is possible to identify general relationships between environmental exposures and cancer risk. Although these relationships do not necessarily prove causation, they can support causal hypotheses when they show biological plausibility and consistent findings across studies. In scientific research, an *association* refers to any relationship between two variables, while a *correlation* specifically describes a linear relationship between them. *Relative risk* is a specific measure of association that quantifies how much more likely an exposed group is to have an outcome compared to an unexposed group (Roberts et al., 2019). This report seeks to be transparent about the level of certainty of the relationships between Environmental Risk Factors of Cancer. Recommendations and action steps were derived from the findings with the overarching goal of reducing the cancer burden in Iowa.

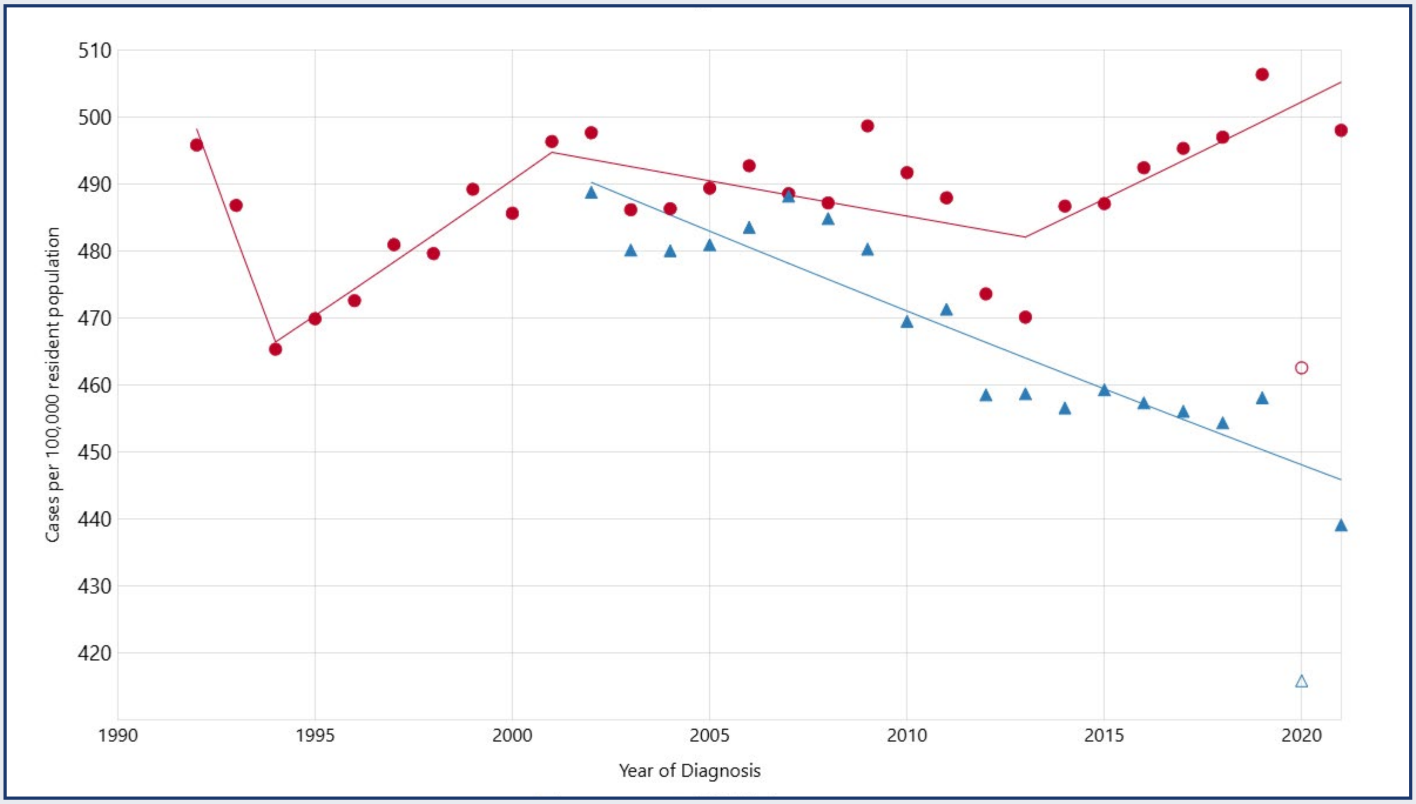
BACKGROUND

Cancer in Iowa

Before examining individual risk factors and exposure pathways, it is important to understand key data that describe Iowa's overall cancer profile, including trends in incidence, geographic spread, and cancer sites (locations in and on the body). However, this report is not exhaustive. It does not break down cancer rates by all demographic categories, such as disparities by race or ethnicity.

Figure B.1 shows changes in age-adjusted cancer rates over time in Iowa and nationally (National Cancer Institute, 2025b). This data from the National Cancer Institute shows that as average rates in the United States declined, Iowa's progress on cancer rates reversed course and started to climb in 2012. This increase is more than a number; it represents thousands of Iowans' lives that have been profoundly altered, or more tragically, lost.

FIGURE B.1 **Cancer Incidence in Iowa and the United States, All Ages (1992 – 2021)**



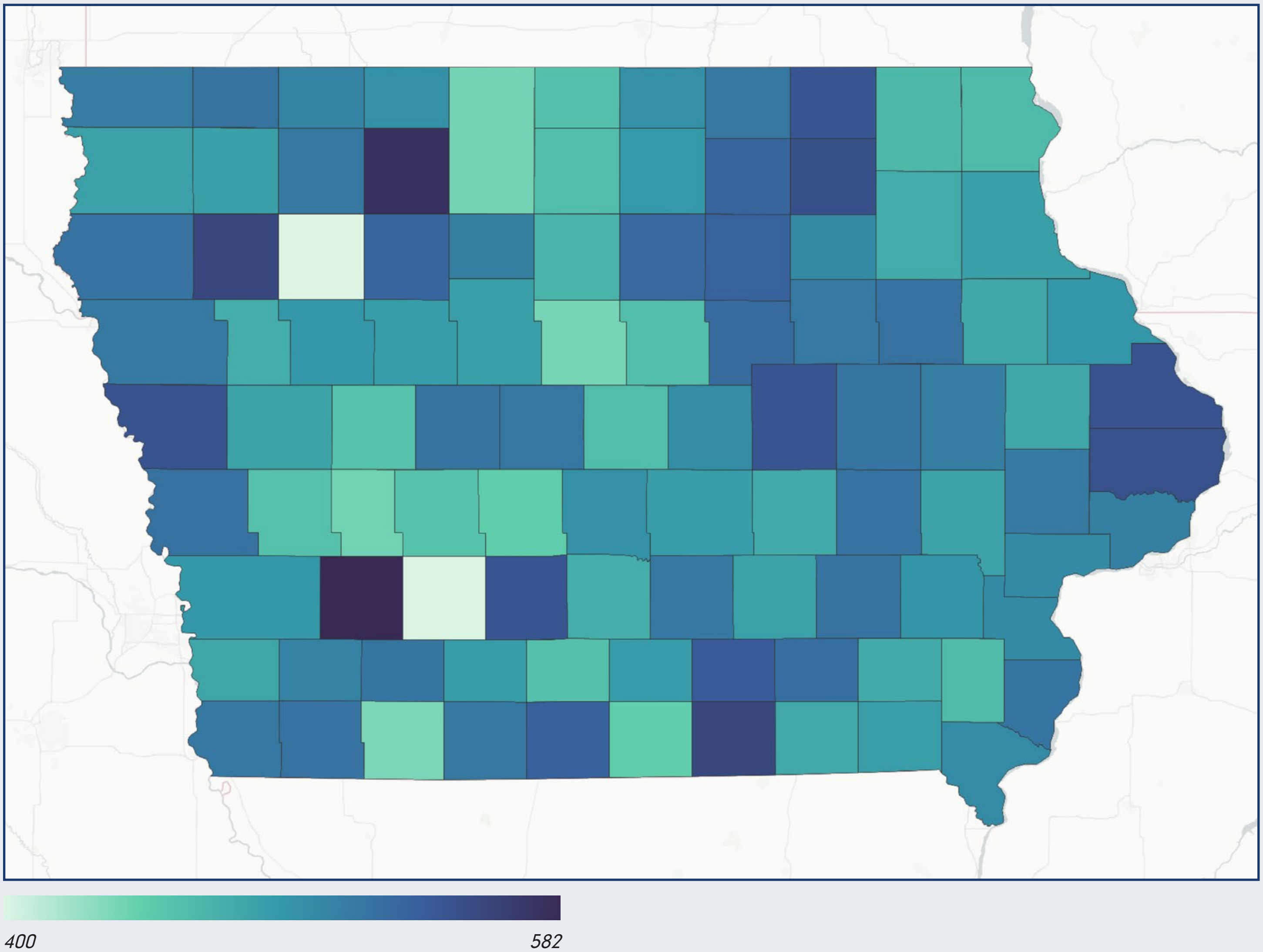
● Iowa ▲ United States

Notes: Created by statecancerprofiles.cancer.gov on 01/29/2026. Regression lines calculated using the Joinpoint Regression Program (Version 5.1). The 2020 incidence rate is displayed but not used in the fit of the trend line(s).
Source: National Cancer Institute, 2025b

The Iowa Cancer Registry estimates that 21,200 people would be diagnosed with cancer in 2025 (Iowa Cancer Registry, 2025a). This is more than the combined populations of Adams, Ringgold, Audubon, and Taylor Counties (Iowa State Data Center, 2024). These rates are not consistent across the state but impact some communities more than others. Figure B.2 illustrates the cancer incidence at the county level for Iowa over the years 2017 – 2021. (Iowa Cancer Registry, 2025b).

Cancer affects both urban and rural areas across Iowa; however, **rural counties are disproportionately represented** among those with the highest cancer incidence.

FIGURE B.2 **Cancer Incidence in Iowa by County (2017 – 2021)**

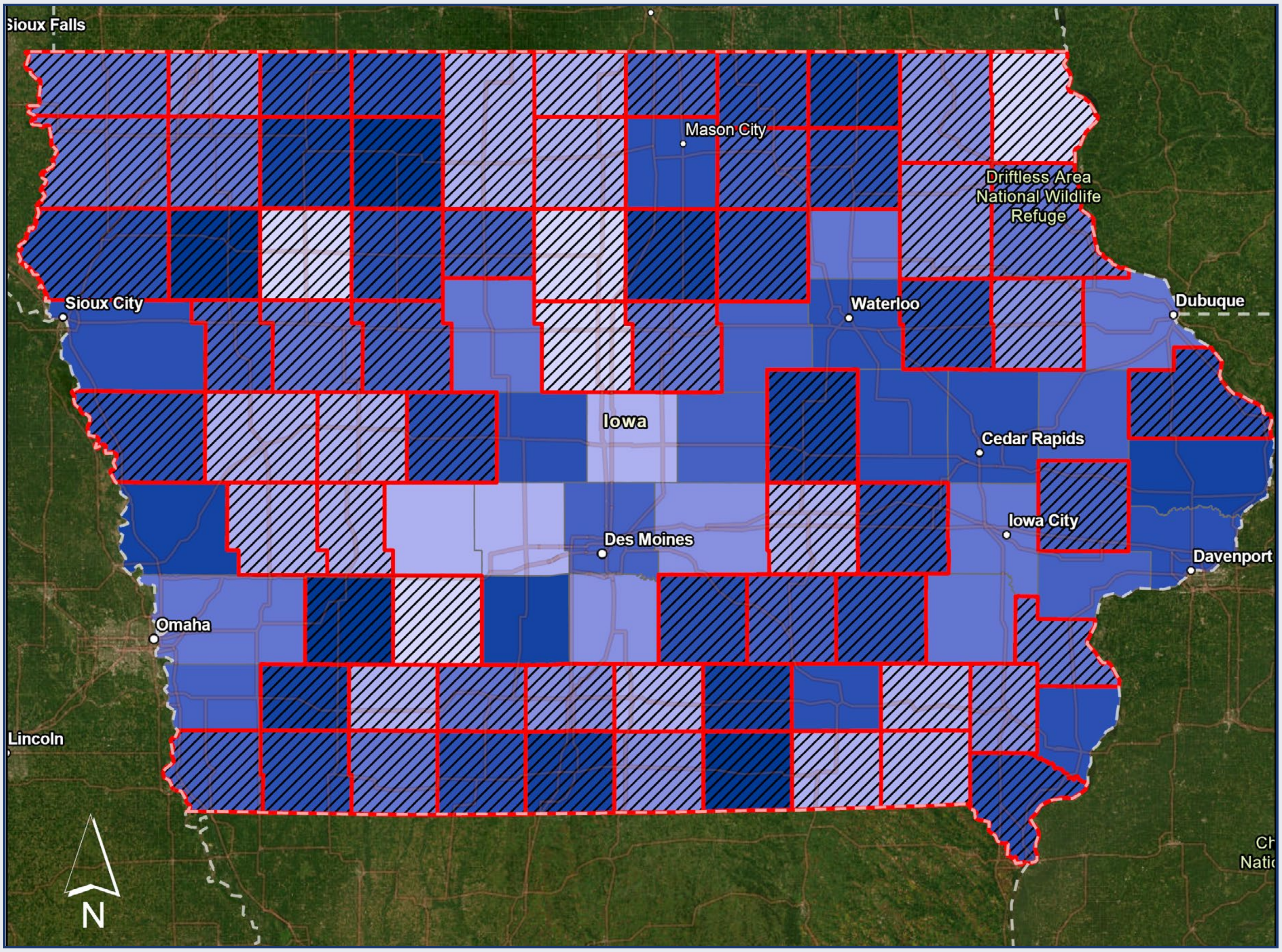


Source: Iowa Cancer Registry, 2025b

In fact, 80% of the 25 counties with the highest cancer rates in the state are rural, while only about 70% of Iowa counties are rural (U.S. Department of Agriculture [USDA], 2023; National Cancer Institute, 2025b). Figure B.3 illustrates cancer rates across Iowa overlayed with counties designated as rural areas.

80% of the 25 counties with the highest cancer rates in the state are rural.

FIGURE B.3 **Five-Year Average Cancer Incidence in Iowa's Rural Counties (2017 – 2021)**



County with a Total Urban Population <20,000

Cancer Incidence (Age-Adjusted per 100k)

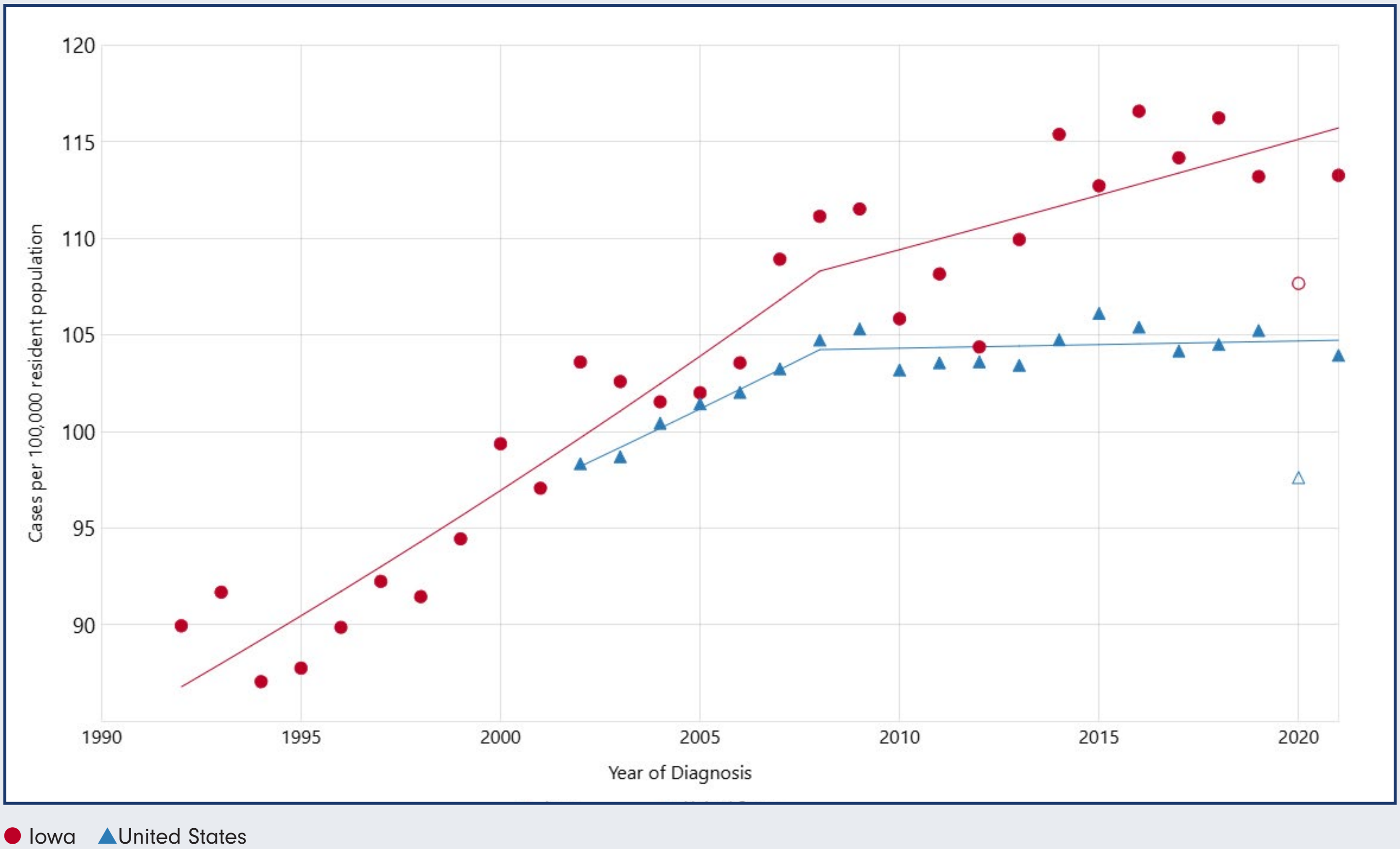
- 396.90 – 425.40
- 425.41 – 460.00
- 460.01 – 473.50
- 473.51 – 487.80
- 487.81 – 504.10
- 504.11 – 522.20
- 522.21 – 546.20
- 546.21 – 580.00

Some numbers rounded for simplicity

Sources: U.S. Department of Agriculture, Economic Research Service, 2023; National Cancer Institute, 2025b

Another troubling trend is cancer incidence among younger Iowans. **Cancer incidence for people under 50 in Iowa is rising faster than the national average**.

FIGURE B.4 **Trend in Cancer Incidence in People Under 50 – Iowa and U.S.**



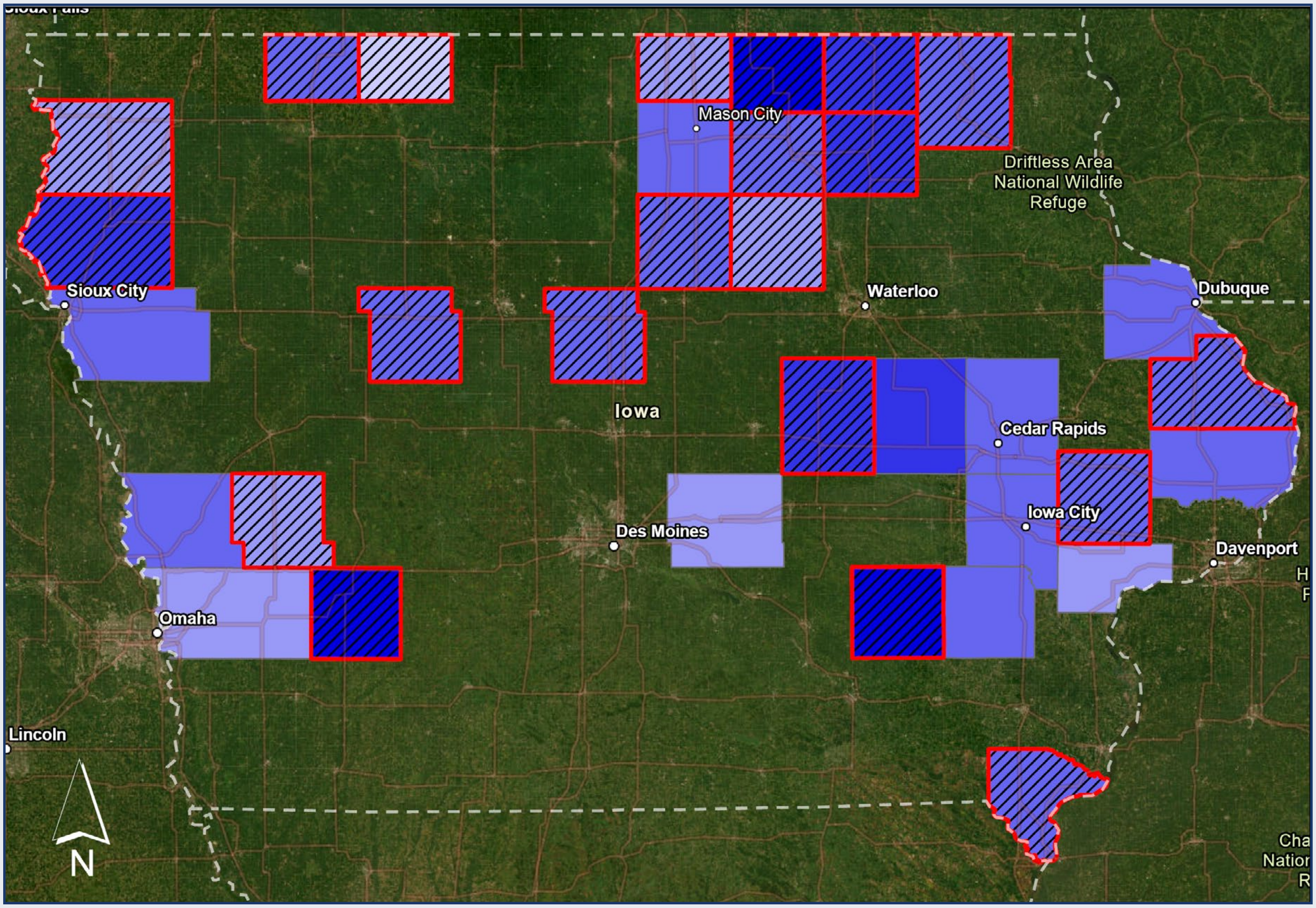
Notes: Created by statecancerprofiles.cancer.gov on 12/31/2025. Regression lines calculated using the Joinpoint Regression Program (Version 5.1). The 2020 incidence rate is displayed but not used in the fit of the trend line(s).

Source: National Cancer Institute, 2025b

Figure B.5 shows that the trend of people under 50 receiving a cancer diagnosis is being driven largely by counties outside of central Iowa, with the Siouxland, Council Bluffs, Cedar Rapids-Iowa City corridor, and a group of counties in the Northeast quadrant of the state leading this rise.

33 counties in Iowa have rising cancer incidence in people under 50 years old.

FIGURE B.5 **Iowa Counties with Rising Cancer Incidence in People Under 50 Years Old (Five-Year Trend from 2017 – 2021)**



County with a Total Urban Population <20,000

Cancer Incidence (Age-Adjusted per 100k)

- 89.7
- 89.8 – 114.8
- 114.9 – 131.9
- 132 – 145
- 146 – 166.3

Some numbers rounded for simplicity

Sources: U.S. Department of Agriculture, Economic Research Service, 2023; National Cancer Institute, 2025b

Cancer Trends of Concern

In February 2026, the University of Iowa College of Public Health published the interim findings report, Key Drivers of Cancer in Iowa Project, in an effort to identify and analyze trends in Iowa's concerning cancer rates. The analysis used age-adjusted rates, which help to correct for differences in population levels and age differences among states.

The interim findings report also organized states into "clusters" based on similar demographic and behavioral risk factors. Iowa's cluster included Nebraska, Minnesota, North Dakota, South Dakota, and Wisconsin. This cluster of states had "the highest, or among the highest, rates of all cancers combined, and each of the five most common cancers (prostate, breast, melanoma, lung, and colorectal)" (University of Iowa College of Public Health, 2026). Within this cluster of states, Iowa had the highest age-adjusted cancer incidence rate overall as well as the highest rates of lung and colorectal cancers. Iowa also had the second-highest rate of breast cancer and third-highest prostate cancer and melanoma rates in this cluster.

The report concluded that, "These findings suggest that while demographic characteristics and behavioral risk factors explain a large proportion of Iowa's high cancer incidence rate, there are still other factors contributing to the higher rates of these cancers observed in Iowa" (University of Iowa College of Public Health, 2026). The interim key drivers of cancer report found that in 2022, Iowans experienced 1,298 more cancer cases ("excess" cases) than if Iowa rates had been the same as the rest of the states in the Iowa cluster. When compared to the U.S., an estimated 2,582 excess cases occurred in Iowa (University of Iowa College of Public Health, 2026).

Overall, Iowa's cancer incidence between 2017 and 2021 was 10.7% higher than the national rate. Table B.1 shows how Iowa's age-adjusted incidence rate for cancer sites most often associated with environmental risk factors differed from the national rate in the five-year period between 2017 and 2021 (National Cancer Institute, 2025b).

Within this cluster of states, **Iowa had the highest age-adjusted cancer incidence rate overall** as well as the highest rates of lung and colorectal cancers.

Iowa also had the second-highest rate of breast cancer and third-highest prostate cancer and melanoma rates in this cluster.

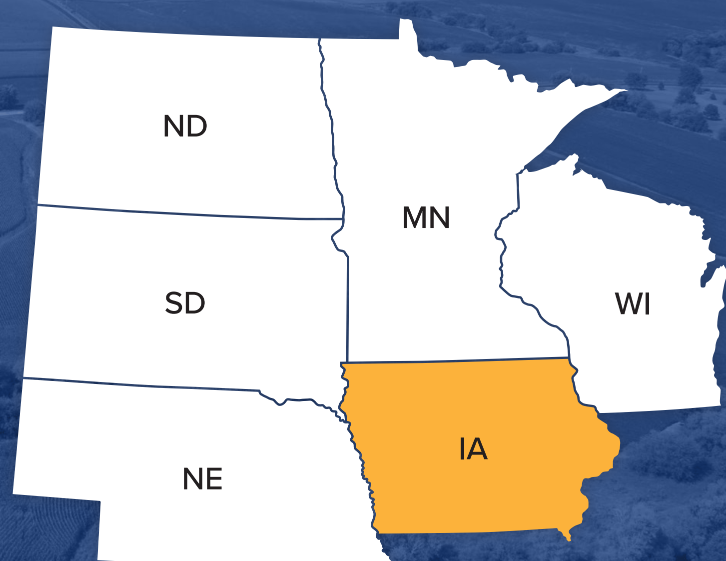


TABLE B.1 **Age-Adjusted Incidence Rates by Cancer Site, Iowa and United States (2017 – 2021)**

Age-Adjusted Incidence Rates by Cancer Site, per 100,000 People All Stages (2017–2021)	Iowa Rate	USA Rate	Difference
All Cancer Sites	491.8	444.4	47.4
Bladder	21.9	18.8	3.1
Brain and Other Nervous System	6.7	6.3	0.4
Breast (Female)	136.9	129.8	7.1
Breast (in situ) (Female)	29.7	29.3	0.4
Cervix (Female)	7.6	7.5	0.1
Childhood (Ages <15, All Sites)	16.4	16.8	-0.4
Childhood (Ages <20, All Sites)	17.9	18.4	-0.5
Colon and Rectum (Colorectal)	39.9	36.4	3.5
Esophagus	5.7	4.5	1.2
Kidney and Renal Pelvis	20.5	17.3	3.2
Leukemia	16.7	14.1	2.5
Liver and Bile Duct	7.2	8.6	-1.4
Lung and Bronchus	60.8	53.1	7.7
Melanoma of the Skin	31.4	22.7	8.7
Non-Hodgkin Lymphoma	21.3	18.5	2.8
Oral Cavity and Pharynx	14.4	12.0	2.4
Ovary (Female)	9.7	10.1	-0.4
Pancreas	13.8	13.5	0.3
Prostate (Male)	125.9	113.2	12.7
Stomach	4.6	6.3	-1.7
Thyroid	13.7	12.9	0.8
Uterus (Corpus and Uterus, Not Otherwise Specified) (Female)	30.3	27.8	2.5

■ Indicates Iowa exceeds the U.S. rate

Source: National Cancer Institute, 2025b

The National Cancer Institute State Profiles tool uses regression analysis to identify incidence trends over time. The latest data, covering the period from 1992 to 2021, show that some cancers were steadily increasing or decreasing in Iowa while others exhibited variable trends, with alternating periods of growth and decline over time. Table B.2 shows these trends in more detail and how they compare based on cancer site. The table also lists the most common cancers in Iowa in terms of both incidence and number of cases (National Cancer Institute, 2025b; U.S. Cancer Statistics Working Group, 2025).

TABLE B.2 Cancer Incidence and Case Count in Iowa

CANCER SITE	2022 Iowa Incidence and Cases: All Iowans		% Change in Cancer Incidence 1992 – 2021: Iowans Under 50		% Change in Cancer Incidence 1992 – 2021: All Iowans	
	Incidence per 100K people	Number of Cases	Time Period	Average Change/Year	Time Period	Average Change/Year
Breast	139.30	2,799	1992 – 2012	0.20%	1992 – 2012	-0.40%
			2012 – 2021	1.70%	2012 – 2021	1.80%
Prostate	134.20	2,898	Too few data points		2013 – 2021	3.60%
Lung and Bronchus	57.40	2,551	2007 – 2021	-4.20%	2007 – 2021	1.00%
Colorectal	42.30	1,648	1992 – 2021	2.80%	1992 – 2021	-1.50%
Melanoma of the Skin	34.90	1,351	1992 – 2021	2.30%	1992 – 2021	3.40%
Uterine	31.90	668	1992 – 2021	1.30%	1992 – 2021	0.70%
Non-Hodgkin Lymphoma	21.90	893	1992 – 2021	-0.20%	1992 – 2009	1.10%
					2009 – 2021	-0.60%
Kidney and Renal Pelvis	21.40	849	1992 – 2021	3.70%	1998 – 2005	4.60%
					2005 – 2021	1.50%
Urinary Bladder	20.40	879	Too few data points		1992 – 2004	1.30%
					2004 – 2021	-0.40%
Leukemia	17.80	720	1992 – 2021	0.90%	1992 – 2021	0.50%
Oral Cavity and Pharynx	14.50	582	1992 – 2021	0.90%	1992 – 2007	0.00%
					2007 – 2021	2.20%
Thyroid	14.10	480	1992 – 2014	4.50%	1992 – 2009	5.40%
			2014 – 2021	-0.20%	2009 – 2021	0.90%
Pancreatic	13.70	200	Too few data points		1992 – 2021	1.30%
Ovarian	10.20	600	1992 – 2021	-2.00%	1992 – 2000	0.30%
					2000 – 2021	-2.30%
Testicular	7.20	107	Not included in this table - see Figure A1 in Appendix A.			
Liver and Intrahepatic Bile Duct	7.50	328	Too few data points		1992 – 2017	4.20%
					2017 – 2021	-1.80%
Stomach	5.90	249	Too few data points		1992 – 2018	-1.30%
					2018 - 2021	6.10%

Incidence increase rank for most recent trend period: 1 2 3 4 5 Most Improvement

Sources: National Cancer Institute, 2025b; U.S. Cancer Statistics Working Group, 2025

Although a regression analysis was not available from the National Cancer Institute for testicular cancer, a figure illustrating yearly age-adjusted incidence rates for testicular cancer in Iowa and the U.S. is included as Figure A.1 in Appendix A. Iowa was tied for the seventh-highest average incidence rate for testicular cancer in the U.S. in the 2018 – 2022 time period (U.S. Cancer Statistics Working Group, 2025).

Table B.2 illustrates several key takeaways about cancer trends in Iowa:

- Incidence rates among younger people (Iowans under age 50), rose faster than the general population for four types of cancer: colorectal, uterine, kidney and renal pelvis, and leukemia.
- Among Iowans under 50, the rise in incidence of kidney and renal pelvis cancer was the steepest (3.7% per year from 1992 – 2021), followed by colorectal (2.8% per year from 1992 - 2021), melanoma (2.3% per year from 1992 – 2021), breast (1.7% from 2012 – 2021 after a flat trend from 1992 – 2012), and uterine (1.3% per year from 1992 – 2021).
- For the total population of Iowa, stomach cancer saw the sharpest increase with rates rising 6.1% per year between 2018 and 2021, followed by prostate, melanoma, oral cavity/pharynx, and breast cancers.
- Breast cancer trends for all women in Iowa reversed course sharply in 2012 from flat/declining to increasing by almost 2% per year.
- Oral cavity and pharynx cancer incidence in the all-ages population began to rise in 2007 after holding steady since 1992.
- Stomach cancer in the all-ages population was declining between 1992 and 2018; in 2018, it started to rise sharply at an average rate of 6.1% per year.
- The incidence rate for kidney and renal pelvis cancer for Iowa women grew faster than the rate for men, at an average of 2.2% per year between 2005 – 2021. For men, rates of kidney and renal pelvis cancer grew by 1.3% per year.

Further analysis of this data and accompanying risk factors, in addition to those identified in this report, would bolster the ability of researchers and the state to craft effective prevention strategies and policy interventions.

Iowa's cancer incidence rate for people under 50 for all cancer types combined is higher than the national average with Iowa's rate for the most recent five-year period at 113 cases per 100,000 people, while the national average rate is 105 cases per 100,000.

METHODOLOGY

This report was completed using a mixed-methods research approach that combines a literature review, qualitative data from Iowans themselves, and analysis of cancer and environmental data. The process prioritized high-quality sources to ensure that the assessment reflects current scientific consensus and emerging trends.

The cancer data analysis in this report primarily focuses on cancer sites that are associated with environmental risk factors. This set of cancer sites includes those with the highest incidence rates in Iowa. However, this analysis is not exhaustive or inclusive of all cancer sites or environmental risk factors. It does not break down cancer rates by all demographic categories, such as disparities by race or ethnicity. The report places some emphasis on people under age 50 in response to anecdotal observations shared by medical professionals that more patients appear to be receiving cancer diagnoses earlier in life. The report begins to examine that age group separately to determine distinctive trends in Iowa compared to other states; however, more research is needed to determine age-related patterns and relationships to environmental risk factors.

The selection of the four primary environmental risk factors examined in the report (**pesticides**, **PFAS**, **nitrate**, and **radon**) was guided by a panel of scientific experts convened for this project.

At the start, the committee recommended beginning with a single-contaminant review focused on pesticides, given Iowa's high agricultural use and the strong body of epidemiologic literature available.

As the project progressed, additional conversations with experts and a preliminary scan of existing research showed that PFAS and nitrate also had substantial and emerging evidence linking them to potential cancer risks. Based on this input, the project's scope was expanded to include these contaminants. Because pesticide use in Iowa is extensive and diverse, the pesticide review and analysis were further refined to focus on the pesticide classes and active ingredients most commonly used in Iowa and the chemicals with the strongest epidemiologic evidence of potential cancer associations. Radon was included as well because it is a well-established carcinogen, is highly relevant to Iowa due to the state's geology, and is a known cause of lung cancer.

Literature Review

Each environmental risk factor category was examined through a separate literature review that included peer-reviewed publications and studies, primary research articles, systematic reviews, and health assessments produced by United States and international health agencies. To ensure comprehensive coverage, references listed in relevant articles were reviewed to find additional primary research and high-quality review papers. The literature review strategy was intended to be broad, but like any search, studies can be missed.

For each study that met the criteria, authors extracted key findings, including:

- Exposure type and measurement
- Population studied
- Cancer-related outcomes
- Major results
- Strengths and limitations of the study

Other Risk Factors

Iowans raised concerns about toxic sites in their communities as well as industrial pollution as possible sources of carcinogens, and the expert panel affirmed these concerns. This report contains a brief overview of other potential sources of carcinogens that are related to environmental pollution. This is an area that is important for further exploration and may be appropriate for investigation of cancer clusters in specific communities and regions. The summary of other risk factors is not comprehensive but intended to lead to more research questions and areas for inquiry, as well as to provide additional information to communities in Iowa considering potential environmental risks that could be contributing to high cancer rates.

Listening Sessions

During the summer of 2025, the Iowa Farmers Union joined IEC and The Harkin Institute to host 16 cancer listening sessions across the state, in both rural and urban locations. More than 550 people attended these sessions, and 303 participants completed voluntary and anonymous surveys. The survey used for the listening sessions was developed using guidance from Chapter 2 of the Iowa Cancer Plan, which identifies radon and environmental exposures as risk factors (Iowa Cancer Plan, 2023). Because the plan does not contain a detailed categorization or comprehensive analysis of the types of environmental exposures, IEC organized potential exposures into five broad categories.

The survey data and qualitative feedback from these sessions revealed the specific concerns of people who were motivated to spend an evening or lunch hour talking about cancer. The top five environmental risk factors of concern identified by respondents were, in order:

1. Agricultural exposures (pesticides, fertilizers)
2. Drinking water contamination (lead, nitrates)
3. Land contamination (industrial pollution in soil)
4. Outdoor air pollution (particulate matter, ozone, etc.)
5. Indoor air pollution (radon, asbestos)

In addition, attendees overwhelmingly indicated that they lacked sufficient information about environmental risk factors. Their feedback, along with the research conducted for this project, helped shape the scope of this report, including the decision to draft a stand-alone section on radon and to discuss concerns around toxic sites in communities.

External Review

IEC solicited review of this report and incorporated feedback from more than a dozen experts in cancer epidemiology, environmental risk factors, and environmental law. The scientific researchers and subject-matter experts provided insight, advice, and critical feedback to help shape the report's scope, strengthen its analysis, and ensure the use of accurate, accessible resources. The feedback provided was considered in a collaborative process and incorporated into the final report.

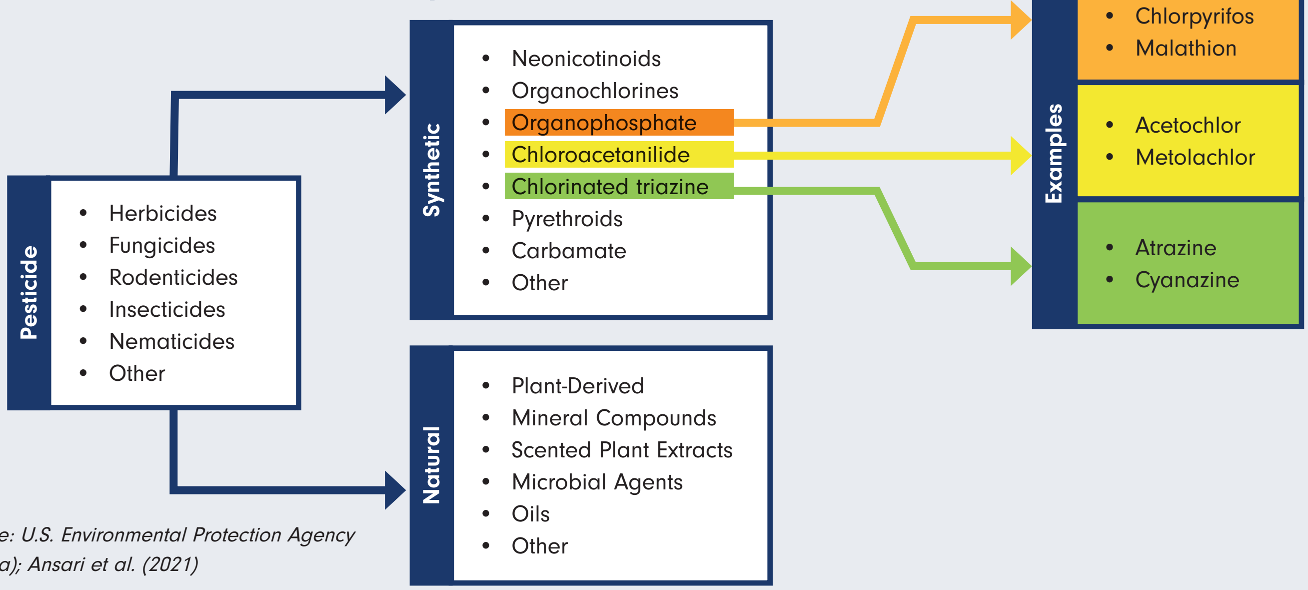
REVIEW AND ANALYSIS OF ENVIRONMENTAL RISK FACTORS OF CANCER

SECTION 1 Environmental Risk Factors Analysis: Pesticides

A pesticide is a broad category of substances that includes insecticides, fungicides, herbicides, and rodenticides, identified in further detail in Figure 1.1. Pesticides are agents used to kill and discourage the propagation of weeds, insects, fungi, or other threats to plants, animals, and humans. There are 527 pesticides evaluated in the National Pesticide Synthesis Project, with varying compounds of active and inert ingredients (U.S. Geological Survey [USGS], 2019).

Pesticides are heavily used in modern agriculture, with more than 1.1 billion pounds applied annually in the United States alone and a global market exceeding $75 billion in 2023 (Carvalho, 2017; Gossett, 2024; Polaris Market Research, 2024). Agriculture accounts for 90% of pesticide use in the United States with the remaining 10% applied in commercial, industrial, and home and garden settings (Atwood & Paisley-Jones, 2017). While agriculture has long relied on pest controls, modern chemical compounds were synthesized in the 1930s and introduced in the United States in the 20th century.

FIGURE 1.1 Simplified Pesticide Type Chart



Source: U.S. Environmental Protection Agency (2014a); Ansari et al. (2021)

Concerns about environmental and health impacts have increased in recent decades, including pesticide resistance, toxicity to nontarget species, and widespread contamination of air, soil, water, and food (Gossett, 2024). Many pesticides, both legacy and currently used, are highly persistent in the environment, degrading slowly and leading to accumulation across ecosystems (Bonmatin et al., 2015; Woodrow et al., 2019; Thompson et al., 2020). International agreements such as the Stockholm Convention have restricted or banned certain organochlorine pesticides, including dichlorodiphenyltrichloroethane (DDT) and endosulfan (International Agency for Research on Cancer [IARC], 2016; Stockholm Convention, 2024). DDT was widely used from the 1940s until its ban in the United States in 1972. Still, with a half-life of approximately 30 years in soil and up to a century or more in aquatic environments, DDT exemplifies how persistent pesticides remain active and bioaccumulate in the environment and wildlife long after use (U.S. Environmental Protection Agency [EPA], 1972, 2014b; IARC, 2016; Agency for Toxic Substances and Disease Registry, 2022).

Pesticides in the U.S. are primarily regulated by the EPA as authorized by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA) (7 U.S. Code § 136 et seq.; 21 U.S. Code § 301 et seq.). Specifically, the EPA's Office of Pesticide Programs (OPP) sets maximum levels of pesticide residues that are allowed in food and feed crops.

Pesticide manufacturers are required to complete a registration process with the EPA before offering a pesticide for sale (7 U.S.C. § 136a). The process is focused on the active ingredients in the pesticide, not the inert ingredients or the pesticide in combination with other chemicals *(id.)*. The manufacturer is required to provide scientific data regarding the toxicity of the pesticide and how it behaves in the environment *(id.)*. If the pesticide will be used on food or feed crops, the manufacturer must also specify a methodology for determining how much of the pesticide or its residues shows up in food and what the safe limit should be for those residues (21 U.S.C. § 346a). Finally, the EPA performs a cost-benefit analysis to determine whether the pesticide will cause "unreasonable adverse risk" to people or the environment; if the pesticide fails this standard, it is not approved for registration (7 U.S.C. § 136a). If it does meet the standard, then the EPA sets labeling requirements for the pesticide that detail how and when the pesticide can be used and what protections must be used to ensure worker safety (7 U.S.C. § 136a(c)(5)). The EPA also classifies pesticides as either general use (approved for use by the general public) or restricted use (requiring applicators to go through a training process administered by the state) *(id.)*. For more about Iowa pesticide regulations, see the Regulatory Oversight of Environmental Risk Factors section of this report.

The EPA sets allowable residue "tolerance" levels in food and feed for each specific pesticide using a "reasonable certainty of no harm" standard (21 U.S.C. § 346a). This tolerance level is based on lifetime exposure to the specific pesticide with special consideration for potential harms to infants and children *(id.)*. Manufacturers can, and do, request changes to tolerance levels, and tolerance levels are reviewed every five years. States generally cannot set lower tolerance levels than the EPA (21 U.S.C. § 346a(n)).

> **The process for pesticide registration in the U.S. does not require independent research or data but relies on industry studies in addition to peer-reviewed science.**

Tolerance levels are set based on evaluation of individual active ingredients and do not consider how exposure to multiple pesticides (or their "inert" ingredients) may have additive effects or may interact to increase health risks (see 21 U.S.C. § 346a). Multiple pesticides that have been banned in several global contexts are still widely used in the U.S. (Canada, 1999; European Commission, 2020; EPA, 2024a; Eur-Lex, n.d.). One contributing factor is that the EPA did not formally incorporate epidemiological evidence into its pesticide risk assessment process until 2016, when it issued a framework outlining how studies of human health effects should be evaluated and integrated into regulatory decisions (EPA, 2016a). This, in addition to other differences in how scientific evidence is considered and weighed, can help explain why international groups and the EPA can assess the same chemical yet reach different conclusions about potential risks. The regulatory gaps and variations in risk assessment methodology raise concern for ongoing human and environmental exposures, particularly in agricultural and residential contexts.

Newer compounds may carry health risks not yet determined, and in many cases, regulatory frameworks are unable to keep pace with innovation (Carvalho, 2017). Additionally, the U.S. pesticide registration and review system under FIFRA has been criticized for relying on outdated toxicity thresholds and failing to fully appreciate the effects of cumulative, low-dose exposures (Landrigan & Goldman, 2011; Sprinkle & Payne-Sturges, 2021; Vandenberg et al., 2023). Information about pesticide carcinogenicity and other chronic health effects is also available from the IARC, the European Food Safety Authority (EFSA), and in independent peer-reviewed studies, reviews, and meta-analyses (World Health Organization [WHO], 2020; IARC, 2025).

Pesticide Exposure Pathways

Pesticide exposure pathways include dermal (skin), ingestion (eating and drinking), and inhalation (breathing). People may make direct contact with pesticides during pesticide manufacturing and application or through environmental channels such as air, water, house dust, and soil (Curwin et al., 2005; Ward et al., 2006; Aktar, Sengupta & Chowdhury, 2009; Gossett, 2024). Occupational exposures are common, particularly among farmers and commercial and private pesticide applicators who are often exposed through dermal and inhalation pathways, especially during spraying or due to windborne drift (López-Gálvez et al., 2019; Tudi et al., 2022; EPA, 2025a; Tucker et al., 2025). Although occupational exposures are widely recognized, significant risks also exist for people living near treated areas (Ward et al., 2006; Roberts et al., 2012; López-Gálvez et al., 2019; Dereumeaux et al., 2020; Racca et al., 2025; Silva et al., 2025).

Multiple application methods can contribute to environmental dispersion, including air-blast and aerial spraying, fumigation, greenhouse and irrigation-based applications, handling of pesticide-coated seed, and granular and powdered soil applications (Tudi et al., 2022). Common routes of environmental and residential exposure include pesticide drift, volatilization (evaporation and airborne spread), and the transport of airborne dust particles carrying pesticide residues to surrounding populations (Harnly et al., 2009; Madrigal et al., 2023). Residential respiratory, dermal, and ingestion exposures occur from pesticide use in gardens, during landscaping, for insect control inside and outside homes, and through pesticides tracked into homes (Ward et al., 2006; Liu & Schelar, 2012; Roberts, et al., 2012; Webb et al., 2021; Perkins et al., 2024).

> **Pesticides can persist in the environment and may degrade or transform into other chemicals that may present exposure risks.**

Because some pesticides and/or their transformation products are persistent in the environment for a long time, people may experience repeated exposures in both indoor and outdoor environments. In addition, these chemicals can accumulate in the environment, food, water, and living things (Ward et al., 2006; Aktar, Sengupta & Chowdhury, 2009; Gossett, 2024). Ingestion of pesticide residues in food and drinking water is a primary exposure route for the public (WHO, 2022; Valentim et al., 2023; EPA, 2024b). Food products, including produce, grains, meats, dairy products, fish, and poultry contain pesticide residues (Food and Agriculture Organization of the United Nations & WHO, 2022). Pesticide concentrations in water differ based on hydrogeologic factors. According to the USGS (2016), some herbicides, such as atrazine, were present in significantly higher concentrations in streams with drained soils from loose, loess sediment than in streams draining common till soils. Pesticides may persist for decades in soil and water and have been found in shallow alluvial aquifers in both urban and rural areas (USGS, 2016). Groundwater contamination is especially concerning in rural areas, where private wells are not routinely monitored (Hladik et al., 2018; Bradley et al., 2023; Thompson et al., 2023).

Studies conducted over several decades have consistently found pesticides and their transformation products in Iowa surface water, public source water wells, aquifers, and private wells — with atrazine and metolachlor typically found most frequently followed by acetochlor (Hruby et al., 2015; Woodward et al., 2019; Bradley et al., 2023; Meppelink et al., 2025).

One shortcoming of many studies is their focus on the "parent" pesticide and not the chemicals that are formed as the pesticide degrades, which means studies may miss critical data about water contamination and possible health consequences (Kolpin et al., 2000). More research is needed in Iowa to determine pesticide prevalence in various environmental conditions, waterbody types, and food sources.

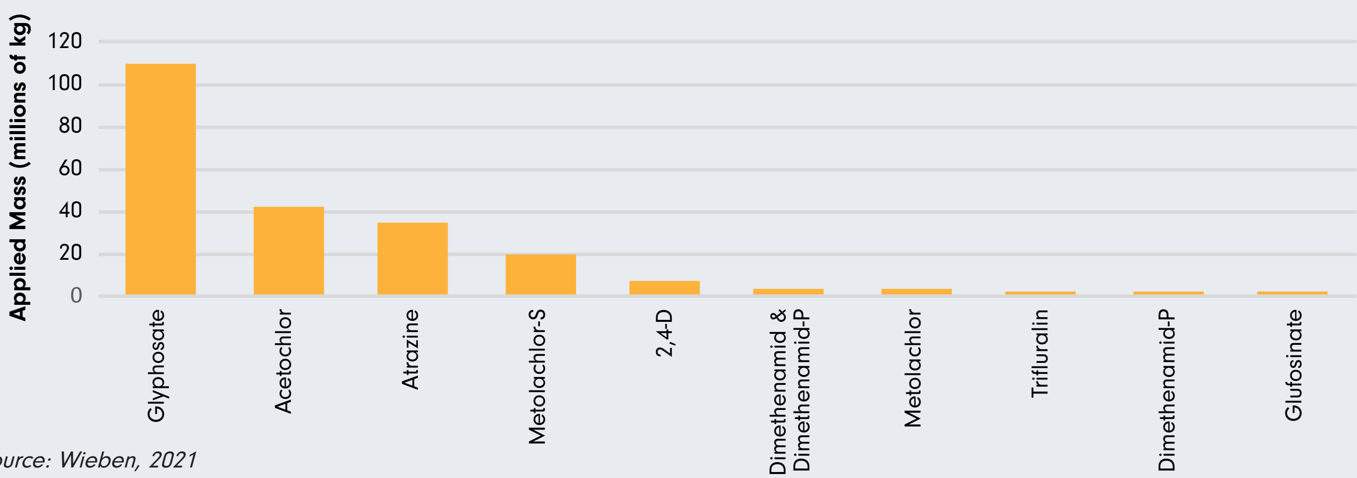
Statewide pesticide application rates in Iowa are **significantly higher** than in other parts of the country.

Pesticides in Iowa

Iowa had the fourth-highest use of pesticides by weight of any U.S. state in the five-year period from 2015 – 2019, exceeded by California, Florida, and Illinois (Wieben, 2021). Iowa has the highest prevalence of agricultural land use of any of these states with 85% of land in agriculture compared to 75% in Illinois, 43% in California, and 28% in Florida (Cole, 2024; Florida Department of Agriculture and Consumer Services, 2024; Illinois Department of Agriculture, 2024; U.S. Department of Agriculture [USDA], 2024). This highlights the strong connection between Iowa's intensive agricultural land use with high pesticide application rates as compared to other states.

The top three pesticides used in Iowa between 2010 and 2019 were glyphosate, acetochlor, and atrazine, as shown in Figure 1.2 (Wieben, 2021). Therefore, this report focuses on the application of these three pesticides in Iowa and the related cancer risks. This is not a comprehensive review of all pesticide types used in Iowa; there are many chemicals of concern that are not covered in this review, which is an area for future work.

FIGURE 1.2 **Application of Agricultural Pesticides in Iowa (2010-2019)**



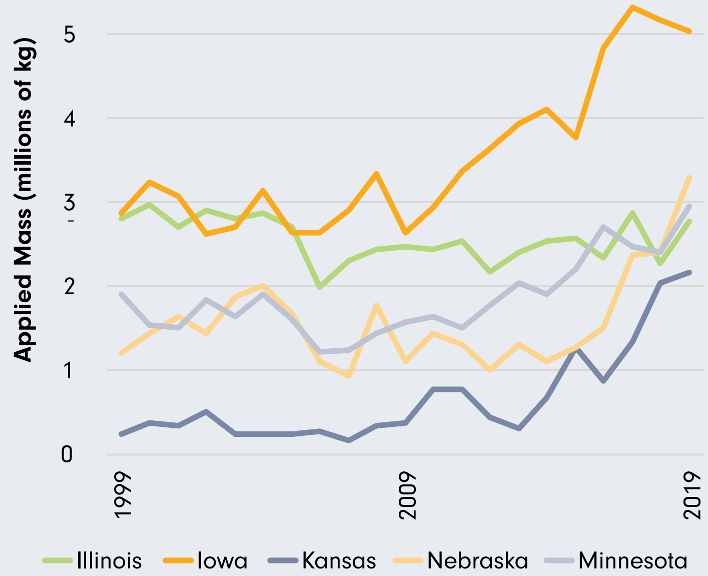
Source: Wieben, 2021

Acetochlor

A common herbicide in Iowa, acetochlor is used to combat broadleaf weeds, such as dandelion, clover, and creeping oxalis. In 1994, the EPA approved acetochlor for use on corn. However, the agency conditioned future approvals on reductions in the use of other corn herbicides of known health concern, including alachlor, metolachlor, atrazine, 2,4-dichlorophenoxyacetic acid (2,4-D), butylate, and S-ethyl dipropylthiocarbamate (EPTC). Since that time, tolerance levels approved by EPA have increased despite evidence of carcinogenicity in rate studies (EPA, 2024a). Acetochlor has been banned for use in the European Union since 2012 due to findings of genotoxicity, potential to contaminate water, and high risk to aquatic life, birds, and non-target plants (UN Environment Programme, 2018).

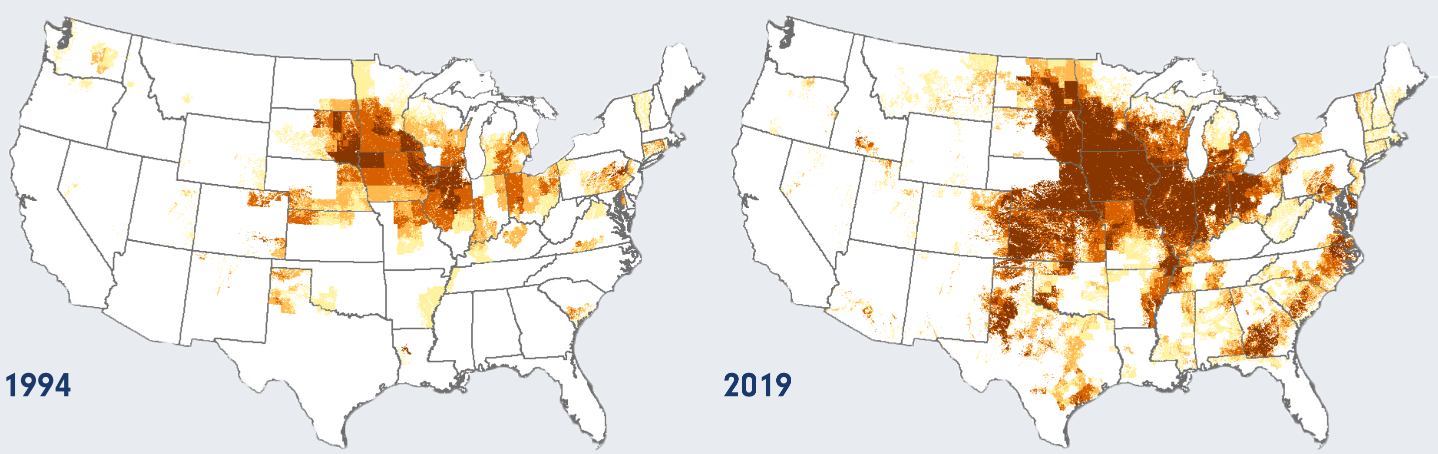
Figure 1.3 shows that acetochlor use in agriculture is most prevalent in Iowa and the Midwest, and its use grew significantly between 1994 and 2019. Data from the USGS in Figure 1.4 shows that acetochlor use has grown throughout the Midwest, which contains the top five states for acetochlor use. Iowa has been the leading state in acetochlor use since 2006. In the five-year period between 2015 – 2019, Iowa's use of acetochlor was about 80% higher than Nebraska's, the next-highest state for acetochlor use (Wieben, 2021).

FIGURE 1.4 Trends in Estimated Acetochlor Use in the Top Five U.S. States



Source: Wieben, 2021

FIGURE 1.3 Estimated Agricultural Use for Acetochlor (1994 and 2019)



Estimated use on agricultural land, in pounds per square mile:
< 1.46 | 1.46 – 10.30 | 10.31 – 43.25 | > 43.25 | None

Source: USGS, 2019. Estimated Annual Agricultural Pesticide Use.

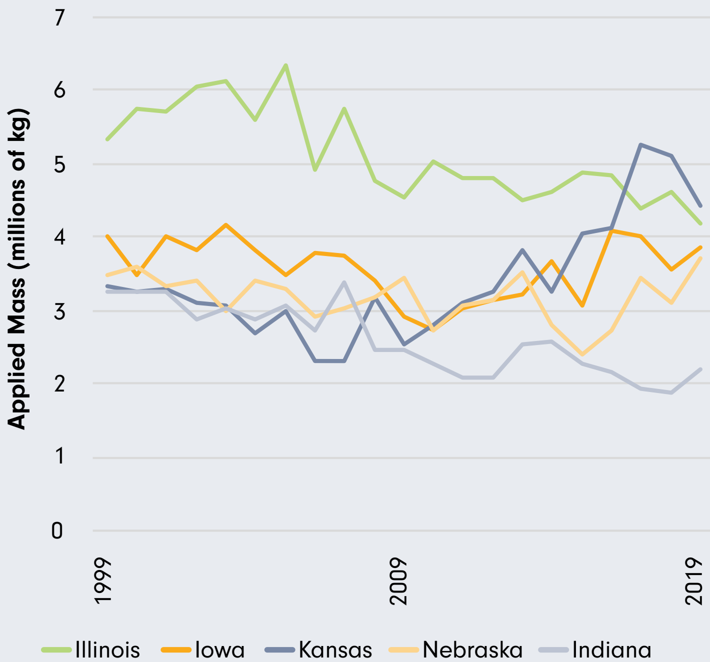
These maps illustrate that acetochlor application has remained widespread and persistent across Iowa over multiple decades. The maps are not intended to suggest any health risks in these locations; rather, they show where residents and applicators may have had the potential for prolonged exposure to acetochlor over time.

Atrazine

Atrazine is an herbicide that has been in use since the 1950s to prevent broadleaf weeds in crops and turf grasses (EPA, 2020). In 2004, atrazine was banned in the European Union after atrazine levels impacted groundwater beyond the regulatory standard for environmental protection. The EPA has set a drinking water standard for atrazine at 0.003 mg/L to protect against cardiovascular and reproductive impacts (EPA, 2024c).

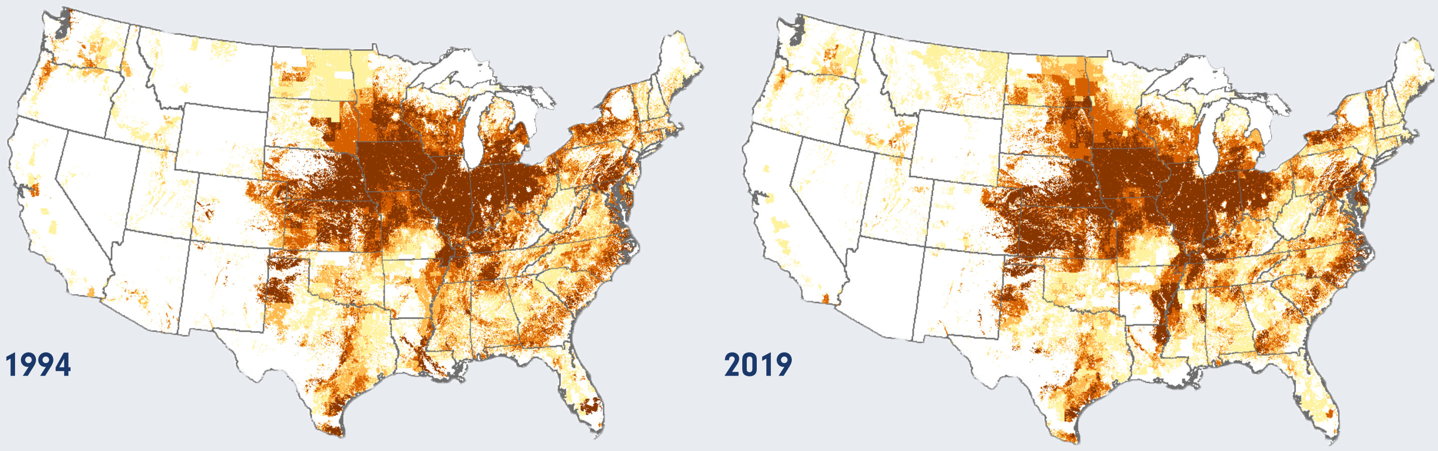
Figure 1.5 shows that atrazine use is focused across the corn belt states, with relatively similar application patterns in 1994 and 2019. Data from the USGS in Figure 1.6 shows varying trends among the top five states for atrazine usage, with some states trending downward as others have increased. Estimated use of atrazine in Iowa declined by roughly one-third between 1999 and 2010 before increasing again through 2019 to nearly the same levels as 1999 (Wieben, 2021).

FIGURE 1.6 Trends in Estimated Atrazine Use in the Top Five U.S. States



Source: Wieben, 2021

FIGURE 1.5 Estimated Agricultural Use for Atrazine (1994 and 2019)



Estimated use on agricultural land, in pounds per square mile:
< 2.93 | 2.93 – 17.39 | 17.40 – 63.35 | > 63.35 | None

Source: USGS, 2019. Estimated Annual Agricultural Pesticide Use.

These maps illustrate that atrazine application has remained widespread and persistent across Iowa over multiple decades. The maps are not intended to suggest any health risks in these locations; rather, they show where residents and applicators may have had the potential for prolonged exposure to atrazine over time.

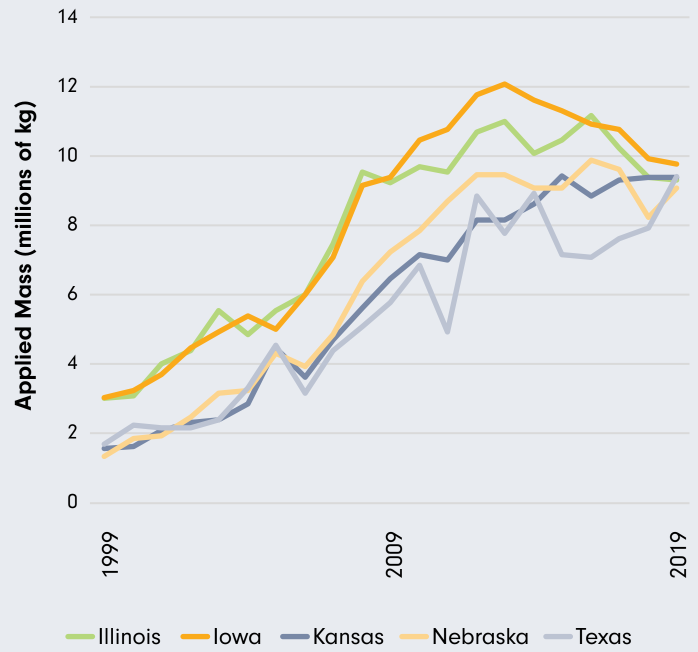
Glyphosate

Glyphosate is the most widely used herbicide globally and is used to kill broadleaf weeds and grasses in crops and landscaping. In 1974, Monsanto introduced the herbicide for agricultural use under the Roundup brand name; Roundup Ready soybean seeds were approved for use by the EPA ahead of the 1996 growing season after which use of glyphosate increased significantly (Parry, 2008; Wieben, 2021).

> **Iowa had the highest glyphosate use of any U.S. state in the five-year period from 2015 to 2019**

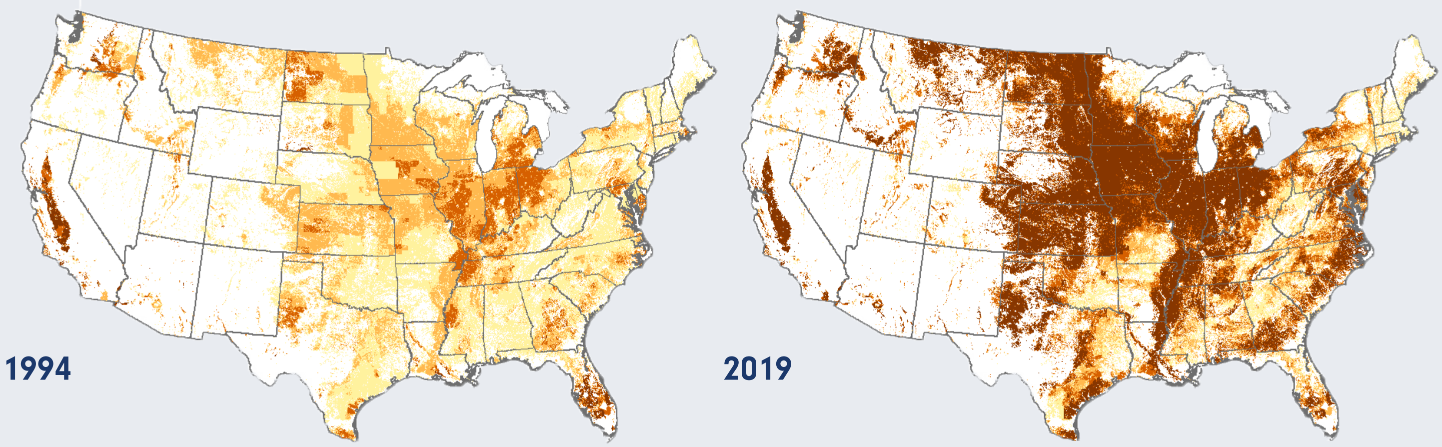
Figure 1.7 shows that glyphosate use in agriculture increased substantially between 1994 and 2019 but remains higher in the midwestern region of the U.S. than in other regions. Data from the USGS in Figure 1.8 shows that estimated use of glyphosate increased steadily between 1999 and 2006, then increased at a faster rate before peaking in 2013 and declining through 2019. Even with this decline in the later years of available data, glyphosate use in Iowa more than tripled between 1999 and 2019.

FIGURE 1.8 Trends in Estimated Glyphosate Use in the Top Five U.S. States



Source: Wieben, 2021

FIGURE 1.7 Estimated Agricultural Use for Glyphosate (1994 and 2019)



Estimated use on agricultural land, in pounds per square mile:
< 5.71 | 5.71 – 27.97 | 27.98 – 114.64 | > 114.64 | None

Source: USGS, 2019. Estimated Annual Agricultural Pesticide Use.

These maps illustrate that glyphosate application has remained widespread and persistent across Iowa over multiple decades. The maps are not intended to suggest any health risks in these locations; rather, they show where residents and applicators may have had the potential for prolonged exposure to glyphosate over time.

Pesticides and Cancer Risks

Concerns regarding pesticide exposures and cancer risks emerged decades ago as increasing evidence suggested certain pesticides were carcinogenic (Weichenthal et al., 2010). A continually growing body of evidence documents a range of harms, including neurotoxicity, reproductive harm, endocrine disruption, and cancer (Alavanja et al., 2013; Kim et al., 2017; Mostafalou & Abdollahi, 2017).

Researchers have identified multiple potential biological mechanisms for cancerous effects including oxidative stress that can lead to DNA damage (Sapbamrer et al., 2019; Ataei & Abdollahi, 2022; Sule et al., 2022). Additional potential mechanisms include endocrine disruption, suppression of the immune system, pesticide accumulation in fat tissues, and genotoxicity (Andreotti et al., 2010; Stanganelli et al., 2020; Ataei & Abdollahi, 2022). These factors can increase an individual's cancer risk, depending on the pesticide used.

Acetochlor

The cancer incidence associated with the occupational use of acetochlor was first studied within the Agricultural Health Study (Agricultural Health Study, 2025). The researchers observed an increased risk of colorectal cancer among pesticide applicators with high lifetime use of acetochlor and increased risk of lung cancer among those with any use of the pesticide. The study also found increased risk of lung cancer in study participants who used an acetochlor/atrazine mixture. Borderline statistically significant findings also linked an increased risk of melanoma and pancreatic cancer to acetochlor use. The same study called for more research on acetochlor use and rare or subtype cancers, specifically for under-studied populations such as women. The study did not evaluate cancer sites more common in females such as breast or thyroid, nor did it consider genetic susceptibilities for the targeted cohorts (Lerro et al., 2015).

Atrazine

Remigio et al. (2024) investigated atrazine exposures and associations with multiple cancer sites, updating an initial such review that took place in 2011 (Beane Freeman et al., 2011). These studies used data from the Agricultural Health Study. The 2011 analysis did not find significant associations with cancer sites. However, the Remigio analysis from 2024 considered the effect of lag (earlier exposures leading to later cancer development) and had more years of data to work with. This updated review found strong associations between atrazine use and endocrine-disrupting effects as well as a number of specific cancers including lung, pharyngeal, oral cavity, and kidney cancers, non-Hodgkin lymphoma, and aggressive prostate cancer (Remigio et al., 2024).

The updated analysis showed increased rates of renal cell carcinoma among applicators with the highest numbers of days of use for multiple pesticides, including atrazine. Applicators less than 50 years of age, who had ever used atrazine, had an increased risk of non-Hodgkin lymphoma (Beane Freeman et al., 2011; Remigio et al. 2024). Additionally, there was a positive and statistically significant association between incidence of aggressive prostate cancer in applicators under 60 years of age who were in the highest quartile of atrazine use. The authors noted that exposure to atrazine was linked to higher risks of aggressive prostate cancer and non-Hodgkin lymphoma, especially in people diagnosed at younger ages (Remigio et al., 2024).

Research by Mo et al. (2025) found that atrazine leads to the formation and progression of colorectal cancer in multiple ways. The analysis found atrazine leads to persistent inflammation of the gastrointestinal tract, oxidative stress, and a variety of genetic changes that make colorectal cancer more likely and, once diagnosed, more likely to persist and spread in the body. Numerous studies have resulted in findings that atrazine disrupts key sex hormones and that long-term atrazine exposure increases the risk of tumors, especially hormone-dependent tumors such as breast cancer, prostate cancer, and epithelial ovarian cancer (Hu et al., 2016; Chen et al., 2021; Wang et al., 2023; Remigio et al., 2024).

A working group of the IARC in 2025 classified atrazine as "probably carcinogenic to humans" based on sufficient evidence of cancer in animals and strong mechanistic evidence. Specifically, they found evidence that atrazine causes non-Hodgkin lymphoma in humans as well as malignant tumors, mammary cancer, and uterine cancer in lab animals (Cattley et al., 2025).

Glyphosate

In 2015, glyphosate was classified by the IARC as a probable human carcinogen, and California added it to its Proposition 65 list of carcinogens (IARC, 2015; OEHHA, 2015; OEHHA, 2025). The IARC review of glyphosate found evidence of a link between glyphosate and non-Hodgkin lymphoma in humans. The review also found convincing evidence that glyphosate "can cause cancer in laboratory animals" (IARC, 2015). An interim review by the EPA in 2020, however, claimed no human health risks from glyphosate exposure and that it is "unlikely" to be a human carcinogen. An updated FIFRA review is planned for 2026 (EPA, 2025b).

The EPA and the IARC reached opposite conclusions on glyphosate safety due primarily to reliance on different sets and types of studies with the EPA focusing on glyphosate as a stand-alone chemical, while the IARC also placed significant weight on analyses of glyphosate pesticides in their formulation and in the chemicals formed during its breakdown. Finally, the EPA evaluation was focused on exposures to the general public through diet, rather than examining occupational exposures, which are often higher (Benbrook, 2019). To further complicate the public understanding of glyphosate safety, an evaluation and risk assessment published in 2000 that has been used to support the safety of the chemical was recently retracted due to "findings that are unreliable, either as a result of major error (e.g., miscalculation or experimental error), or as a result of fabrication (e.g., of data) or falsification (e.g., image manipulation)" (Williams et al., 2026).

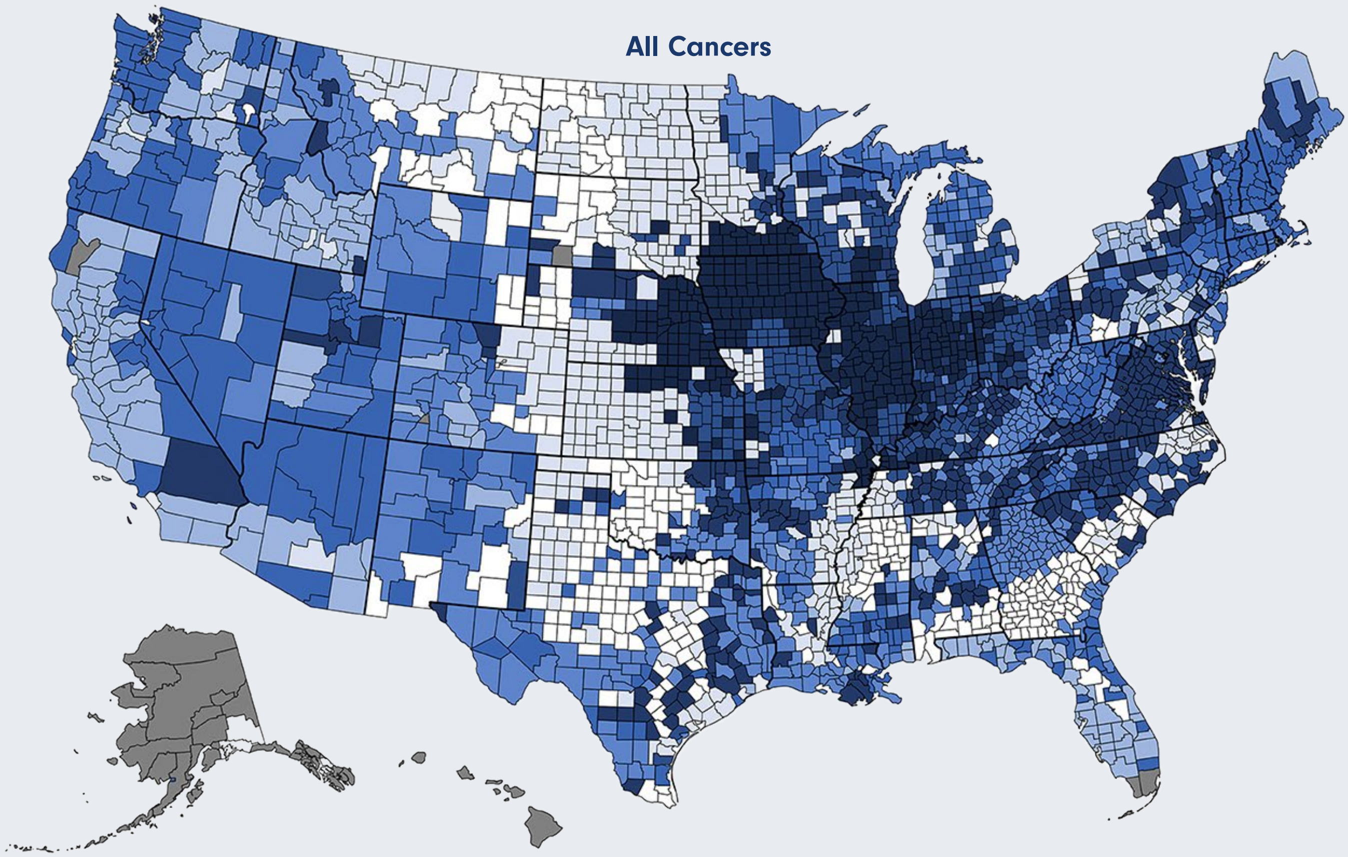
A 2018 analysis of data from the Agricultural Health Study found a possible association between high glyphosate use and acute myeloid leukemia but no association between glyphosate use and any other tumor type (Andreotti et al., 2018). A different analysis from the Agricultural Health Study found an association between higher glyphosate use and genotoxicity (Chang et al., 2023).

Ten human-cell-based studies associated glyphosate and glyphosate-based herbicides with changes induced in gene expression, DNA damage, and reduced cell viability. These studies found that glyphosate-based herbicides showed greater cytotoxicity than glyphosate alone. These findings raise concerns regarding potentially carcinogenic effects of the metabolites of glyphosate and glyphosate-based herbicides (Schluter et al., 2024). Research by Davoren and Schiestl (2018) argues that glyphosate's prevalence and complex compound structure require updated research methodologies to consider the pesticide's effect on endocrine or microbiome disruption.

Excess Cancers Attributable to Pesticides

Gerken et al. (2024) performed a comprehensive analysis of pesticide use and cancer incidence across the United States. This analysis corrected for some potential confounding factors including smoking rates, socioeconomic vulnerability rates, agricultural land use, and population. Findings demonstrated that the impact of pesticide use on cancer incidence may be similar to that of smoking. The study found that the leading corn-producing states of the Midwest have the most increased cancer risk associated with pesticide exposure, as illustrated in Figure 1.9. Specifically, the study found associations between pesticide use and higher incidence of leukemia, non-Hodgkin lymphoma, bladder, colon, lung, and pancreatic cancer as shown in Figure 1.10.

FIGURE 1.9 **Additional Cancer Cases Attributed to Pesticide Use (2024)**



Additional cases per year (US 2020 Adjusted)

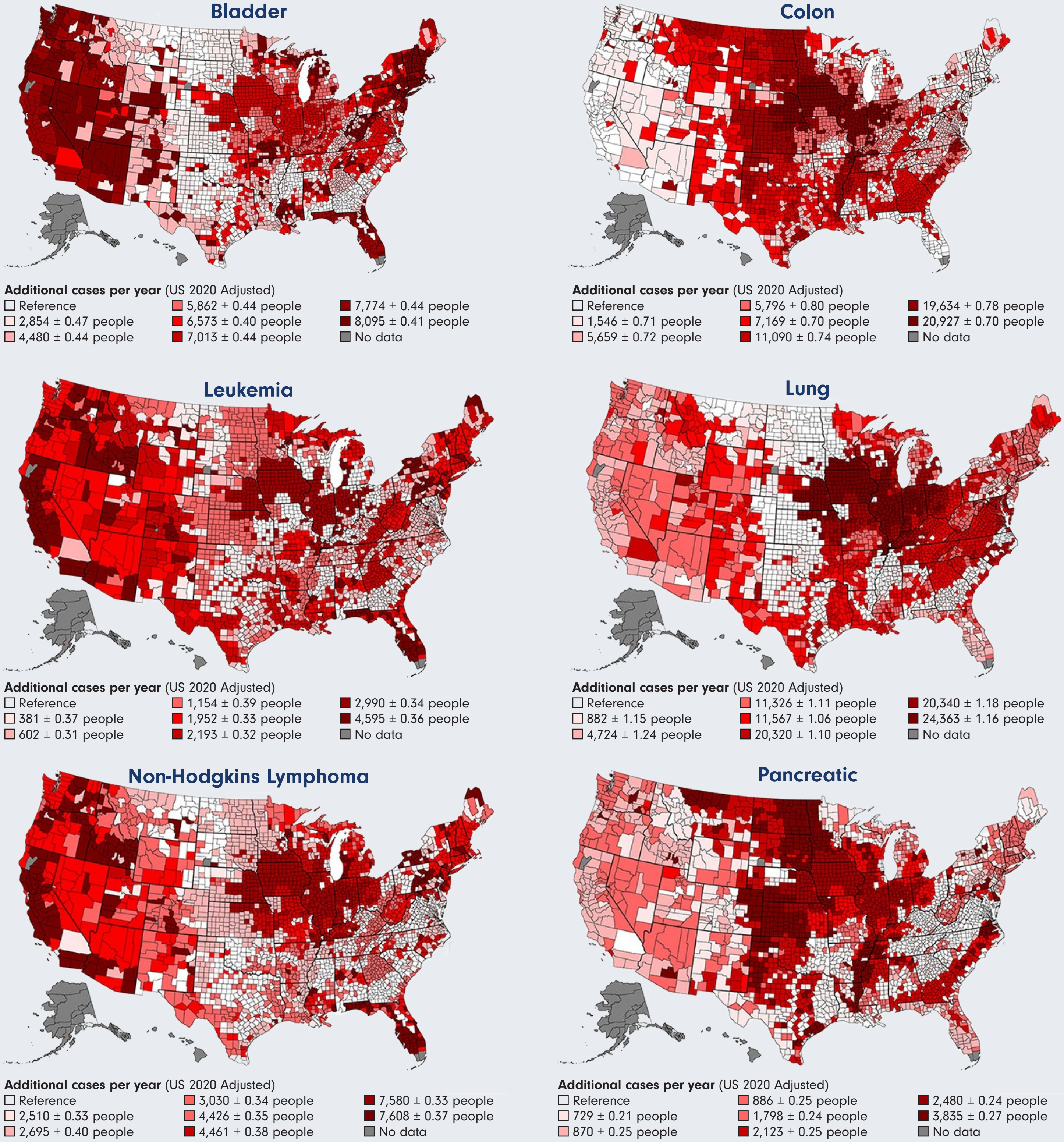
- Reference
- 41,645 ± 4.44 people
- 44,833 ± 4.77 people
- 46,797 ± 3.96 people
- 57,688 ± 4.26 people
- 86,727 ± 4.66 people
- 96,150 ± 4.21 people
- 154,541 ± 4.57 people
- No data

Source: Gerken et al., 2024

The study also found that specific pesticides were more associated with specific types of cancer. Of the pesticides discussed in this report, atrazine was a top contributor to excess cancers in regions with high added risk for all cancers and colon cancers. Glyphosate was a top contributor to excess cancers in regions with high added risk for all cancers, colon cancers, and pancreatic cancer (Gerken et al., 2024).

Findings demonstrated that the impact of pesticide use on cancer incidence may be similar to that of smoking.

FIGURE 1.10 **Additional Cancer Cases per Cancer Type in a Single Year that can be Attributed to Differences in Agricultural Pesticide Pattern Use**



Source: Gerken et al., 2024

Pesticide Complications, Mitigating Factors, and Amplifiers

The "Cocktail" Effect

Research has established links between specific pesticide types and various cancers, yet far less is known about the cumulative, additive, and synergistic effects of exposure to multiple pesticides on the human body. Epidemiological studies evaluating connections between pesticides use and cancer risk are often limited to an independent pesticide type or chemical ingredient. Iowa farmers frequently opt to use a cocktail of pesticides, which can be used over multiple growing seasons, to protect against weeds, pests, and fungi. Pesticides can also be applied to distinct or targeted areas of concern, but they still have the potential to spread into untreated areas. Combining pesticides may increase the risk of certain cancer types or other health problems (Lerro et al., 2020; Shekar et al., 2024). The effects of multiple or combined pesticide exposure need to be considered as an amplifying agent for cancer risk, and future studies should evaluate the effects of these mixtures.

Effects of "Inert" Ingredients in Pesticides

Pesticides typically have both active and "inert" ingredients where the active ingredient kills the pest, and the inert ingredients include substances such as emulsifiers and solvents. Harmful substances may also be created when the pesticide reacts with other substances that have been used in cleaning or packaging, creating toxic chemicals that are not regulated. The active ingredients require a safety review, but the inert ingredients do not and are often not even listed on the pesticide label (Donley et al., 2024). Research has shown that inert ingredients can increase genotoxicity and hormone disruption, two common pathways for cancer to emerge (Cox & Surgan, 2006).

PFAS

Many pesticides contain per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals," and the use of these chemicals in pesticides is increasing. A study by Donley et al. (2024) found 14% of all pesticide active ingredients in the U.S. are PFAS. For active ingredients approved in the last 10 years, this has increased to 30%. The next section of this report, Section 2: Environmental Risk Factors Analysis: PFAS looks more closely at PFAS and cancer.

Effects of Pesticide Resistance

Pesticide resistance is a growing concern in which targeted weeds, pests, and fungi adapt to withstand pesticide effectiveness and lethality. As manufacturers respond to the declining efficacy of existing pesticides by developing new and more potent formulations, this potentially exacerbates resistance and increases public health risks (Corbel et al., 2016; EPA, 2016b).

Data on Exposures

Existing research has primarily focused on pesticide applicators and their immediate families and has not adequately covered other exposed populations, especially in rural areas. Further research on exposed populations is needed.

Table 1.1 summarizes the specific associations of pesticides with cancer sites and the trends in those cancers in Iowa. Information about associations is drawn from the literature discussed in this report. Strength of association varies by cancer site and study.

TABLE 1.1 **Pesticide Types, Associated Cancer Sites, and Trends in Iowa**

PESTICIDE AND ASSOCIATED CANCER SITES	IOWA TRENDS IN ASSOCIATED CANCER SITES
ACETOCHLOR **Colorectal** **Lung** **Melanoma** **Pancreatic** (Lerro et al., 2015)	**Colorectal:** Incidence is rising in younger Iowans. From 1992 – 2021, incidence rose an average of 2.8% per year in Iowans under 50. This is the second-highest rate of increase for cancer sites in this group. Since 2010, incidence has also increased by 1.3% per year in Iowans under age 65. Incidence has been declining by 3.5% per year for Iowans over age 65 since 1998 with the trend in Iowa overall declining despite increasing incidence in younger people. Iowa's colorectal cancer rate exceeds the national average and has the fourth-highest incidence rate of cancers in Iowa.
	Lung: Since 2007, incidence has been falling by 4.2% per year in people under 50 in Iowa. Incidence is still rising an average of 1% per year in the Iowa population as a whole. Iowa's lung cancer rate exceeds the national average. Iowa ranks 18th nationally in rate of lung cancer mortality.
	Melanoma: Ranks 3rd in cancer sites for rate of increase for Iowans under age 50 (2.3% increase per year since 1992) and for all age groups (3.4% increase per year since 1992). In 2022, melanoma was 3rd in incidence rate among cancer sites in Iowa and in number of cases. Iowa's melanoma rate exceeds the national average.
	Pancreatic: Incidence of pancreatic cancer increased among all Iowans by an average of 1.3% per year between 1992 and 2021. Iowa's pancreatic cancer rate is about the same as the national rate.
ATRAZINE **Colorectal** (Gerken et al., 2024; Mo et al., 2025) **Pharyngeal** (Remigio et al., 2024) **Kidney** (Renal Cell Carcinoma) (Remigio et al., 2024) **Lung** (Remigio et al., 2024) **Non-Hodgkin Lymphoma** (including under 60 years old) (Remigio et al., 2024; Cattley et al., 2025) **Prostate** (Remigio et al., 2024; Mo et al., 2025)	**Colorectal:** Incidence is rising in younger Iowans. From 1992 – 2021, incidence rose by an average of 2.8% per year in Iowans under 50. This is the second-highest rate of increase for cancer sites in this group. Since 2010, incidence has also increased by 1.3% per year in Iowans under age 65. Incidence has been declining by 3.5% per year for Iowans over age 65 since 1998 with the trend in Iowa overall declining despite increasing incidence in younger people. Iowa's colorectal cancer rate exceeds the national average.
	Pharyngeal: Most data sources combine oral cavity and pharynx cancers into one data set. Oral cavity and pharynx cancers have been on the rise in Iowa since 2007. The rate of oral cavity and pharynx cancers in the total Iowa population was flat between 1992 and 2007. In 2007, the trend shifted to reflect growth of 2.2% per year, the 4th – highest incidence rate increase of cancer sites in Iowa. Iowa's incidence rate for oral cavity and pharynx cancer is higher than the national average.
	Kidney and Renal Pelvis: Fastest-rising cancer in Iowans under 50, growing an average of 3.7% per year in this age group. For the full population of Iowa, this cancer increased by 5.6% per year until 2005 then slowed to 1.5% per year. The reduction in growth rate was primarily seen in men. The growth rate for women of all ages in Iowa continued to be around 2.2% per year after 2005. Iowa's incidence rate for kidney and renal pelvis cancer exceeds the national average.
	Lung: Since 2007, incidence has been falling by 4.2% per year in people under 50. Incidence is still rising an average of 1% per year in the Iowa population as a whole. Iowa's lung cancer rate exceeds the national average. Iowa ranks 18th nationally in rate of lung cancer mortality.
	Non-Hodgkin Lymphoma: Increased by 1.1% per year from 1992 – 2009 in total Iowa population; incidence has been falling by 0.6% per year since 2009. There were 893 cases in Iowa in 2022. Iowa's non-Hodgkin lymphoma rate exceeds the national average.
	Prostate: Second-highest incident rate for cancers in Iowa in 2022 (134.2 per 100,000) and rate of increase (3.6% per year from 1992 – 2021) among total population in Iowa; first in number of cases in 2022 (2,898 cases). Iowa's prostate cancer rate exceeds the national average.

Table 1.1 continued on following page

TABLE 1.1 Pesticide Types, Associated Cancer Sites, and Trends in Iowa, continued

ATRAZINE, CONTINUED **Breast** (Hu et al., 2016)	**Breast:** Breast cancer is the site with the highest incidence rate in Iowa. Breast cancer trends for all women in Iowa reversed course sharply in 2012 from flat/declining to increasing by almost 2% per year. Breast cancer has been growing by 1.7% per year in women under 50 since 2012 — the 4th-highest rate of increase of any cancer site for people under 50 in Iowa. Iowa's breast cancer rate exceeds the national average.
Ovarian (Chen et al., 2021)	**Ovarian:** Epithelial ovarian cancer is the most common type of ovarian cancer, representing about 95% of ovarian cancers. Ovarian cancer incidence declined an average of 2% per year in Iowa women under 50 from 1992 – 2021. For the total female population of Iowa, ovarian cancer incidence increased by 0.3% per year on average from 1992 – 2000 before declining by 2.3% per year on average through 2021. Iowa saw 600 cases of ovarian cancer in 2022. Iowa's ovarian cancer rate is about the same as the national average.
GLYPHOSATE **Non-Hodgkin Lymphoma** (IARC, 2015)	**Non-Hodgkin Lymphoma:** Increased by 1.1% per year from 1992 – 2009 in total Iowa population; incidence has been falling by 0.6% per year since 2009. There were 893 cases in Iowa in 2022. Iowa's non-Hodgkin lymphoma rate exceeds the national average.
Acute Myeloid Leukemia (Andreotti et al., 2018)	**Acute Myeloid Leukemia:** Incidence rates for all leukemia types increased by 0.9% per year between 1992 and 2021 for people under 50 and 0.5% per year for the Iowa population as a whole. Incidence of acute myeloid leukemia has been on an upward trend in Iowa since 2007 while incidence in the U.S. has remained relatively flat. Iowa's incidence exceeds the national average (Centers for Disease Control [CDC] Wonder database). Data trends for acute myeloid leukemia in Iowa and the U.S. are available in the Appendix figures A.2 and A.3.
PESTICIDE EXPOSURE MIX **Leukemia** (Gerken et al., 2024)	**Leukemia:** Incidence has been increasing by 0.9% per year in Iowans under age 50 in the 1992 – 2021 timeframe. Incidence in the total Iowa population increased an average of 0.5% per year in this same period. Iowa leukemia incidence exceeds the national average.
Pancreatic (Gerken et al., 2024) **Non-Hodgkin Lymphoma** (Gerken et al., 2024)	**Pancreatic:** Increased by 1.3% per year in the 1992 – 2021 timeframe among all Iowans. Pancreatic cancer in Iowa is about the same as the national average.
Bladder (Gerken et al., 2024)	**Bladder:** 879 Iowans were diagnosed with bladder cancer in 2022. Incidence rates in the total Iowa population increased by 1.3% per year on average from 1992 – 2004. Between 2004 and 2021, incidence has been relatively flat. Iowa's bladder cancer rate exceeds the national average. Iowa's pancreatic cancer rate is about the same as the national rate.
Colorectal (Gerken et al., 2024)	**Colorectal:** Incidence is rising in younger Iowans. From 1992 – 2021, incidence rose an average of 2.8% per year in Iowans under 50. This is the second-highest rate of increase for cancer sites in this group. Since 2010, incidence has also increased by 1.3% per year in Iowans under age 65. Incidence has been declining by 3.5% per year for Iowans over age 65 since 1998 with the trend in Iowa overall declining despite increasing incidence in younger people. Iowa's colorectal cancer rate exceeds the national average and has the 4th-highest incidence rate of cancers in Iowa.
Lung (Lerro et al., 2015; Gerken et al., 2024)	**Lung:** Since 2007, incidence has been falling by 4.2% per year in people under 50 in Iowa. Incidence is still rising an average of 1% per year in the Iowa population as a whole. Iowa's lung cancer rate exceeds the national average. Iowa ranks 18th nationally in rate of lung cancer mortality.

Source: National Cancer Institute, 2025; U.S. Cancer Statistics Working Group, 2025

SECTION 2 Environmental Risk Factors Analysis: PFAS

Per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals," are a group of manufactured chemicals that were first synthesized in the late 1930s and heavily used in manufacturing by the mid-20th century. They consist of linear chains of carbon atoms with multiple attached fluorine atoms, which can be short-chain or long-chain depending on the number of carbon atoms. There are more than 12,000 types of PFAS (Smalling et al., 2023; Dong et al., 2025). The unique properties of PFAS chemicals have made them attractive for a myriad of household and industrial uses (e.g., oil and water repellency, temperature and acid resistance, and friction reduction), as well as in pesticides. These same properties, however, have also translated into their extreme stability in the environment (Sunderland et al., 2019; Anik et al., 2025; Botelho et al., 2025). Because PFAS break down extremely slowly, they accumulate in the environment and across all levels of the food chain (Shearer et al., 2020). As a result, PFAS are considered "toxic, persistent, and ubiquitous [widespread] contaminants" that are harmful to both environmental and human health (Dilparic et al., 2025).

Newer, short-chain PFAS (e.g., perfluorobutanoic acid [PFBA]) are manufactured as theoretically safer alternatives to legacy long-chain PFAS due to their increased potential to disperse in soil and water, decreasing the potential for bioaccumulation within the environment (Li et al., 2023; Smalling et al., 2023). However, short-chain PFAS are highly mobile in air and water and degrade slowly in aquatic systems. Ultrashort-chain PFAS (e.g., trifluoroascetic acid [TFA]) have recently been documented as prevalent in the environment, raising potential toxicity concerns depending on duration and potency of exposure (Li et al., 2023; Jagani et al., 2025).

Sources of PFAS chemical exposure are numerous and widespread, including environments in and around homes and workplaces. Biomonitoring studies have detected PFAS in human hair, blood serum, and urine, indicating widespread human exposure across populations (Piva et al., 2021; CDC, 2024).

PFAS Exposure Pathways

Levels of specific human exposures to PFAS depend on factors such as the source of environmental pollution, exposure pathway, and characteristics of the exposure, such as duration and length of time (Poothong et al., 2020; Anik et al., 2025). Many products containing PFAS are used daily, including water-resistant textiles and clothing, stain- and water-resistant carpet and furniture, and personal care products, such as dental floss, sunscreen, and waterproof cosmetics (Boronow et al., 2019; Espartero et al., 2022).

Additionally, while some legacy PFAS have been phased out of products in the United States, they can persist in the environment and be present in imported products. Thousands of non-legacy PFAS may currently be in use (Brennan et al., 2021).

The most common exposure pathway for the general public is through water ingestion, which is considered a repeated and lifelong exposure (Post et al., 2012; Anik et al., 2025). Exposure levels vary with characteristics of the source water. In one study, detection rates of PFAS were twice as high in public water supplies that relied on groundwater sources compared with those using surface water, while short-chain PFAS were more frequently found in surface water systems. The greatest concentrations of PFAS in drinking water are typically detected near industrial facilities that manufacture or use PFAS, as well as at locations where aqueous film forming foam has been released, such as military bases, major airports, and other fire training sites (Levin et al., 2024).

Another study analyzed tap water using an advanced testing method that can detect many more PFAS than standard approaches. Researchers identified 75 different PFAS, including 57 that would not have been identified using typical monitoring methods. This suggests that current water testing may significantly underestimate the amount of public exposure to PFAS from drinking water (Boettger et al., 2025). Research also suggests that municipal wastewater treatment plants are significant pathways (though not original sources) of contamination, particularly for downstream drinking water supplies. The PFAS discharged by wastewater treatment plants may contribute to drinking water contamination for more than 23 million Americans, emphasizing the importance of reducing PFAS pollution closer to its source and preventing it from entering wastewater systems in the first place (Ruyle et al., 2025).

Exposure can also occur when PFAS-contaminated irrigation water or biosolids (organic matter from wastewater treatment facilities) are applied on agricultural land. PFAS can then enter the food supply through plant/crop uptake, in addition to seeping into soil and groundwater (Liu et al., 2017; Masoner et al., 2020; Bolan et al., 2021a; Bolan et al., 2021b; Bonato et al., 2025).

Additionally, airborne exposure to PFAS is emerging as a significant concern. A recent study highlighted that PFAS can attach to PM2.5 particles (fine particles in the air with a diameter of 2.5 micrometers or smaller), which are inhaled and pose significant health risks, particularly from carcinogenic PFAS such as perfluorooctanoic acid (PFOA). These particles contribute to long-range transport of PFAS pollution and respiratory health concerns, even at low concentrations (Sangkham et al., 2025).

Occupational contact with PFAS may be a significant risk factor, with exposure up to 100 times higher than those in the general population (He et al., 2025). High risk occupations include industrial, chemical, electronic, and textile manufacturing, landfills, wastewater treatment plants, firefighting, aerospace and military operations, and construction sites where PFAS-containing waste, effluent, or emissions are released into the environment (Leary et al., 2020; Peaslee et al., 2020; Graber et al., 2021; Mazumder et al., 2023; Paris-Davila et al., 2023; He et al., 2025; Sabba et al., 2025). PFAS exposure is magnified when a person has both occupational and residential/community PFAS exposures (Shin et al., 2011a; Shin et al., 2011b; Steenland et al., 2013; Li et al., 2025).

Recent efforts to regulate PFAS exposure reflect increasing recognition of their potential health risks. Scientific findings regarding the toxicity and persistence of PFAS in drinking water led the U.S. Environmental Protection Agency (EPA) to set maximum contaminant levels (MCL) for six PFAS in tap water (EPA, 2025; Ruyle et al., 2025), including:

- Perfluorooctanoate (PFOA) – 4 ng/L
- Perfluorooctane sulfonate (PFOS) – 4 ng/L
- Perfluorohexane sulfonate (PFHxS) – 10 ng/L
- Perfluorononanoic acid (PFNA) – 10 ng/L
- Hexafluoropropylene oxide dimer acid (HFPO-DA) – 10 ng/L
- Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS – 1 (unitless hazard index)

Estimates indicate that more than 200 million people in the United States may drink tap water with PFOA and PFOS levels above 1 ng/L, and tens of millions of people may drink water with levels equal to or greater than 10 ng/L. In addition, typical treatment for drinking water systems may be ineffective in removing PFAS, and thousands of additional PFAS compounds that are not subject to regulation are being used throughout the country (Andrews & Naidenko, 2020).

PFAS in Iowa

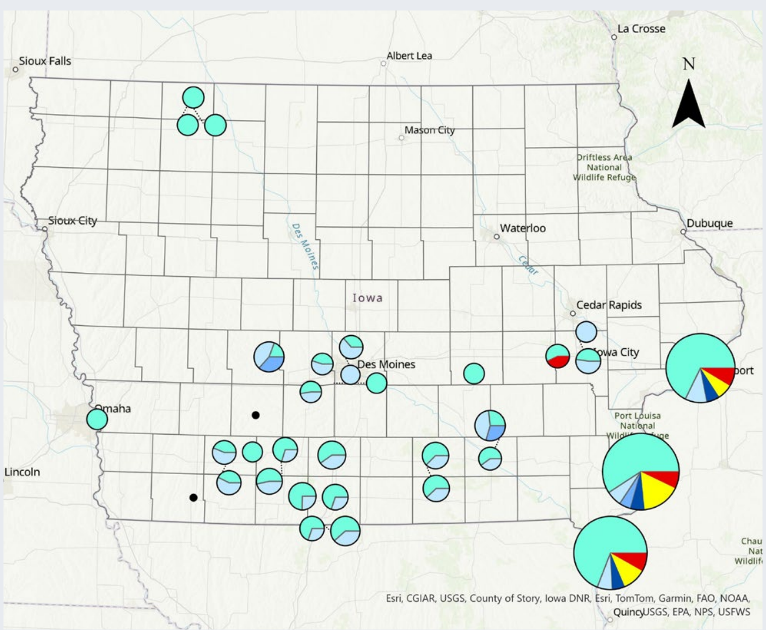
Given their environmental persistence, PFAS have been detected globally in soils, watersheds, drinking water systems, air emissions, aquatic and terrestrial wildlife, and humans, making them a global health concern (Sun et al., 2016; Boone et al., 2019; Thackray et al., 2020; Bolan et al., 2021a; Brennan et al., 2021; D'Ambro et al., 2021; Maizel et al., 2021; Anik et al., 2025; Dilparic et al., 2025). PFAS chemicals have been detected in multiple water sources in Iowa, and recent research has aimed to quantify the extent of PFAS contamination in the state. In a statewide assessment in Iowa, researchers tested streams across agricultural regions and identified PFAS contamination in 32% of the 60 streams sampled and the presence of nine different PFAS compounds. The highest PFAS concentrations were in streams where wastewater treatment effluent was directly discharged (Kolpin et al., 2021). Similarly, in another study in Iowa, PFAS were detected in nine of the 15 stream samples, with total PFAS concentrations ranging from 6.7 ng/L to 36.8 ng/L. PFAS were also detected in 12 of the 15 sediment samples at the same sites, and all assessed fish samples were contaminated with PFOS (Meppelink et al., 2025).

Another recent study reported that PFAS were detected in 94% of surface waters and 30% of groundwater samples in Iowa.

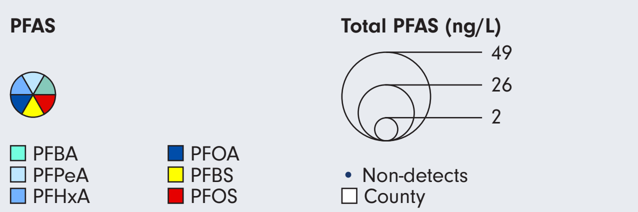
Groundwater showed higher average concentrations than surface waters, at approximately 44 ng/L and 10 ng/L, respectively. Surface waters had higher levels of short-chain PFAS (PFBA and perfluoropentanoic acid [PFPeA], but the Mississippi River had higher concentrations of legacy long-chain PFAS (PFOS and PFOA). Figures 2.1 and 2.2 demonstrate how community water sources have been affected by PFAS contamination, potentially due to proximity to a PFAS manufacturing facility and to sites where firefighting foam was used (Dilparic et al., 2025).

Although not conducted explicitly in Iowa, research by Bradley et al. (2025) examined PFAS levels in a Mississippi River island community and detected elevated PFAS contamination in private wells. These findings may underscore the vulnerability of alluvial groundwater systems in floodplains and near rivers, which highlights the importance of monitoring contaminant levels.

FIGURE 2.1 **PFAS in Iowa Surface Waters used as Public Drinking Water Supplies**

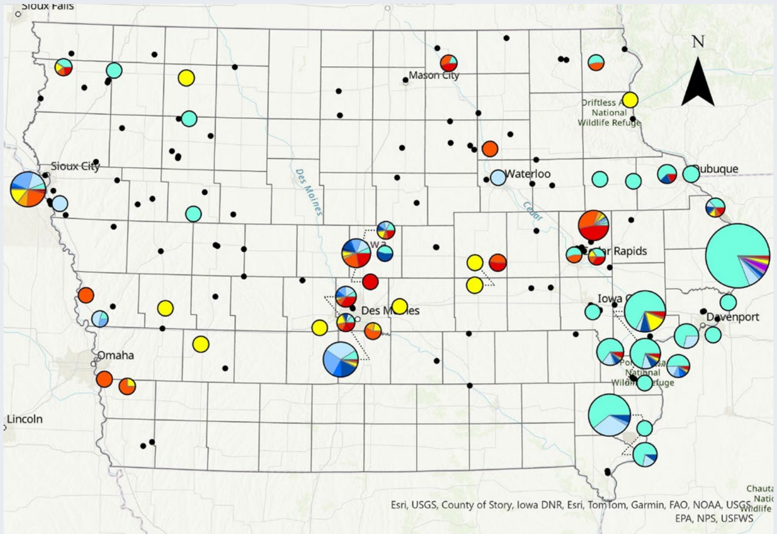


PFAS in surface water sources used by public drinking water supplies in Iowa tested by the Iowa Department of Natural Resources (IDNR). Surface water sources (n = 31) with PFAS detections are indicated with pie charts proportional to total PFAS concentration (size) and composition (colored wedges). Drinking water supplies with no PFAS detected (n = 2) are indicated with black dots. County lines indicated in black (Dilparic et al., 2025).

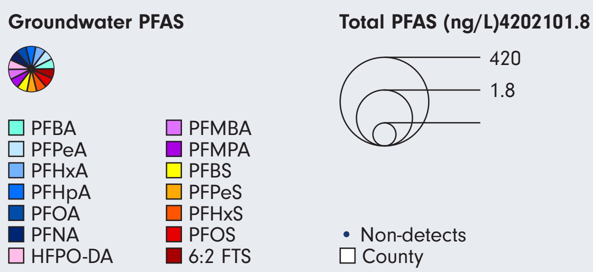


Source: Dilparic et al., 2025

FIGURE 2.2 **PFAS in Iowa Groundwater Sources used as Drinking Water Supplies**



PFAS in groundwater sources of public drinking water supplies tested by the IDNR. Groundwater sources (n = 52) with PFAS detections are indicated with pie charts proportional to total PFAS concentration (size) and composition (colored wedges). Drinking water supplies with no PFAS detected (n = 117) are indicated with black dots. County lines indicated in black.



Source: Dilparic et al., 2025

PFAS and Cancer Risks

Scientists have suggested several ways that PFAS exposure could contribute to cancer. The International Agency for Research on Cancer (IARC, 2025) notes that PFOA and PFOS compounds have long half-lives, which allow for sustained biological activity. This finding suggests multiple key pathways that increase the carcinogenic potential of PFOA and PFOS because these chemicals can build up in the body over time, leading to cellular damage caused by oxidative stress. PFAS may also interfere with hormones, such as mimicking estrogen or blocking male hormones, and may weaken the immune system, which can reduce the body's ability to detect and fight cancer (Boyd et al., 2022; Chang et al., 2023; Ayodele & Obeng-Gyasi, 2024; IARC, 2025).

Kidney and Testicular Cancer

Much of the existing epidemiological evidence suggests strong, consistent associations between kidney and testicular cancers and PFAS exposure, particularly for PFOA, which has been deemed carcinogenic by the IARC (2025). This conclusion is supported by a recent meta-analysis showing that kidney cancer risk increases with higher overall exposure to PFAS, particularly at high exposure levels. Additionally, the authors observed that high PFAS exposure resulted in significantly increased risk of testicular cancer (Seyyedsalehi & Boffetta, 2023).

These results also align with findings from Bartell and Vieira (2021), who found that risk for both testicular and kidney cancer increased for each 10 ng/mL increase in PFOA blood serum levels. Though "most likely causal," the authors note the small number of studies on testicular cancer and overlapping cohorts.

Other Cancer Sites

In a separate meta-analysis of 14 studies focused on hematological (blood) cancers, Sassano et al. (2025) observed no significant elevation of risk for leukemia, lymphoma, or hematological cancers overall. However, there was a small but significant association with non-Hodgkin lymphoma. Another recent meta-analysis of case-control studies observed a significant association between PFOS exposure and prostate cancer and between mixed PFAS exposure and ovarian cancer (Yang et al., 2025). Other meta-analyses also found a statistically significant increase in ovarian cancer risk with PFAS exposure. However, the associations between breast cancer and PFAS exposure were inconclusive, meaning more epidemiologic evidence is needed to determine the risk (Chang et al., 2024; Seyyedsalehi et al., 2024). Overall, the weight of epidemiological evidence indicates strong, consistent associations between PFAS exposure and kidney and testicular cancers, while associations with other cancer types remain mixed or warrant further investigation.

PFAS Complications, Mitigating Factors, and Amplifiers

While many robust studies of PFAS have already been conducted, including cohort, case-control, and ecological studies, the evidence base continues to expand, further clarifying the understanding of exposure risks. The review of available studies suggests a need for additional research with rigorous exposure assessment to clarify the potential risks associated with PFAS exposure. It also illustrates a need for a more in-depth understanding of the potential effects from exposures to ultrashort-chain PFAS.

Table 2.1 summarizes the specific associations of PFAS with cancer sites and the trends in those cancers in Iowa. Information about associations is drawn from the literature discussed in this report. Strength of association varies by cancer site and study.

TABLE 2.1 PFAS Types, Associated Cancer Sites, and Trends in Iowa

PFAS TYPE AND ASSOCIATED CANCER SITES	IOWA TRENDS IN ASSOCIATED CANCER SITES
PFOA **Kidney** (Bartell & Vieira, 2021; Seyyedsalehi & Boffetta, 2023) **Testicular** (Bartell & Vieira, 2021; Seyyedsalehi & Boffetta, 2023)	**Kidney and Renal Pelvis:** Fastest-rising cancer in Iowans under 50, growing an average of 3.7% per year in this age group. For the full population of Iowa, this cancer increased by 5.6% per year until 2005 then slowed to 1.5% per year. The reduction in growth rate was primarily seen in men. The growth rate for women of all ages in Iowa continued to be around 2.2% per year after 2005. Iowa's incidence rate for kidney and renal pelvis cancer exceeds the national average.
	Testicular: Despite the lack of access to regression analysis data, the CDC Wonder database showed that the incidence among the total population in Iowa has increased slightly from 1999 – 2022. The CDC Wonder database also shows that Iowa's incidence was consistently above the U.S. incidence in this period (see Appendix A, Figure A.1). Iowa was tied for the 7th-highest average incidence rate for testicular cancer in the U.S. in the 2018-2022 period.
PFOS **Prostate** (Yang et al., 2025)	**Prostate:** Second-highest incident rate for cancers in Iowa in 2022 (134.2 per 100,000) and rate of increase (3.6% per year from 1992 – 2021) among total population in Iowa; first in number of cases in 2022 (2,898 cases). Iowa's prostate cancer rate exceeds the national average.
MIXED TYPES **Ovarian** (Chang et al., 2024; Seyyedsalehi et al., 2024; Yang et al., 2025) **Non-Hodgkin Lymphoma** (Sassano et al., 2025)	**Ovarian:** Ovarian cancer incidence declined an average of 2% per year in Iowa women under 50 from 1992 – 2021. For the total female population of Iowa, ovarian cancer incidence increased by 0.3% per year on average from 1992 – 2000 before declining by 2.3% per year on average through 2021. Iowa saw 600 cases of ovarian cancer in 2022. Iowa's ovarian cancer rate is about the same as the national average.
	Non-Hodgkin Lymphoma: Increased by 1.1% per year from 1992 - 2009 in total Iowa population; incidence has been falling by 0.6% per year since 2009. There were 893 cases in Iowa in 2022. Iowa's non-Hodgkin lymphoma rate exceeds the national average.

Source: National Cancer Institute, 2025; U.S. Cancer Statistics Working Group, 2025

SECTION 3

Environmental Risk Factors Analysis: Nitrate

Nitrogen is an essential element required for all living organisms. Biological and atmospheric processes continuously cycle nitrogen among the air, water, soil, and living organisms maintaining a relative equilibrium. Although abundant in the environment, nitrogen must first undergo chemical transformations to become nitrate, the form that plants can readily use for growth (University of Missouri Extension, 2022).

Nitrate (NO_3^-) is a negatively charged ion composed of nitrogen and oxygen, produced naturally in the environment. It also moves through the systems of living organisms, returning to the environment through decomposition and as waste in livestock manure and sewage. Manure is commonly used as a fertilizer for crop production because it provides forms of nitrogen that soil bacteria transform into plant-available nitrate (Lory et al., 2007). Nitrate can also be manufactured synthetically for use in fertilizers, food preservation, pharmaceuticals, and the production of munitions and explosives (U.S. Environmental Protection Agency [EPA], 2025b). Synthetic nitrogen fertilizers have become increasingly popular since the 1940s because they provide a cost-effective source of nutrients for plants at the most opportune time in the growing cycle (Pardey & Alston, 2021).

Once applied to the landscape, both synthetic fertilizers and manure are transformed by soil bacteria into nitrate and other forms of nitrogen available for plant growth. Research indicates that the majority of applied nitrogen contributes to plant growth, but a significant portion is lost from the system through volatilization into the air, leaching into groundwater, runoff into surface water, or remains in the soil (Wienhold, 1995; Govindasamy, 2023). Nitrate that persists in the soil may be incorporated into organic matter, where it can remain for years before being re-released, absorbed by new plant growth, or leached into groundwater.

> **Because only a fraction of applied nitrogen fertilizer is converted to plant matter, the remaining nitrate accumulates in the soil or is transported into groundwater and surface water, eventually entering drinking water supplies (Essien et al., 2020).**

Nitrate is easily dissolved by water, making it susceptible to movement through the soil. Its concentrations often vary seasonally, as runoff and groundwater flow transport nitrate into streams, lakes, and other waterbodies. In agricultural areas, nitrate also ends up in subsurface tile drainage systems. These drains were installed to improve crop production by removing excess water from fields; however, they also rapidly channel nitrate from the soil into streams and downstream water bodies, bypassing natural removal processes (Central Iowa Source Water Resource Assessment [CISWRA], 2025). The widespread use of synthetic fertilizers and manure has significantly increased nitrate concentrations in the environment, particularly in areas with intensive agricultural activity (Essien et al., 2020). These changes have disrupted the natural balance of the nitrogen cycle in the environment (Organisation for Economic Co-operation and Development, 2018).

Nitrate Exposure Pathways

Exposure to nitrate occurs through ingestion of contaminated drinking water and by eating certain nitrate-containing foods, such as processed meats and leafy vegetables (Iowa Water Quality and Public Health Consortium, 2021). Once consumed, nitrate follows several pathways in the body as it circulates through the digestive system, blood, saliva, and tissues, while undergoing chemical changes. The process begins in the mouth, where bacteria reduce a portion of the nitrate to nitrite (NO_2). This mixture is swallowed and enters the stomach, where additional nitrate is converted to nitrite. Nitrite is then absorbed into the bloodstream, which can reduce the blood's oxygen-carrying capacity — an effect that is particularly dangerous for infants. In the gastrointestinal tract, especially the acidic stomach, nitrite also reacts to form N-nitroso compounds (NOCs), such as nitrosamines and nitrosamides, some of which are recognized as animal carcinogens. Nitrate can also move from the stomach into the small intestine, where it is absorbed into the bloodstream through the intestinal wall. About 75% of ingested nitrate is ultimately excreted in urine, while the remainder is absorbed by the kidneys and recirculated through the body (International Agency for Research on Cancer [IARC], 2010; Ward et al., 2018; Picetti et al., 2022). Although nitrate is not directly carcinogenic, its conversion to nitrite and NOCs in the oral cavity and gastrointestinal tract is the potential mechanism by which ingestion can increase cancer risk (Ward et al., 2018).

Experts believe that the source of nitrate is critical to determining its transformations in the body. When consumed with antioxidants, such as vitamin C found in fruits and vegetables, nitrate is more likely to be converted into beneficial, heart-healthy nitrogen oxides rather than nitrosamines. In contrast, foods high in added nitrates but low in antioxidants, such as cured meat, have a greater potential to form nitrosamines in the body (IARC, 2010; Karwowska & Kononiuk, 2020; Chazelas et al., 2022; Bowles et al., 2024).

Nitrate in Iowa

Nitrate load in Iowa's waterways has grown over time, and concentrations have steadily increased as the landscape has been reengineered from tallgrass prairie to intensive row crop agriculture.

> **Iowa has converted its historic prairie and wetland to row crops, installing the most subsurface tile drainage of any state by far with more than 13 million farm acres drained by tile in 2022 — 47% higher than Illinois, the next-highest state with 8.8 million farm acres drained by tile (U.S. Department of Agriculture [USDA], 2024).**

Iowa has lost approximately 97.5% of its wetlands, which previously covered 4 to 6 million acres of the state and now represent less than 37,000 acres (Iowa Department of Natural Resources [IDNR], 1988; IDNR, 1990).

FIGURE 3.1 **Iowa Land Cover**

Source: Rosburg et al., 2021

Nitrate concentrations in Iowa are among the highest in the United States. Research from the Central Iowa Source Water Resource Assessment (CISWRA) (2025) shows that the Des Moines and Raccoon rivers rank in the top 1% of rivers nationwide for nitrate concentration, with 80% of this contamination originating from agricultural sources. Around the year 1900, nitrate levels in central Iowa averaged less than 1 mg/L NO_3-N, but yearly averages are now above 6 mg/L (see Figure 3.2).

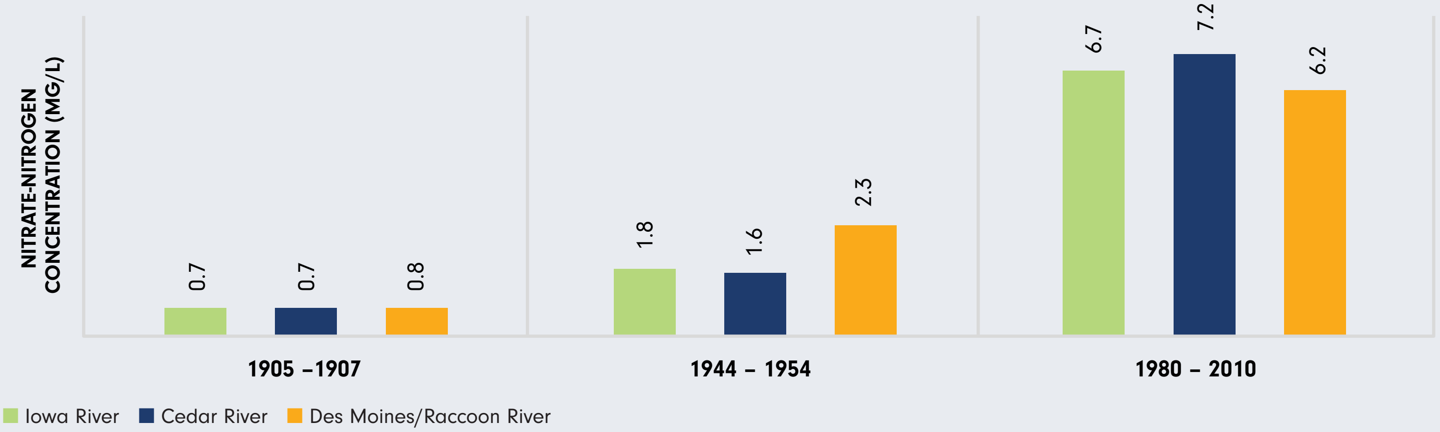
U.S. drinking water standards express nitrate as nitrate-nitrogen (NO_3-N), which accounts only for the nitrogen portion of the nitrate ion, whereas many international standards are based on the full nitrate (NO_3^-) ion. Therefore, when analyzing international studies, the nitrate concentration must be divided by 4.43 to convert the value to nitrate-nitrogen. For the remainder of this report, concentrations reported in mg/L refer to nitrate-nitrogen.

> The Des Moines and Raccoon rivers rank in the top 1% of rivers nationwide for nitrate concentration, with 80% of this contamination originating from agricultural sources.

High nitrate levels are not limited to surface waters; groundwater wells throughout Iowa also show elevated concentrations. The U.S. Geological Survey's (USGS) National Water Quality Assessment (NAWQA) study found significant decadal-scale changes in groundwater nitrate concentrations among wells sampled in 1988 – 2000 and again in 2001 – 2010, varying by agricultural, urban, and mixed land uses (Lindsey et al., 2012). Additional research indicates that well depth is the most important predictor of nitrate contamination because deeper wells generally access older groundwater, which typically has lower nitrate levels.

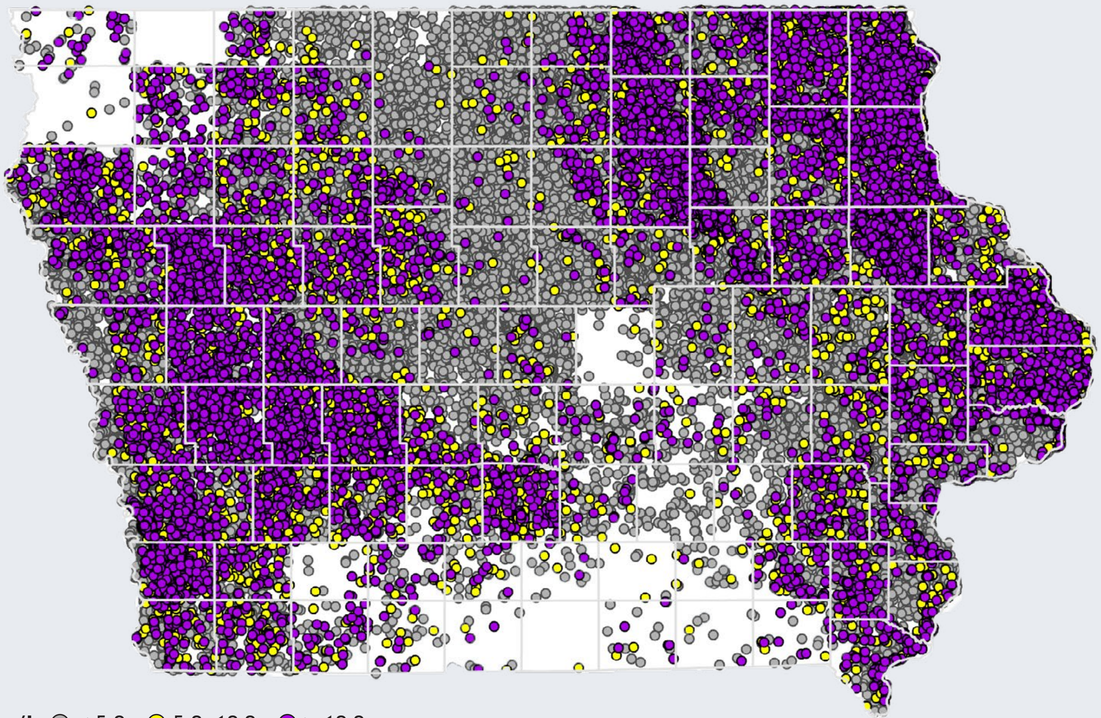
Shallow wells less than 100 feet deep and wells located in the karst region of northeast Iowa are at the greatest risk for nitrate contamination (Wheeler et al., 2015). Wells near concentrated animal feeding operations (CAFOs), agricultural areas, old septic systems, and other heavily fertilized landscapes (such as golf courses) are also at high risk for contamination. Data indicates that nitrate levels in groundwater under agricultural land can be three times the national background level of 1 mg/L NO_3-N (Dubrovsky et al., 2010).

FIGURE 3.2 **Long-Term Historical Nitrate Concentrations in Iowa's Rivers**



Source: Data derived from CISWRA, 2025

FIGURE 3.3 **Observed Nitrate Concentrations in Iowa Private Wells (2000 – 2024)**



Nitrate as N, mg/L: < 5.0 5.0–10.0 > 10.0

Map created by Darrin Thompson, Center for Health Effects of Environmental Contamination, University of Iowa, and Daniel Gilles, IIHR–Hydroscience & Engineering, University of Iowa (personal communication, February 26, 2026) using data from the Iowa Well Information System (see Iowa Department of Natural Resources, n.d.).

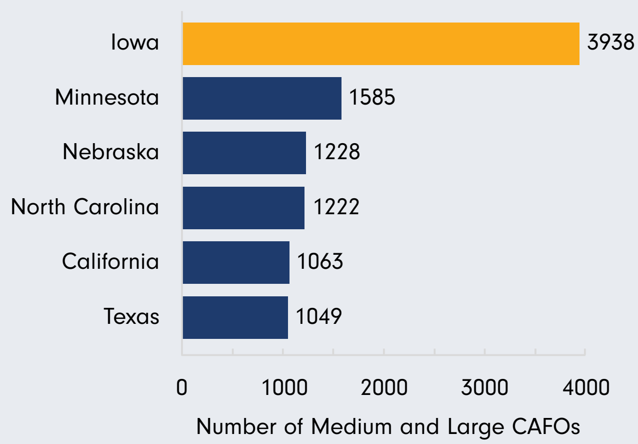
Nitrate contamination of groundwater is most evident in western Iowa and the karst region of northeast Iowa (Figure 3.3).

Agricultural activity is the dominant source of nitrate pollution in Iowa's watersheds (Iowa Department of Agriculture and Land Stewardship [IDALS] et al., 2025).

In 2024, 11.9 billion pounds of synthetic fertilizer were purchased in Iowa (IDALS, 2024), the majority of which is presumed to have been applied to agricultural fields.

Excess application of animal manure also contributes to nitrate contamination, and Iowa has more CAFOs than any other state (Figure 3.4) (EPA, 2025a).

FIGURE 3.4 **Number of EPA-Identified Animal Feeding Operations (AFOs) by State (2024)**



Note: Includes AFOs that meet the NPDES regulatory definition of a Medium CAFO plus AFOs that meet the NPDES regulatory definition of a Large CAFO, with or without an NPDES CAFO permit.

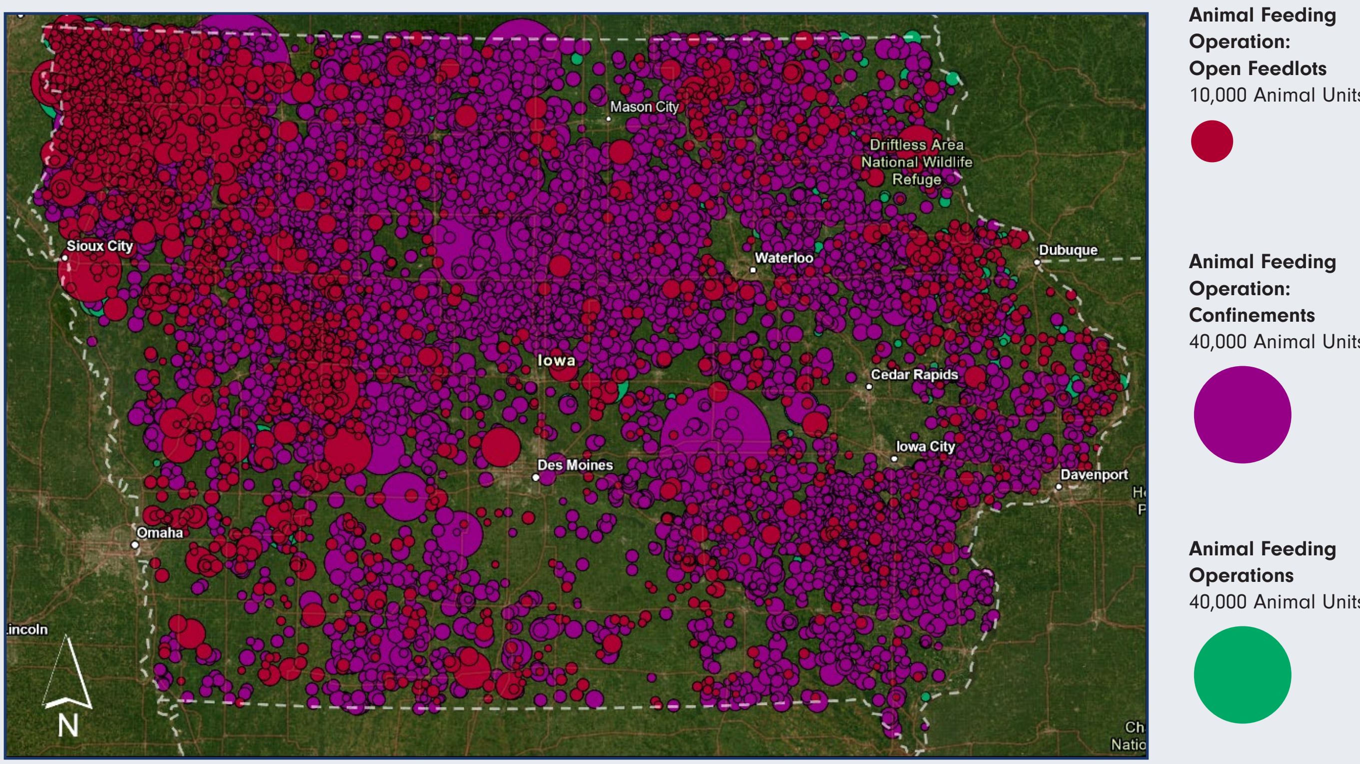
Source: EPA 2024 NPDES CAFO Permitting Status Report (2025a)

Iowa has approximately 2.5 times as many CAFOs as the next highest state.

Many more animal operations exist in Iowa beyond EPA's definition of "medium" and "large" CAFOs included in this figure, but using this reporting metric allows for consistent state-to-state comparison. Most medium-sized CAFOs (500-1000 animal units) in Iowa are not designated as CAFOs for Clean Water Act purposes and, therefore, are not included in these totals. Even using this conservative estimate, Figure 3.4 shows that Iowa has approximately 2.5 times as many CAFOs as the next highest state. (For more information about animal units, see Figure 3.5.) Most of these facilities do not operate under National Pollutant Discharge Elimination System (NPDES) discharge permits, and the livestock in facilities across the state are estimated to generate over 109 billion pounds of manure annually (Food and Water Watch, 2024). Figure 3.5 shows the number and location of AFOs in Iowa as of 2024.

Most of these facilities do not operate under National Pollutant Discharge Elimination System (NPDES) discharge permits, and the livestock in facilities across the state are estimated to generate over 109 billion pounds of manure annually (Food and Water Watch, 2024).

FIGURE 3.5 **Animal Feeding Operations (AFOs) in Iowa (2024)**



Source: Kohrt, C. & IDNR, 2024

Note: Animal units (AUs) are not usually a one-to-one representation of a single animal. Instead, AUs are a unit of measurement that is calculated by multiplying the number of individual animals by a special equivalency factor that is based on size and species and is defined in Iowa Administrative Code Chapter 65 (IAC Chapter 65, 2025). For example, each feeder cow is one AU, and each hog over 55 pounds is 0.4 AUs.

When fertilizer or manure enters waterways, the environmental consequences are severe. From 2013 through 2025, the IDNR recorded 205 instances of manure discharge into Iowa waters (IDNR, 2026). One of the largest occurred in 2013, when a spill in O'Brien County killed more than 865,000 fish along a 28-mile stretch of Mill Creek (IDNR, 2019). Similarly, in 2024, a catastrophic spill released 265,000 gallons of liquid nitrogen fertilizer into the East Nishnabotna River near Red Oak, killing more than 750,000 fish and countless aquatic organisms along a 60-mile stretch of the river extending into Missouri (Haack et al., 2015; IDNR, 2024). Incidents like these are not uncommon in Iowa and contribute to the rising nitrate levels in both surface water and groundwater.

High nitrate concentrations in waterways threaten drinking water supplies across the state. Approximately 46.5% of Iowans receive their drinking water from a public water supply that relies on surface water or groundwater heavily influenced by surface water quality (IDNR, 2025). In June 2025, the nitrate levels in the Raccoon River reached 19.39 mg/L, nearly double the federal drinking water standard of 10 mg/L NO_3-N. Removing nitrate from drinking water is expensive, often costing $16,000 or more per day for the Des Moines area (Des Moines Water Works, 2025). The Raccoon River is not an isolated case; smaller streams and rivers frequently exceed the drinking water standard throughout the year, especially after flooding or heavy rains due to agricultural runoff. To monitor these conditions, nitrate concentration data are available throughout the spring, summer, and fall at the Iowa Water Quality Information System (IWQIS) website (https://iwqis.iowawis.org/app/).

Nitrate and Cancer Risks

In addition to disrupting ecosystem balance, high nitrate concentrations also pose risks to humans. Health concerns in infants prompted the EPA to regulate nitrate-nitrogen (NO_3-N) levels in drinking water to prevent methemoglobinemia (blue baby syndrome). The maximum contaminant level (MCL) of 10 mg/L was established in 1975 solely to protect infants who were drinking formula mixed with water containing high nitrate concentrations. As nitrate is converted into nitrite in the body, the resulting nitrite binds to hemoglobin, reducing its ability to carry oxygen. This process causes a bluish discoloration of an infant's skin, difficulty breathing, and low oxygen levels. While these effects may occur at any age, methemoglobinemia is particularly life-threatening for infants, where the condition can progress rapidly to coma and death.

Since the 1970s, other adverse health issues have been identified with high nitrate concentrations in drinking water, including effects at concentrations below the 10 mg/L MCL. Nitrate exposure has been linked to many serious health risks including birth defects, reproductive health risks, thyroid issues, and several types of cancer (Schullehner et al., 2018; Ward et al., 2018; Blaisdell et al., 2019; Stayner et al., 2022; Jensen et al., 2023). Certain populations are at a higher risk of these conditions, especially children, infants, pregnant women, and residents of agricultural areas who obtain their drinking water from private wells (Zirkle et al., 2016; Jones, 2025).

In 2006, IARC completed a review of the scientific literature on ingested nitrate and nitrite from dietary and drinking water sources. Due to a lack of studies focused on specific cancer sites, the 2006 review found inadequate epidemiologic evidence to link nitrate in drinking water to cancer in humans. However, the IARC also concluded that ingested nitrate or nitrite is "probably carcinogenic to humans" under conditions that promote the formation of N-nitroso compounds (NOCs) (IARC, 2010). Since this review, many epidemiological studies have investigated the relationship between nitrate in drinking water and specific cancer sites in the body. Many of these studies suggest an association between nitrate exposure and cancer incidence, yet research on many individual tumor sites remains limited given the large number of potential cancer types (Jones et al., 2016; Jones et al., 2017; Ward et al., 2018; Levin et al., 2024).

A November 2025 literature review of studies conducted between 2016 and 2024 on the health effects of nitrate found patterns of increased risk for cancer, particularly of the urinary tract, bladder, kidney, prostate, and thyroid (Christensen et al., 2025). Especially noteworthy is that **associations with cancer for many of these studies appear at nitrate concentrations below the current EPA safe drinking water limit** of 10 mg/L NO_3-N.

Experts indicate that the following cancer sites offer the strongest evidence for an association between ingested nitrate and cancer.

Colorectal Cancer

Colorectal cancer is one of the most studied cancer types in relation to nitrate exposure from drinking water. Nearly all of the epidemiological studies (cohort and case-control) on this topic found a statistically significant association between nitrate exposure and increased risk of colon or colorectal cancer, though not necessarily rectal cancer (De Roos et al., 2003; McElroy et al., 2008; Espejo-Herrera et al., 2016; Fathmawati et al., 2017; Schullehner et al., 2018; Jones et al., 2019; Chambers et al., 2022; Erichsen et al., 2025).

Key findings from these studies include:

- De Roos et al. (2003) did not find an overall increased risk of colorectal cancer across all participants. However, among individuals with long-term exposure (10 or more years) to nitrate-nitrogen levels of 5 mg/L or greater, the risk of colon cancer more than doubled in those with low vitamin C intake, high red meat consumption, or chronic bowel inflammation, suggesting an interaction with dietary factors that inhibit or increase NOC formation.
- McElroy et al. (2008) reported a 190% increased risk for proximal colon cancer among individuals exposed to the highest nitrate-nitrogen levels (greater than or equal to 10 mg/L) compared with those with levels below 0.5 mg/L.
- Espejo-Herrera et al. (2016) found that individuals consuming drinking water with nitrate-nitrogen levels higher than 2.3 mg/L per day had a 50% greater risk of colorectal cancer compared with those ingesting concentrations less than 1.1 mg/L per day. Risk was more pronounced in subgroups with additional risk factors, and men were more affected than women.
- Fathmawati et al. (2017) observed a 200% increased risk of colorectal cancer among individuals consuming well water with nitrate concentrations above 2.5 mg/L. Among those with more than 10 years of exposure, the risk rose to more than 300%.
- In contrast, Jones et al. (2019), studying postmenopausal women using public water supplies in Iowa, did not find a statistically significant association between nitrate exposure and colon or rectal cancer.
- Schullehner et al. (2018) conducted a large-scale longitudinal cohort study involving 2.7 million people. This study found an increased risk of colorectal cancer at nitrate-nitrogen levels greater than 0.9 mg/L, well below the current regulatory standard of 10 mg/L. Importantly, the risk decreased with lower exposure levels, suggesting the nitrate dose is an important factor.
- Erichsen et al. (2025) found that higher nitrate intake from tap water was associated with a higher rate

of distal colon cancer, though not colorectal cancer overall. In addition, participants whose household water supply had nitrate-nitrogen concentrations greater than 2.1 mg/L had a 52% higher rate of colon cancer, but not rectal cancer.

Ovarian Cancer

The Iowa Women's Health Study found that postmenopausal women who consumed drinking water with average nitrate-nitrogen concentrations over 3 mg/L for more than four years had twice the risk of developing ovarian cancer compared with those with lower exposures. This elevated risk persisted through follow-up, especially among women in the highest quartile of average nitrate levels in public water supplies. Similarly, women using private wells also experienced increased risk compared with those using public water supplies with nitrate exposures below 0.5 mg/L NO_3-N (Inoue-Choi et al., 2015).

More recent research strengthens these findings. A 2025 study reported that each doubling of nitrate concentration in drinking water was associated with a 9% increase in risk of high-grade serous ovarian cancer, the most aggressive ovarian cancer subtype. The association was weaker for other ovarian cancer subtypes, suggesting a more specific link to the high-grade serous form. When nitrate was evaluated alongside other environmental contaminants, such as arsenic, uranium, and trihalomethanes, the combined exposure was associated with a 75% higher risk of high-grade serous ovarian cancer. Notably, nitrate alone contributed nearly 46% of this combined risk, even at concentrations below current regulatory limits (Spaur et al., 2025). In another 2025 study that used Agricultural Health Study data, women exposed to average nitrate levels over 3 mg/L in their drinking water had a 35% greater risk of ovarian cancer compared with those exposed to less than 0.8 mg/L NO_3-N (Ammons et al., 2025).

Bladder Cancer

Research on the relationship between nitrate in drinking water and bladder cancer has shown mixed results. Two studies that evaluated nitrate intake levels around 2 mg/day NO_3-N found no clear association (Zeegers et al., 2006; Espejo-Herrera et al., 2015), though these exposures were relatively low.

In contrast, a 2016 study by Jones et al. found that postmenopausal women exposed to nitrate-nitrogen levels above 3 mg/L had an elevated risk of bladder cancer after adjusting for age and smoking. The risk of developing bladder cancer increased 60% when evaluating women exposed to average nitrate concentrations of 5 mg/L in their drinking water for four or more years. In addition, the study found no association between cancer and nitrate from dietary plant sources (Jones et al., 2016).

A 2020 study also observed a significant association between nitrate consumption and bladder cancer. Individuals who drank water with average nitrate levels above 2 mg/L NO_3-N experienced a 50% increased risk of bladder cancer compared with those whose drinking water contained nitrate below 0.2 mg/L (Barry et al., 2020). These findings suggest that higher and prolonged exposure to nitrate in drinking water may increase bladder cancer risk.

Kidney (Renal Pelvis) Cancer

In a 2017 analysis of the Iowa Women's Health Study, researchers found that nitrate-nitrogen concentrations exceeding 5 mg/L in public water supplies were associated with a higher risk of kidney (renal) cancer (Jones et al., 2017). While this research did not find significant interactions with smoking or vitamin C intake, an earlier case-control study in Iowa suggested that risk may be elevated among individuals with high red meat consumption or low vitamin C intake. Specifically, Iowans exposed to average nitrate levels over 5 mg/L for more than 10 years had a 90% higher risk of kidney cancer under these dietary conditions (Ward et al., 2007).

Other Cancer Sites

Although fewer studies exist for other cancers, some have identified associations between specific cancer types and nitrate exposure, often below the current U.S. drinking water standard of 10 mg/L NO_3-N (Levin et al., 2024).

- Among women in Iowa using public water supplies with nitrate levels above 5 mg/L for five years or more, the risk of thyroid cancer was 2.6 times higher compared with women whose supplies never exceeded 5 mg/L NO_3-N (Ward et al., 2018).
- A 2023 study reported that long-term nitrate exposure above 3 mg/L NO_3-N could increase the risk of prostate cancer, particularly aggressive forms of the disease. Stronger associations were reported for younger men and those with lower dietary fiber, vitamin C, and fruit and vegetable intake (Donat-Vargas et al., 2023).
- Several studies have found potential links between nitrate exposure and brain and central nervous system cancer in children (Weng et al., 2011; Stayner et al., 2021; Christensen et al., 2025).
- There is mixed evidence regarding breast cancer with an increased risk specifically among postmenopausal women exposed to the highest nitrate concentrations who also consume more red meat or have higher folate intake (Yang et al., 2010; Inoue-Choi et al., 2012; Espejo-Herrera et al., 2016; Christensen et al., 2025).
- Research on nitrate in drinking water and stomach (gastric) cancer remains mixed. A 2022 literature review identified a positive cancer association reported for each 2.3 mg/L increase in nitrate-nitrogen concentration (Picetti et al., 2022). However, a 2025 literature review did not find enhanced risk for stomach cancer with a higher intake of nitrate from drinking water sources (Christensen et al., 2025).
- Studies investigating nitrate and cancers of the esophagus, small intestine, endometrium, pancreas, and lungs have generally found no significant associations (Ward et al., 2008; Coss et al., 2011; Quist et al., 2017; Medgyesi et al., 2022; Christensen et al., 2025).

Nitrate Complications, Mitigating Factors, and Amplifiers

The interaction between nitrate from drinking water and various dietary and lifestyle factors is complex and not yet fully understood. While further research is needed to clarify these biochemical pathways, existing studies indicate that certain conditions can increase the formation of carcinogenic compounds in the human body. As noted, elevated nitrate levels in drinking water appear to pose a greater cancer risk when combined with other known risk factors, such as smoking and diets high in processed or red meats (Espejo-Herrara et al., 2016; Barry et al., 2020; Bondonno et al., 2024; Christensen et al., 2025; Erichsen et al., 2025).

Conversely, some dietary components may inhibit the formation of harmful compounds. Nutrients and compounds such as vitamin C, vitamin E, dietary fiber, flavonoids, and tea polyphenols have been associated with a reduced risk of cancer potentially linked to nitrate exposure (IARC, 2010; Donat-Vargas et al., 2023; Bondonno et al., 2024; Erichsen et al., 2025). These findings provide further support for the protective role of diets rich in fruits and vegetables.

The health effects of nitrate exposure may also be heightened for certain population subgroups when nitrate interacts with other chemicals ingested through drinking water. Rather than acting in isolation, nitrate can combine with co-occurring contaminants to amplify health risks. For example, a study by Rhoades et al. (2013) in Nebraska found that people exposed to high nitrate in their drinking water were three times as likely to develop non-Hodgkin lymphoma when the pesticide atrazine was also present. These findings suggest that cumulative and interactive exposures may place some populations at greater risk than would be predicted by nitrate levels alone. This underscores the importance

A study in Nebraska found that people exposed to high nitrate in their drinking water were three times as likely to develop non-Hodgkin lymphoma when the pesticide atrazine was also present (Rhoades et al., 2013). These findings suggest that cumulative and interactive exposures may place some populations at greater risk than would be predicted by nitrate levels alone.

of considering chemical mixtures in drinking water when evaluating public health impacts, particularly for populations relying on water sources affected by agriculture activities.

Of additional concern, recent environmental chemistry research from the University of Nebraska–Lincoln has shown that when groundwater containing high levels of nitrate interacts with uranium (a radioactive heavy metal), the nitrate ion can mobilize the heavy metal (Westrop et al., 2023). This movement from the soil into groundwater increases the likelihood that uranium reaches drinking water supply wells along with nitrate, compounding risks to human health (see Section 5 for additional information on the association between exposure to heavy metals and cancer).

Nitrate exposure levels are a key variable in determining cancer risk. It is more difficult to assess nitrate-related cancer risk in rural locations that rely on private wells because they are unregulated and often unmonitored. Notably, many studies have reported associations between nitrate and cancer at concentrations below the current MCL of 10 mg/L, which shows that long-term exposure to increased average concentrations leads to higher risk. This raises concern that the existing regulatory limit may not be sufficiently protective against long-term health risks.

Given the research to date, "[i]t is important not to overinterpret epidemiological findings, but it is equally important not to dismiss them when there is a plausible biological mechanism," as in the case of nitrate exposure and cancer risk (Chambers et al., 2022).

While no single study provides definitive proof that nitrate in drinking water causes cancer, the consistency of associations across study designs, populations, and cancer types — especially at levels below current regulatory limits — suggests that nitrate likely contributes as an environmental risk factor.

Table 3.1 summarizes the specific associations of nitrates with cancer sites and the trends in those cancers in Iowa. Information about associations is drawn from the literature discussed in this report. Strength of association varies by cancer site and study.

TABLE 3.1 **Nitrate-Associated Cancer Sites and Trends in Iowa**

ASSOCIATED CANCER SITES	IOWA TRENDS IN APPLICABLE CANCER SITES
Colorectal (De Roos et al., 2003; McElroy et al., 2008 Espejo-Herrera et al., 2016; Fathmawatiet al., 2017; Schullehner et al., 2018; Jones et al., 2019; Chambers et al., 2022; Erichsen, 2025)	**Colorectal:** Incidence is rising in younger Iowans. From 1992 – 2021, incidence rose an average of 2.8% per year in Iowans under 50. This is the second-highest rate of increase for cancer sites in this group. Since 2010, incidence has also increased by 1.3% per year in Iowans under age 65. Incidence has been declining by 3.5% per year for Iowans over age 65 since 1998 with the trend in Iowa overall declining despite increasing incidence in younger people. Iowa's colorectal cancer rate exceeds the national average and has the 4th-highest incidence rate of cancers in Iowa.
Ovarian (Inoue-Choi et al., 2015; Ammons et al., 2025; Spaur et al., 2025)	**Ovarian:** Ovarian cancer incidence declined an average of 2% per year in Iowa women under 50 from 1992 – 2021. For the total female population of Iowa, ovarian cancer incidence increased by 0.3% per year on average from 1992 – 2000 before declining by 2.3% per year on average through 2021. Iowa saw 600 cases of ovarian cancer in 2022. Iowa's ovarian cancer rate is about the same as the national average.
Bladder (Jones et al., 2016; Barry et al., 2020)	**Bladder:** 879 Iowans were diagnosed with bladder cancer in 2022. Incidence rates in the total Iowa population increased by 1.3% per year on average from 1992 – 2004. Between 2004 and 2021, incidence has been relatively flat. Iowa's bladder cancer rate exceeds the national average.
Kidney and Renal Pelvis (Ward et al., 2007; Jones et al., 2017)	**Kidney and Renal Pelvis:** Fastest-rising cancer in Iowans under 50, growing an average of 3.7% per year in this age group. For the full population of Iowa, this cancer increased by 5.6% per year until 2005 then slowed to 1.5% per year. The reduction in growth rate was primarily seen in men. The growth rate for women of all ages in Iowa continued to be around 2.2% per year after 2005. Iowa's incidence rate for kidney and renal pelvis cancer exceeds the national average.
Stomach (Picetti et al., 2022)	**Stomach:** Relatively rare in Iowa, with an incidence rate of 5.9 per 100,000 people for the total population but is by far the fastest-rising cancer site in the full population, with incidence increasing on average 6.1% per year from 2018 – 2021 after steady to declining trends from 1992 – 2018. Iowa's stomach cancer rate was still lower than the national average in the most recent year.
Thyroid (Ward et al., 2018)	**Thyroid:** Increased on average 4.5% per year from 1992 – 2014 before stabilizing in 2014, among Iowans under 50. The trend was similar for the total population in Iowa with incidence rising 5.4% per year up until 2009 when rates stabilized. Iowa's thyroid cancer incidence rate is higher than the national average.
Prostate (Donat-Vargas et al., 2023)	**Prostate:** Second-highest incident rate for cancers in Iowa in 2022 (134.2 per 100,000) and rate of increase (3.6% per year from 1992 – 2021) among total population in Iowa; first in number of cases in 2022 (2,898 cases). Iowa's prostate cancer rate exceeds the national average.
Childhood Brain (Weng et al., 2011; Stayner et al., 2021; Christensen et al., 2025)	**Childhood Brain:** Iowa had the 11th-highest incidence rate of childhood brain and nervous system cancer in the U.S. over the most recent 5-year period available (2016 – 2020) at 3.7 cases per 100,000 people.
Breast (Inoue-Choi et al., 2012)	**Breast:** Breast cancer is the site with the highest incidence rate in Iowa. Breast cancer trends for all women in Iowa reversed course sharply in 2012 from flat/declining to increasing by almost 2% per year. Breast cancer has been growing by 1.7% per year in women under 50 since 2012 — the 4th-highest rate of increase of any cancer site for people under 50 in Iowa. Iowa's breast cancer rate exceeds the national average.

Source: National Cancer Institute, 2025; U.S. Cancer Statistics Working Group, 2025; CDC Wonder database, 2025

SECTION 4 **Environment Risk Factors Analysis:**

Radon

Radon, a colorless, tasteless, and odorless gas, is formed during the decay of radium, a naturally occurring radioactive metal found at high levels in the soil across Iowa. The high levels of radon in the ground result from historical glacial activity that carried rock containing uranium to Iowa's landscape (Environmental Health Sciences Research Center, 2024). Radon itself becomes an inert gas relatively quickly, but the products of its decay, including radioisotopes of polonium, lead, and bismuth, are believed to pose the greatest risk to human health (Kendall & Smith, 2002). Studies demonstrate that over 50% of the average individual's radiation dose comes from exposure to two radon decay products, polonium-218 and polonium-214, accounting for the majority of radiation exposure to the lungs (Buchner & Field, 2008).

Radon Exposure Pathways

Radon gas enters buildings mainly by seeping in through cracks in floors, ceilings, walls, construction joints, floor drains, sump pump systems, ventilation ducts, and other openings, such as moderately porous concrete (Das, 2021). Inhalation is the primary exposure pathway for radon. According to the Iowa Radon Lung Cancer Study, residential radon gas concentrations are highest in the basements of homes, followed by first floors and second floors, respectively. The same study tested more than 1,027 homes in Iowa and found that approximately 60% of the basement radon concentrations and 30% of the first-floor radon concentrations exceeded the Environmental Protection Agency's (EPA) action level of 4 picocuries per liter (pCi/L) of air, with homes in western Iowa having uniformly higher indoor and outdoor radon concentrations than eastern Iowa. The highest first-floor radon concentrations were found in western and central Iowa (Field et al., 2000).

In addition to inhalation, radon's radioactive decay products attach to aerosol particles in the air that can then deposit on skin, irradiating the skin's outer layer. Skin receives the second-highest dose of radiation after the respiratory tract (Vienneau et al., 2017). This exposure pathway has driven inquiries into the role of radon in causing skin cancers, such as melanoma, which are increasing in Iowa at rates much higher than the national average (Iowa Cancer Registry, 2025).

Another potential exposure pathway for radon is through normal water use, including taking showers, running faucets, and cooking. This occurs when dissolved radon in groundwater is released into the ambient air through the use and consumption of water. An estimated 95% of radon exposure is from indoor air, and only about 1% is from drinking water sources (Das, 2021). There is no maximum contaminant level (MCL) established for radon in drinking water supplies despite a 1999 proposed rule from the EPA to set the standard at 300 pCi/L of water for most public water systems with some exceptions for smaller systems. That draft rule cited concerns about internal organ cancers, primarily stomach cancer (EPA, 1999).

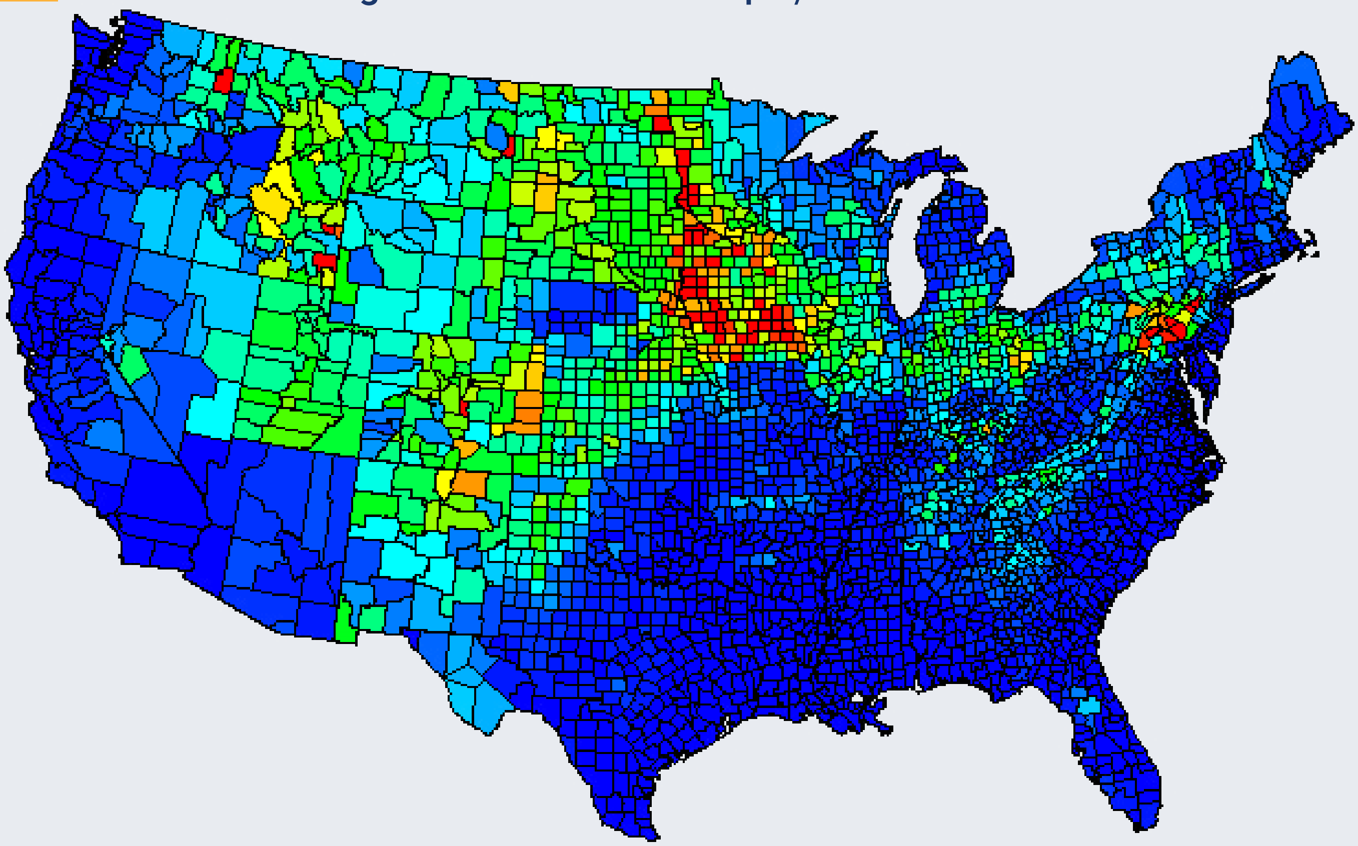
Occupational Exposures to Radon

Working underground is the most common occupational risk that may increase radon exposure. Much of the literature regarding radon exposure and human health outcomes is derived from studying the health outcomes of miners, whose jobs require long periods of time in caves, mines, and other underground areas with higher radon levels. Other occupation locations, such as indoor parking areas, construction excavators, power plants, water treatment plants, fish hatcheries, and those located in basements and on ground floors, can increase exposure to radon and result in negative health outcomes (Field, 1999; Ruano-Ravina et al., 2023). Other occupations in Iowa that may prolong a worker's time in a high-radon area, such as basements, could also lead to enhanced exposures, including plumbers, HVAC professionals, electricians, and carpenters.

Radon in Iowa

The EPA's action level, or the point at which the agency considers radon levels to be elevated, is 4 pCi/L. The EPA also recommends that Americans consider remediating their home if radon levels are between 2 pCi/L and 4 pCi/L (EPA et al., 2025). However, it is important to note that there is no safe level of radon exposure for humans because radon-related DNA damage can happen at any level of exposure (World Health Organization [WHO], 2009). Most radon-induced lung cancers occur at exposures below the EPA's action level (Buchner & Field, 2008). The WHO recommends keeping indoor radon concentrations under 2.7 pCi/L (WHO, 2009). Iowa has among the highest risk levels for radon exposure of any state. Figure 4.1 shows where radon has been present at the EPA's action level of 4 pCi/L (Price et al., 2000). The EPA estimates that the national average indoor radon exposure level is 1.3 pCi/L and the national average outdoor radon exposure level is 0.4 pCi/L (EPA et al., 2025).

FIGURE 4.1 Predicted Percentage of U.S. Homes Over 4 pCi/L



Source: Price et al., 2000

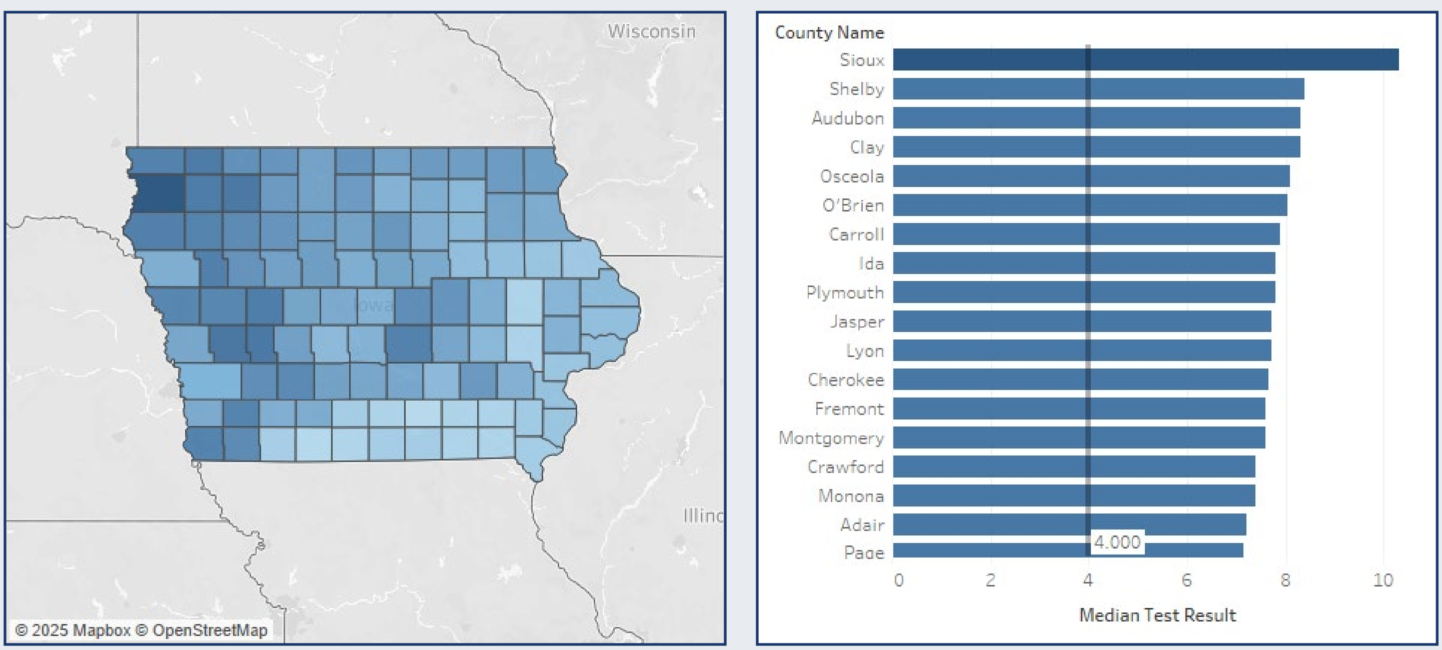
A summary of research by Buchner and Field (2008) found more than half of homes in Iowa can exceed the EPA's radon action level in some indoor spaces. The study estimated that reducing radon concentrations in homes nationwide to 4 pCi/L would reduce radon-related cancers by one-third. In addition, the study found that further reducing concentrations to 2 pCi/L would reduce the number of radon-attributable lung cancer deaths by 50%. The EPA says that radon mitigation systems can reduce radon levels in homes by up to 99% (EPA & Bagnoli, 2016).

The Iowa Department of Health and Human Services is building a comprehensive dataset of radon test results both pre- and post-mitigation. This process has produced a preliminary database referred to as the Radon Dashboard (https://data.idph.state.ia.us/t/IDPH-DataViz/views/RadonDashboard/RadonZipCodeMetrics). This archive collects results from radon tests conducted between 2000 and 2024 by partner organizations and county public health departments. The dashboard makes the results available at the zip code and county levels and includes county-level average results for pre- and post-mitigation tests by building type (commercial and government buildings, daycare and childcare facilities, educational facilities, multifamily residences, and single-family residences).

The statewide average across all counties was 8 pCi/L, which only includes pre-mitigation results from basements, crawlspaces, and subbasements, as shown in Figure 4.2. When first-floor test results are included, the average level across counties drops to 4.68 pCi/L, suggesting lower concentrations at higher floors in a building (Iowa Department of Health and Human Services, 2025).

FIGURE 4.2 **County-Level Average Pre-mitigation Radon Test Results (average results displayed in pCi/L excluding first-floor and higher test results)**

County Results **County Level Average Results**



Source: Iowa Department of Health and Human Services, 2025. Radon Dashboard. Radon Dashboard County Level Metrics

Notably, these long-term averages obscure the risks in homes with significantly higher radon levels. For example, recent data from Palo Alto County shared with the Iowa Environmental Council by public health professionals, demonstrate that several homes tested in 2025 have radon levels as high as 42 pCi/L and an average of 11.44 pCi/L, which is nearly three times the EPA's action level. Palo Alto County has Iowa's highest rates of lung cancer with a rate of 87.26 new cases per 100,000 people between 2017 and 2021 — more than double the national average observed rate of 41.98 new cases per 100,000 people in the same timeframe (Iowa Cancer Registry, 2025; National Cancer Institute, 2025).

Radon and Cancer Risk

"The diversity and consistency of the information indicates that the weight of evidence for radon carcinogenicity is overwhelming," (Buchner & Lubin, 2008). Radon is identified as carcinogenic to humans by the International Agency for Research on Cancer (IARC) and is the second-leading cause of lung cancer in the United States behind smoking, including in Iowa (Oakland & Meliker, 2018). Radon exposure is estimated to kill more people per year than drunk driving, totaling approximately 21,000 deaths per year in the United States (EPA et al., 2025). The EPA suggests that 2,900 of those deaths occur among people who have never smoked (EPA, 2003). According to the Iowa Cancer Consortium (2025), radon is responsible for the deaths of approximately 400 Iowans every year.

Research is clear about the causal association between radon and lung cancer (IARC, 1988; Wang et al., 2002; Darby et al., 2005; Krewski et al., 2005; Darby et al., 2006; Krewski et al., 2006). Associations have also been identified between radon and melanoma (skin cancer) and stomach cancer (EPA, 1999; Vienneau et al., 2017; Das, 2021).

Lung Cancer

Lung cancer is the third most common cancer diagnosed among Iowans, and it is deadly, making up the majority of cancer deaths in the state. In fact, only about 15% of individuals who receive a lung cancer diagnosis live five years beyond their diagnosis (Iowa Cancer Registry, 2025). Iowa stands out among states with similar demographics and behavioral risk profiles with higher age-adjusted lung cancer incidence and late-stage incidence. Iowa consistently had the highest or among the highest lung cancer mortality rate among similar states between 2011 and 2023 (University of Iowa College of Public Health, 2026).

Radon is second only to smoking as a leading cause of lung cancer in the United States (Lantz et al., 2013). It is also the leading cause for people who never smoked (Buchner & Field, 2008). The WHO estimates that radon may be responsible for 3% to 14% of lung cancer cases worldwide (WHO, 2023). There is also a minimum latency period of about five years in the development of cancers caused by radiation exposure (National Research Council, 1988). A study by Lantz et al. (2013) found that lung cancer risk increases as higher radon concentrations are present during exposure.

Other studies have shown that every additional 2.7 pCi/L of radon exposure raises the risk of developing lung cancer by an additional 10% (Lagarde et al., 2001). Pooled North American, European, and Chinese residential radon studies all have reported statistically significant increases (ranging from 8% to 18% depending on the method of analyses) in lung cancer risk at 2.7 pCi/L (Buchner & Field 2008). An Iowa-based study found that 15 years of exposure to radon at 4 pCi/L was associated with a 24% to 83% increase in the odds of developing lung cancer (National Research Council, 1988; Field et al., 2000).

Melanoma and Other Cancers

Multiple studies have sought to confirm radon's role in causing other cancers, including blood, brain, skin, and thyroid. A study in Switzerland found a statistically significant increased risk of death from malignant melanoma and skin cancer in adults with exposure to radon (Vienneau et al., 2017). Another Swiss study found an association between radon exposure and melanoma only for the youngest age cohort (20-29 years old) and mainly among women of lower socioeconomic status (Boz et al., 2024).

Other studies have shown that radon is strongly associated with the risk of some cancers in the blood, skin, stomach, and brain. In addition, radon may also contribute to other cancers, including in the lip and oral cavity, as well as pharynx and laryngeal cancers, but the scientific consensus on these findings is much less pronounced than with lung cancer (Das, 2021).

As noted above, the EPA has cited a strong association with stomach cancer as a reason to propose a rule to establish an MCL of 300 pCi/L for radon in drinking water and estimated 168 annual deaths caused by the ingestion of radon-contaminated drinking water (EPA, 1999). However, it is thought the risk of developing radon-induced cancers from ingesting contaminated drinking water is significantly smaller than the risks proposed by inhalation (Das, 2021). For example, the Risk Assessment of Radon in Drinking Water suggests that 11% of the 168 cancer deaths per year associated with ingesting radon-contaminated drinking water are from radon-induced stomach cancer (National Research Council, 1999). Some robust studies have failed to find a connection between thyroid cancers and radon but call for more research (Oakland & Meliker, 2018). Studies on bone and joint cancers and their relationship with radon have also failed to demonstrate a statistically significant association (Nilles et al., 2023).

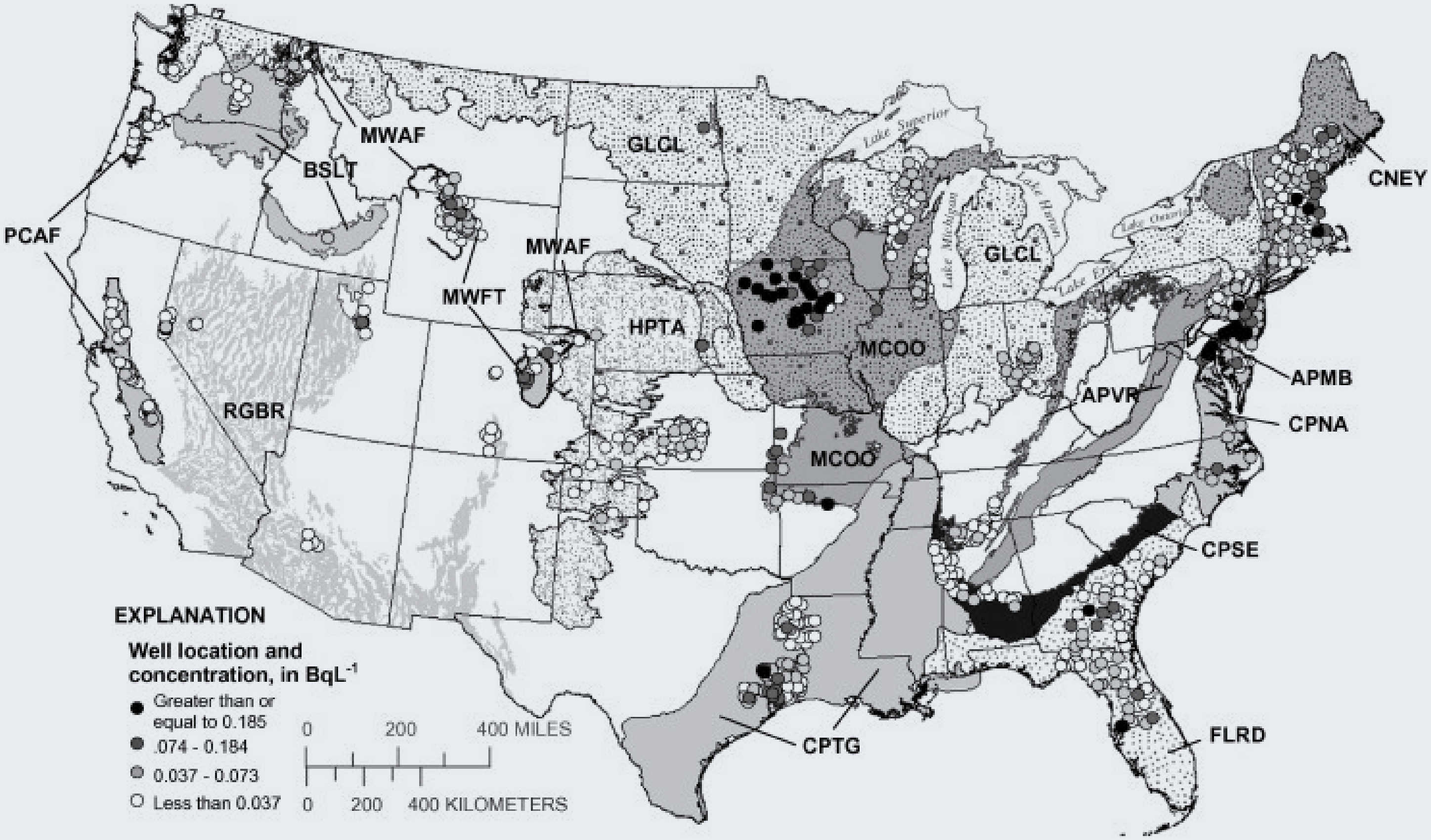
Radium in Water

Radon is produced through the decay of radium, a naturally occurring radioactive element in soil and rock. Peer-reviewed literature regarding radium demonstrates that exposure to high levels of the element results in an increased incidence of bone, liver, and breast cancer. Additionally, the EPA and the National Academy of Sciences have each stated that radium is a known human carcinogen (Agency for Toxic Substances and Disease Registry, 2025).

Radium is present in Iowa, especially in groundwater, and the EPA has set the MCL for radionuclides, including radium, at 5 pCi/L noting that "the primary benefits are reductions in cancer risks; other beneficial health effects (particularly reductions in kidney damage from exposure to uranium) are also possible" (EPA & Industrial Economics, Inc., 2000). A recent study found that the presence and consumption by microbes of nitrates in groundwater can also lead to increased transport of uranium, radium's radioactive parent element, in groundwater supplies (Westrop et al., 2023).

The Iowa Department of Natural Resources' (IDNR) Drinking Water Portal tracks Safe Drinking Water Act violations at public water systems in Iowa. This portal shows 18 violations of the radium MCL between January 1, 2020, and October 1, 2025. These violations were present in rural public water systems as well as urban systems (IDNR, 2025). Samples taken by the IDNR from a survey of municipal drinking water wells in 2018 showed 17% contained radium-226 above the combined radionuclide standard of 5 pCi/L (IDNR, 2018). Shown in Figure 4.3, a 2012 analysis found that the concentrations of radium (including both radium-226 and radium-228) in well water samples greater than or equal to the EPA MCL of 5 pCi/L were commonly found in Iowa (Szabo et al., 2012).

FIGURE 4.3 **Combined Radium Concentrations in Groundwater Samples in the U.S. (1987 - 2005)**



Source: Szabo et al., 2012

Note: This map displays radium concentrations in Becquerels per Liter (Bq/L). The EPA's combined radium limit in drinking water of 5 pCi/L is equivalent to 0.185 Bq/L.

Radon Complications, Mitigating Factors, and Amplifiers

The risk of developing lung cancer from radon for individuals varies based on length of exposure, the concentration of radon levels during exposure, and whether the person was ever a smoker. There is clear evidence of a relationship between smoking, radon exposure, and lung cancer incidence and mortality (Buchner & Field, 2008). The amplifying effect raises the risk of death by lung cancer in smokers exposed to radon beyond 5.4 pCi/L by 20 to 25 times when compared with never smokers exposed to the same level of radon (Riudavets et al., 2022).

More than 85% of radon-induced lung cancer deaths are among smokers (Lantz et al., 2013). Radon and tobacco smoke also act as co-carcinogens in the early phases of cancer development (Riudavets et al., 2022). At 4 pCi/L, the lifetime risk of radon-induced lung cancer death for people who have never smoked is seven per 1,000 people, compared with 62 per 1,000 people who have ever smoked — usually defined as those who have smoked more than 100 cigarettes in a lifetime. As radon levels increase to 10 pCi/L, these risks grow to 18 per 1,000 people for those who have never smoked and 150 per 1,000 people for people who have ever smoked (EPA, 2003).

Iowans have some of the nation's highest rates of prolonged exposure to radon and have a slightly higher than average smoking rate when compared to the national average. Smoking rates in Iowa in 2023 were 13.7% when the national average was 11.4% (American Lung Association, 2025). This relationship plays a key role in the risk of developing radon-induced lung cancer. Analyzing specific locations in Iowa that have higher rates of both smoking and radon may help researchers understand elevated lung cancer rates and could guide further cancer research. Table 4.1 summarizes the specific associations of radon with cancer sites as covered in this report and the trends in those cancers in Iowa. Information about associations is drawn from the literature discussed in this report. Strength of association varies by cancer site and study.

At 4 pCi/L, the lifetime risk of radon-induced lung cancer death for people who have never smoked is 7/1,000 people, compared with 62/1,000 people who have ever smoked (EPA, 2003).

TABLE 4.1 Radon-Associated Cancer Sites and Trends in Iowa

Associated Cancer Sites	Iowa Trends in Applicable Cancer Sites
Lung (EPA, 2003; Buchner & Field, 2008; Lantz et al., 2013; World Health Organization, 2023)	**Lung:** Since 2007, incidence has been falling by 4.2% per year in people under 50. Incidence is still rising at an average of 1% per year in the Iowa population. Iowa's lung cancer rate exceeds the national average. Iowa ranks 18th nationally in rate of lung cancer mortality.
Melanoma (Vienneau et al., 2017; Boz et al., 2024)	**Melanoma:** Ranks third in cancer sites for rate of increase for Iowans under age 50 (2.3% increase per year since 1992) and for all age groups (3.4% increase per year since 1992). In 2022, melanoma was third in incidence rate among cancer sites and in number of cases. Iowa's melanoma rate exceeds the national average.
Stomach (EPA, 1999; Das, 2021)	**Stomach:** Relatively rare in Iowa, with an incidence rate of 5.9 per 100,000 people for the total population but is by far the fastest-rising cancer site in the full population, with incidence increasing on average 6.1% per year from 2018 – 2021 after steady to declining trends from 1992 – 2018. Iowa's stomach cancer rate was still lower than the national average in the most recent year.

Source: Iowa Environmental Council, with data from National Cancer Institute, 2025; U.S. Cancer Statistics Working Group, 2025

SECTION 5 Additional Environmental Risk Factors

While pesticides, PFAS, nitrate, and radon are addressed in detail elsewhere in this report, Iowans have raised concerns about other environmental contaminants that may also contribute to their cancer risk. At the cancer and environment listening sessions held by IEC, The Harkin Institute, and IFU in the summer of 2025, participants consistently pointed to pollution from industrial activities, waste sites, and air emissions as sources of potential exposure. This section provides an overview of additional carcinogenic contaminants present in Iowa's environment that could contribute to Iowa's high and rising cancer rates. Although not exhaustive, it highlights several categories of contaminants with established or emerging links to cancer and is intended to support a more complete understanding of environmental cancer risk factors in Iowa.

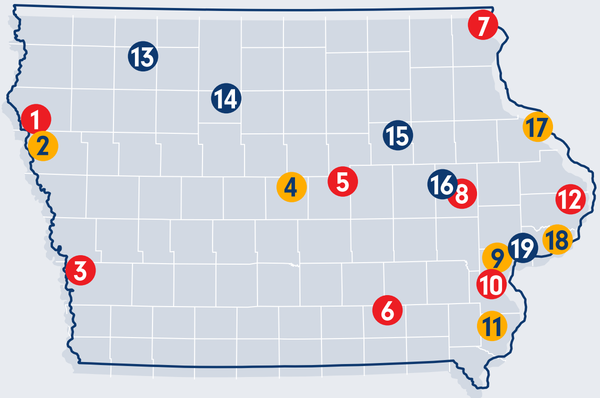
Heavy Metals and Radioactive Substances

Heavy metals are a class of persistent environmental pollutants that include elements like arsenic, cadmium, chromium, lead, mercury, and uranium, which can accumulate in ecosystems, animal tissue, and the human body. They originate from both natural sources and human activities, including mining, burning of fossil fuels, and industrial processes. Heavy metals are harmful to human health when not properly disposed of and managed, and many are categorized as carcinogenic to humans by the International Agency for Research on Cancer (IARC, 2012).

One notable source of heavy metals is coal ash, a waste byproduct of coal-fired power plants. Coal ash contains many heavy metals and radioactive substances and is a pathway for environmental exposure. The Environmental Protection Agency's (EPA) risk assessment highlights that peak pollution risk from coal ash disposal sites often occurs decades or even a century after the waste is initially placed (Schaeffer et al., 2009). Residents living close to unlined or poorly managed ash ponds and landfills risk inhaling dust and wind-blown ash and consuming contaminated drinking water. Nationwide monitoring data showed that 91% of U.S. coal-fired plants have ash landfills or ponds that are leaking these contaminants (Russ et al., 2022). In Iowa, 12 coal plants reported data from monitoring of nearby wells in 2024, and nine of those exceeded federal health standards. In total, Iowa has 69 coal ash landfill sites, many of which are unregulated. Figure 5.1 shows the location, regulatory status, and operators of the 19 coal plant sites in Iowa where these coal ash landfills are located (Iowa Department of Natural Resources [IDNR], 2025a).

The contaminated water that accumulates in these landfills from precipitation filtering through the stored waste is known as leachate. Leachate is contaminated with high levels of heavy metals and is typically collected by subsurface drains before being sent to municipal wastewater treatment facilities. In some cases, leachate is discharged directly into nearby rivers and other surface waters (Rashidi, 2025). Heavy metals can be reduced or removed through drinking water treatment processes, although the efficiency varies by method and type of contaminant (Amjad et al., 2020). However, wastewater treatment facilities may still struggle to fully remove heavy metals and other micropollutants due to their complex chemical properties or concentration, often requiring advanced treatment processes for removal. Thus, wastewater treatment plants are a significant pathway for these persistent contaminants. Pollutants that are not captured during the treatment process may be discharged into nearby water bodies or remain in biosolids applied to surrounding land. As a result, heavy metals and other pollutants are returned to the environment (Matesun et al., 2024). In addition, high levels of contaminants from industrial operations or natural sources may go undetected in systems without frequent, regular monitoring, like private well systems.

FIGURE 5.1 **Locations of Coal Power Plants in Iowa with Coal Ash Landfills**



Regulated under 2015 CCR Rule

Regulated under 2015 CCR Rule and may be regulated under 2024 Legacy CCR Rule

May be regulated under 2024 CCR Rule

Source: Rashidi, 2025

Note: This map contains the locations of active and inactive coal power plants in Iowa. The 69 coal ash landfill sites are associated with these 19 coal plants; some facilities are associated with multiple coal ash disposal sites.

1. **George Neal North (Woodbury County)** MidAmerican Energy Co.
2. **George Neal South (Woodbury County)** MidAmerican Energy Co.
3. **Walter Scott Jr. (Pottawattamie County)** MidAmerican Energy Co.
4. **Ames (Story County)** City of Ames
5. **Sutherland (Marshall County)** Interstate Power & Light
6. **Ottumwa (Wapello County)** Interstate Power and Light
7. **Lansing (Allamakee County)** Interstate Power and Light
8. **Prairie Creek (Linn County)** Interstate Power and Light
9. **Muscatine (Muscatine County)** Muscatine Power and Water
10. **Louisa (Louisa County)** MidAmerican Energy Co.
11. **Burlington (Des Moines County)** Interstate Power and Light
12. **M.L. Kapp (Clinton County)** Interstate Power and Light
13. **Earl F. Wisdom (Clay County)** Corn Belt Power Co-op
14. **Humboldt (Humboldt County)** Corn Belt Power Co-op
15. **Streeter Station (Black Hawk County)** Cedar Falls Utilities
16. **Sixth Street Station (Linn County)** Interstate Power and Light
17. **Dubuque (Dubuque County)** Interstate Power and Light
18. **Riverside (Scott County)** MidAmerican Energy Co.
19. **Fair Station (Muscatine County)** Central Iowa Power Co-op

Particulate Matter (PM2.5 and Ultrafine Particles)

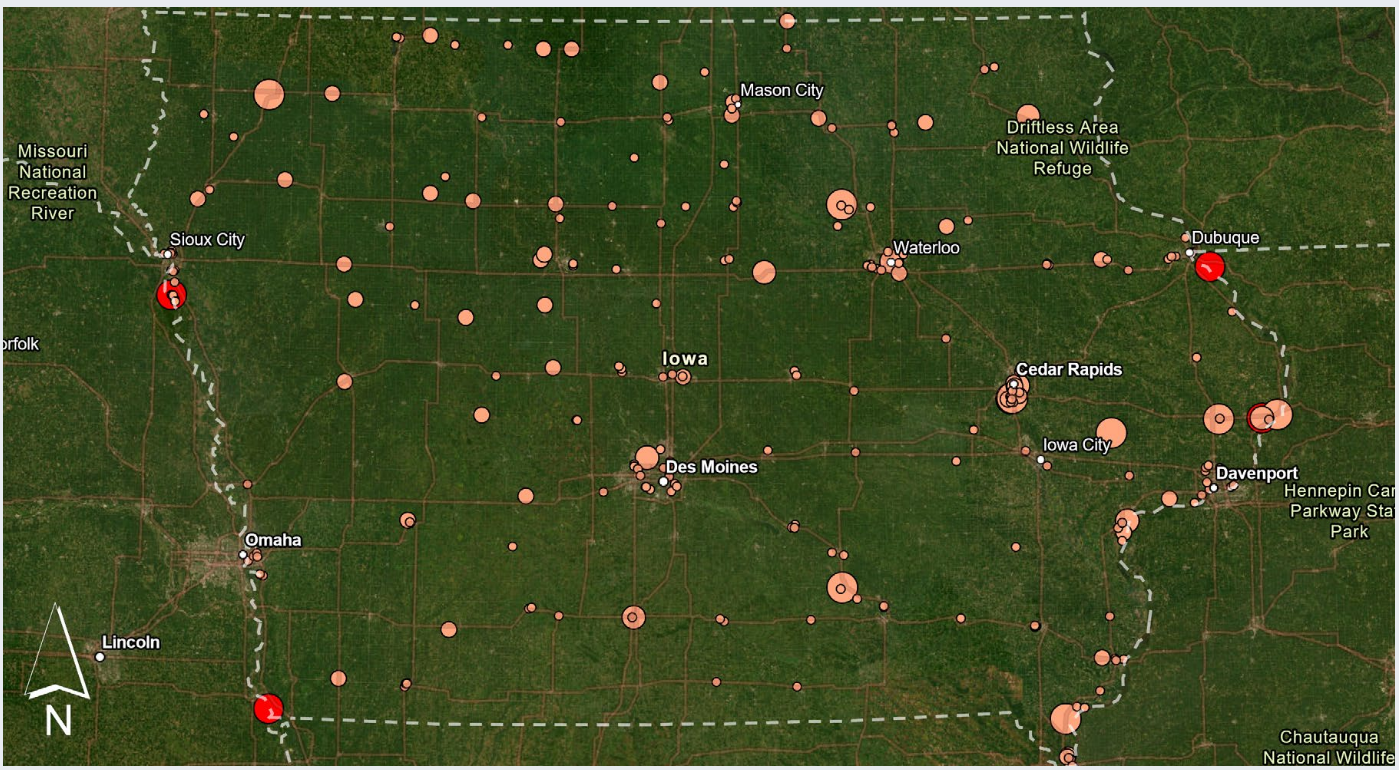
Particulate matter (PM2.5) is a major component of outdoor air pollution and refers to fine particles in the air with a diameter of 2.5 micrometers or smaller. The IARC has classified PM2.5 as carcinogenic to humans (IARC, 2016). Typical forms of PM2.5 in Iowa include airborne dust, soot, smoke, and liquid droplets. The particles can attach to a variety of harmful substances, which can enter airways, lungs, and ultimately the bloodstream of people when they breathe polluted air (Wang et al., 2025). Ultrafine PM (UFP) refers to particles that are generally less than 0.1 micrometer in diameter. Research about UFPs and their association with cancer is still emerging (Chang et al., 2022; Jones et al., 2024).

In Iowa, well-known outdoor sources of both PM2.5 and ultrafine PM can include vehicle exhaust, industrial processes, power plants, construction sites, unpaved roads, and wildfire smoke (EPA, 2025a). An analysis of the health impacts of PM2.5 exposure between 2002 and 2019 found that while PM2.5 emissions related to nitrogen oxides (NO_x), sulfur oxides (SO_x), and volatile organic compounds (VOCs) declined significantly during this time frame, agricultural emissions rose from the second-smallest to the largest contributor of PM2.5. This was attributed mainly to a 20% increase in ammonia (NH_3) emissions (Bekbulat et al., 2025). CAFOs release ammonia in large quantities during the manure management process, including through the volatilization of nitrogen in animal manure stored in lagoons, airborne dust, and other pollutants that impact air quality (Burkholder et al., 2006). More information about areas of high PM2.5 concentrations in Iowa can be found on the EPA's Air Quality Data webpage at https://www.epa.gov/outdoor-air-quality-data.

Other Industrial Air Toxics

Research has shown an unequal burden of carcinogenic industrial air emissions among sociodemographic groups (Madrigal et al., 2024; Smith, 2024). The EPA's Toxic Release Inventory (TRI) provides information to the public when there is a release of a toxic substance, including carcinogens, from an industrial facility into the air, water, or soil. Iowa has four facilities that rank in the top 100 nationally for total pounds of on-site and off-site releases of toxins: CF Industries' ethanol facility in Sergeant Bluff (61st nationally), Equistar Chemicals' liquid petroleum facility in Clinton (73rd nationally), Archer Daniels Midland's corn processing plant in Clinton (80th nationally), and ADM's plant in Cedar Rapids (98th nationally) when looking at all chemicals in the electric power, chemicals, and petroleum industries (EPA, 2025e). Two facilities just across the river from Iowa also rank in the top 100: Omaha Public Power District's power facility in Nebraska City near Council Bluffs and the East Dubuque Nitrogen Facility in East Dubuque, Illinois. At a statewide level, Iowa facilities released a total of approximately 2 million pounds of chemicals classified by the Occupational Safety and Health Administration (OSHA) as carcinogens in 2024 (EPA, 2025d). Figure 5.2 aggregates these two datasets from the TRI and shows total releases in pounds in Iowa. The EPA's TRI can be accessed at: https://www.epa.gov/toxics-release-inventory-tri-program.

FIGURE 5.2 **Statewide Toxic Releases in Pounds**



EPA TRI OSHA Releases All Iowa
Total On- and Off-site Disposal or Other Releases

- 0 - 6,700
- 6,701 - 26,000
- 26,001 - 64,000
- 64,001 - 158,000
- 158,001 - 1,990,000

EPA TRI Top 100 Facilities
Total On- and Off-site Disposal or Other Releases

- 1,471,000 - 3,690,000
- 3,690,001 - 7,620,000
- 7,620,001 - 14,900,000
- 14,900,001 - 33,200,000
- 33,200,001 - 452,000,000

Source: EPA Toxic Release Inventory, 2025e

In addition, coal plant pollution from the electric power industry is one of the largest sources of carcinogenic air pollution in Iowa. These facilities are required to report toxic releases under a number of federal laws and regulations, including the Toxic Substances Control Act, the Clean Air Act, and the Clean Water Act. Burning coal produces SO_x, NO_x, VOCs, heavy metals, dioxins, furans, and other hazardous air pollutants (EPA, 2006; U.S. Department of Energy, 2024). Large coal generators are currently operating in Black Hawk County, Louisa County, Pottawatomie County, Wapello County, and Woodbury County.

Legacy Chemical Contamination

Legacy industrial pollution at Superfund sites, landfills, and hazardous waste facilities have left numerous locations across Iowa contaminated with hazardous substances that pose ongoing risks to soil, groundwater, and public health. The EPA created the Superfund program to deal with the nation's worst hazardous waste sites (EPA, 2025c). These locations can contain a mix of toxic contaminants such as lead, asbestos, radiation, and other carcinogens and toxins that are found both in the soil and groundwater. According to a 2025 study, the most frequent mixtures of three individual carcinogenic compound or metals at 1,582 U.S. Superfund sites include: nickel, arsenic, and cadmium (496 sites); benzene, arsenic, trichloroethylene (451 sites); benzene, vinyl chloride, trichloroethylene (420 sites); and arsenic, vinyl chloride, trichloroethylene (386 sites) (Dunnick et al., 2025). Each site's contamination is unique to the prior industrial processes that produced the waste present at the site.

Iowa has 13 listed Superfund sites in 12 communities on the EPA's National Priorities List (NPL). Iowa also has 11 deleted Superfund sites and one proposed Superfund site (EPA, 2025b). Active Superfund sites in Iowa can be found on the Superfund NPL Where You Live Map (https://www.epa.gov/superfund/search-superfund-sites-where-you-live). However, even sites that are no longer listed as Superfund sites can continue to pose a hazard to local communities, especially if they are not regularly monitored. While the NPL contains the sites of most urgent concern to EPA, Iowa's contaminated sites registry includes a broader list of 2,555 landfills, brownfields, and hazardous waste facilities (IDNR, 2025b), available at: https://www.iowadnr.gov/environmental-protection/land-quality/hazardous-waste-contaminated-sites/site-registry.

REGULATORY OVERSIGHT OF ENVIRONMENTAL RISK FACTORS

Federal and state laws provide limited protection against the environmental risk factors of cancer that affect Iowans. Pesticide regulations are not adequate to ensure safety; nitrate is underregulated in drinking water sources; PFAS enter air and water with minimal controls. Radon is left to homeowners to monitor and mitigate, and industrial air emissions can go unreported, with extremely limited air monitoring for toxics by the Iowa Department of Natural Resources (IDNR).

Pesticide Regulations

Federal law requires registration and approval under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. § 136a). The U.S. Environmental Protection Agency (EPA) approves a pesticide for restricted or general use if it concludes that the benefits outweigh the risks and there will be no "unreasonable adverse effects on the environment" *(id.)*. The EPA's evaluation of risk assumes the pesticide is applied in compliance with labeling requirements, such as wearing protective equipment *(id.)*. Under the Federal Food, Drug, and Cosmetic Act, the EPA sets maximum levels of registered pesticides allowed in food (21 U.S.C. § 346a). Seeds coated with pesticides to protect the seed do not have to register under the law (40 C.F.R. § 152.25).

State pesticide restrictions apply to pesticides regulated under federal law as of 2007 (Iowa Code § 206.20; Iowa Administrative Code r. 21-45.30). As a result, Iowa does not regulate common pesticides such as metolachlor formulations (Purdue University, 2026). Iowa requires commercial pesticide applicators to obtain a license and certification if they apply pesticides to land they do not own or apply a product with restricted uses to land they own (Iowa Code § 206.6). The pesticide applicator certification requires passing an exam about safe pesticide application (Iowa Code § 206.5). Pesticide dealers must register pesticides that they apply in the state (Iowa Code § 206.12). They must report any unintended pesticide releases or losses (Iowa Code § 206.14). Each pesticide dealer must report sales of each pesticide annually (Iowa Code § 206.6(7)) and retain records for three years (Iowa Code § 206.15; Iowa Admin. Code r. 21-45.26). State law has no requirement for licensees or applicators to report how much was applied in specific locations.

Any pesticides applied to water also require permits under the Clean Water Act. The IDNR has created a general permit that allows multiple permittees to operate under the same terms (IDNR, n.d.-b). The permit limits pesticides applied to water or that drift into water. However, compliance with those limits is not regularly monitored by IDNR. Permittees must retain records of pesticide applications for three years, but they only need to provide those records upon request to the IDNR, Iowa Department of Agriculture and Land Stewardship (IDALS), or EPA *(id.)*.

PFAS Regulations

In 2024, the EPA adopted primary drinking water regulations under the Safe Drinking Water Act for five categories of PFAS, as well as combinations of them. The regulations require public water suppliers to meet these PFAS concentration limits by 2029 (EPA, 2024a). In 2025, the EPA announced an intent to withdraw four of the six recommended drinking water standards, retaining requirements for only PFOA and PFOS (EPA, 2025a). Iowa has not adopted any PFAS criteria in its water quality standards, though the IDNR identified them as a topic for consideration in the state's triennial review of water quality standards (IDNR, 2025).

National and local settlements have resulted in funding to cover some drinking water treatment costs for PFAS. In August 2025, Des Moines Water Works received $3 million from such a settlement. Other cities have also been involved in lawsuits and settlements to receive funding from 3M, a major manufacturer of PFAS (Brummer, 2025). Although 3M committed to phase out production of PFAS by the end of 2025, it has not yet done so (Johnson, 2025). Federal regulation adopted in 2024 limits PFAS use in food packaging (Food and Drug Administration, 2024). No federal or state laws limit potential public exposure to other PFAS-containing products, nor do federal or state laws require monitoring of PFAS in land-applied biosolids.

Nitrate Regulations

Iowa's Nutrient Reduction Strategy (NRS) sets a goal to reduce nitrate in surface water by 45%, but only "point sources" of this pollution, such as city water systems, are regulated (IDALS et al., 2025). Iowa does not regulate nitrate from nonpoint sources or in private drinking water sources. Nitrate enters Iowa's environment primarily from nonpoint sources (93%), including manure and synthetic fertilizer for agricultural production. Animal feeding operations generate the vast majority of livestock manure in Iowa. Municipal and industrial point sources discharge a small fraction of nitrate in the water (IDALS et al., 2025).

Large livestock operations in Iowa must submit management plans for animal waste: manure management plans for confinement operations (Iowa Code § 459.312) and nutrient management plans for open feedlots (Iowa Code § 459A.208). In these plans, operators must identify fields and rates for manure application (Iowa Code § 459.312). The allowable manure application rates are based on a soil phosphorus index (Iowa Admin. Code r. 567-65.111(12)) or the rate needed for optimum crop yields (Iowa Admin. Code r. 567-65.111(13)). The operator can determine the "optimum" yield by averaging past yields (excluding the lowest yield year) or adding 10% to past yields (Iowa Admin. Code r. 567-65.111(4)). However, there is no centralized Geographic Information System (GIS) for these plans. The IDNR has limited staff capacity to provide oversight, and operators' compliance reports are not available to the public (Iowa Stat. § 459.312).

Iowa requires dealers of synthetic fertilizer to obtain a license and pay a fee (Iowa Code § 200.4). Dealers must pay a fee of 95 cents for each ton of fertilizer sold (Iowa Code § 200.8), and IDALS reports cumulative sales (Iowa Code § 200.13). Iowa's Groundwater Protection Act required the IDNR to adopt rules governing cleanup of groundwater contamination creating a risk to human health, and the cleanup must employ the best technology or practices available (Iowa Code § 455E.5). However, agricultural producers are specifically exempt from costs and damages if they apply fertilizer in compliance with soil tests and product labels (Iowa Code § 455E.6).

The Safe Drinking Water Act requires public water suppliers to ensure there is less than 10 mg/L nitrate-nitrogen in all finished drinking water (40 C.F.R. § 141.62(b)). Every public drinking water supplier must meet this standard at all times *(id.)*. Iowa has a water quality standard for nitrate that applies to rivers and lakes designated as drinking water sources (Iowa Admin. Code r. 567-61.2(3)). The IDNR has sought to apply that standard as a long-term, chronic standard averaged over three years while drinking water providers are required to supply safe water in the short-term (IDNR, 2023). This means drinking water providers must bear the costs of providing additional treatment to ensure the finished drinking water always meets the 10 mg/L nitrate maximum contaminant level (MCL), despite fluctuating concentrations in source water.

Radon Regulations

Most Iowans are exposed to naturally occurring radon through air in homes and other buildings. Certified radon testers (Iowa Code §136B.1(2)) must disclose test results to the Iowa Department of Health and Human Services (Iowa Code §§ 136B.2; 558A.4). The EPA recommends installing mitigation in homes with 4 pCi/L and recommends considering mitigation in homes with 2 pCi/L, but it does not require mitigation at any concentration (EPA, 2024b).

Iowa law requires radon testing at childcare centers that operate at ground level or have a basement (Iowa Admin. Code r. 441-109.11(8)). If radon exceeds the EPA action level of 4 pCi/L, state licensing requires the childcare facility to have a radon mitigation plan (Iowa Admin. Code r. 441-109.11(8); Iowa Health and Human Services, 2025).

Public schools must test for radon by July 1, 2027, and at least once every five years (Iowa Code § 280.32). If radon exceeds the EPA action level, the school board must develop a mitigation plan, though there is no requirement to implement the plan (Iowa Code § 280.32). New school construction must use radon-resistant construction techniques (Iowa Code § 280.32). The requirements do not apply to private schools.

Iowa homeowners must disclose known conditions of the property, including any radon tests, upon sale of a property (Iowa Admin. Code r. 193E-14.1). Iowa law also requires buyers to receive a state-issued radon fact sheet (Iowa Admin. Code r. 193E-14.1). There are no laws regarding occupational exposures that specifically address radon in Iowa.

Drinking water is a much smaller route of exposure. The EPA has not adopted a limit for radon in drinking water or in ambient water, nor has Iowa. There is no maximum contaminant level established for radon in drinking water supplies despite a 1999 proposed rule from EPA to set the standard at 300 pCi/L for most public water systems with some exceptions for smaller systems. That draft rule cited concerns about internal organ cancers caused by drinking radon-contaminated water (EPA, 1999).

Industrial Air Emissions and Water Pollution Regulations

The Clean Air Act regulates emissions of potentially toxic substances through the National Emissions Standards for Hazardous Air Pollutants (NESHAPs). Federal regulations restrict emissions by identifying categories of industry that emit hazardous pollution and require use of available emissions control technology (40 C.F.R. pt. 63).

For many industrial categories, sources that annually emit more than 25 tons of hazardous pollutants (or 10 tons of a single hazardous pollutant) must obtain permits with limits on hazardous pollution (IDNR, n.d.-a). For some categories, smaller emissions sources called "area sources" must also obtain a permit (EPA, 2025b). While this approach captures the largest emission sources, any industry not specifically listed in federal regulations falls outside the NESHAP requirements. In Iowa, this includes ethanol and other biofuel facilities. Air toxics reporting is currently voluntary, because a recently proposed rule to require reporting has not been adopted (EPA, 2023).

Groundwater remediation to address contamination is governed by standards set by the IDNR to limit risks from normal contact (Iowa Admin. Code r. 567-137.5). Where they exist, the standards rely on health-based drinking water benchmarks: Maximum Contaminant Levels (MCLs) or health advisory limits. For contaminants without such a benchmark, the standard is calculated using a risk-based formula *(id.)*. Groundwater that is more likely to be used for drinking water has more protective standards *(id.)*.

DISCUSSION AND CONCLUSIONS

ANALYSIS OF THE LITERATURE AND DATA SHOWS:

- **All of the most common cancers** in Iowa have associations with environmental risk factors in the literature.
- **13 of the 16 cancer sites** identified in this report as connected to pesticides, PFAS, nitrate, and radon exceeded the U.S. incidence rate in the most recent five-year period (2017 – 2021).
- Of the adult cancers identified as associated with these environmental risk factors, **11 of the 15 cancer types** have been increasing in the total Iowa population.
- For people under 50 in Iowa, **six of 10 cancer types** associated with pesticides, PFAS, nitrate, and radon have been increasing.

Iowa's cancer burden exists within a complex environmental context. Residents are exposed to a toxic mix of pollutants through drinking water, air, soil, and household environments, yet the cumulative health effects of these exposures have not been fully determined. While individual risk factors are often studied in isolation, far less attention has been paid to how multiple contaminants may interact over time or how long-term, low-level exposure affects cancer risk across the population. This lack of comprehensive analysis limits our ability to fully understand the role environmental contamination may be playing in Iowa's persistently high cancer rates.

There is strong and growing scientific evidence linking several pollutants prevalent in Iowa, including pesticides, PFAS, nitrate in drinking water, and radon, to increased risks of various cancers, as detailed in this report. These contaminants are widespread in Iowa, raising concern that environmental exposure may be a significant contributor to cancer incidence in the state.

Iowa stands out as an outlier compared to most other states in terms of exposure to these environmental risk factors, especially when they occur in combination. The state has some of the highest nitrate levels in drinking water, extensive and intensive pesticide use tied largely to agricultural practices, elevated radon concentrations in homes, and emerging concerns about PFAS contamination. This convergence of risk factors is troubling, particularly given Iowa's consistently high and rising cancer rates relative to national trends.

Emerging patterns also suggest that these impacts are not limited to older adults. Increasing numbers of Iowans under the age of 50 are being diagnosed with cancer, a trend that mirrors national concerns about early-onset cancers but is even more pronounced in Iowa. The reasons for this shift are not well understood and warrant deeper investigation, particularly with respect to environmental exposures that may begin early in life or even before birth.

Geography and demographics further complicate the picture. Rural Iowans appear to experience a somewhat disproportionate share of cancer diagnoses. Similarly, racial disparities in both cancer incidence and mortality are evident in Iowa's cancer data, indicating that some communities bear a heavier burden of disease (Iowa Cancer Registry, 2025). These inequities demand greater attention and more targeted research to understand their root causes and inform effective interventions.

Notably, many of the cancers associated in the scientific literature with nitrate, pesticides, PFAS, radon, and other environmental hazards occur at higher rates in Iowa than in the nation as a whole. This alignment strengthens the hypothesis that environmental risk factors are contributing to the state's elevated cancer burden. While correlation does not prove causation, the consistency of these patterns and the growing understanding of biological mechanisms of cancer create an urgent need for action. We need more comprehensive research, improved monitoring, and preventive policies aimed at reducing exposure and protecting public health.

The Precautionary Principle and Public Health

The analysis presented in this report highlights complex associations between environmental exposures — including pesticides, PFAS, nitrate, and radon — and elevated cancer risks in Iowa. While epidemiological and toxicological studies provide strong evidence of potential harm, conclusively establishing a causal link to cancer is a significant challenge, particularly because cancer often involves long latency periods, multifactorial influences, timing of exposure, and the cumulative effects of low doses. Nevertheless, failing to act despite strong evidence of a connection between environmental exposure and cancer can lead to many unnecessary deaths and serious hardships. It is for this reason that the Precautionary Principle is an important framework for guiding public policy (Kriebel et al., 2001).

> **The Precautionary Principle, in this context, holds that when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.**

Using the precautionary framework, once sufficient scientific evidence has been presented suggesting a link between an environmental risk and a health risk, the burden of proof shifts to those who are arguing against taking protective action. Previous sections of this report have detailed the high burden of cancer in Iowa and the extent to which high-quality, peer-reviewed academic studies have found associations between various environmental risks and cancer. As such, policymakers should prioritize proactive protection and risk prevention, as well as identification and widespread implementation of cost-effective alternative practices and use of substances that are less harmful. These measures should be backed up by the adoption of comprehensive policies designed to aggressively reduce Iowans' exposure to environmental contamination.

Environmental risk factors of cancer, similar to lifestyle choices like smoking, diet, and exercise, are modifiable and can be mitigated to protect the health of Iowans. However, the widespread nature of Iowans' exposures to chemicals in our air, water, and soil will require significant and robust policy change.

POLICY RECOMMENDATIONS AND ACTION STEPS

1. **Effective, Standards-Based Enforcement of Pollution Limits**
   The Iowa Department of Natural Resources (IDNR) should adopt standards for carcinogens in water, air, and soil that protect public health and work across sectors to implement effective and efficient strategies to meet those limits.

2. **Regulatory Reform**
   The legislature should act to reform regulatory oversight in Iowa to prioritize Iowans' health.

3. **Monitoring and Transparency**
   Iowa's state agencies must partner with universities, federal stakeholders, local governments, and Iowans to implement systems that result in transparent and accurate monitoring and public reporting on the most concerning sources of carcinogens in Iowa's water, air, and soil.

4. **Investments in Healthy Air, Water, and Soil**
   Iowa's state government should explore and pursue funding sources for mitigating pollution at the source to reduce exposures across the population.

5. **Research**
   Iowa's state government, universities, and foundations should fund and pursue rigorous research on cancer and environmental risk factors, while protecting the independence of researchers.

1 Effective, Standards-Based Enforcement of Pollution Limits

- **Reevaluate and strengthen the nitrate drinking water standard.** The current federal nitrate maximum contaminant level (MCL) of 10 mg/L in public water supplies was established to prevent methemoglobinemia (blue baby syndrome). Research now links nitrate exposure to a wider range of serious health outcomes, including birth defects, poor pregnancy outcomes, and certain cancers. The EPA should complete the human health risk assessment for nitrate in drinking water the agency initiated in 2023 to ensure that the MCL reflects current science and uses the precautionary principle to ensure protection of public health. In the absence of federal action, states — including Iowa — should adopt a more protective nitrate standard that fully accounts for both acute and chronic health risks.

- **Develop enforceable watershed management action plans for impaired waters in Iowa.** IDNR should develop Watershed Management Action Plans that require comprehensive conservation and pollution management and implementation for pollution sources, including agricultural operations. The plans would be designed to hit a pollution target and require implementation of practices to meet it.

- **Apply PFAS standards.** The EPA has recommended PFAS standards for ambient water, which the IDNR should adopt in full. The EPA has also adopted recommended standards for specific formulations of PFAS in finished drinking water; water providers should be required to comply with these standards. The state should go further and restrict PFAS in drinking water as a class, not just individual formulations.

- **Iowa should adopt the EPA's 2015 human health water quality criteria.** EPA has identified maximum concentrations of carcinogens in water and fish tissue to reduce cancer risks. The IDNR has not adopted the EPA's most recent recommendations.

2 Regulatory Reform

- **Reform administrative penalties.** Iowa has not updated the administrative penalty cap of $10,000 adopted in 1992, reducing its impact by approximately 60% due to inflation. Penalties for environmental violations are not adequate to deter pollution. The legislature needs to raise the administrative penalty cap, index it to inflation, and improve transparency in civil lawsuits.

- **Ensure proper permitting and enforcement of health-based standards for pollution by eliminating or significantly reforming the Iowa Environmental Protection Commission (EPC).** The EPC was created by the legislature in 1986 to set policy, hear appeals, approve licenses and permits, and make budget recommendations. A majority of the volunteer Commission members are, by law, chosen from agriculture and industry. They are not typically experts in regulating environmental contaminants and rely on the IDNR and the governor for direction. The Commission should be given a clear directive and authority to protect people in Iowa from the environmental contamination detailed in this report. The Commission should be structured to more closely mirror the Iowa Utilities Commission, with full-time members who hold some expertise in environmental protection, or it should face elimination. If eliminated, the funding allocated to the EPC should be directed toward meaningful reductions of cancer risk factors in Iowa's environment.

- **Adopt legislation to manage nitrogen fertilizer practices based on groundwater nitrate levels.** When groundwater reaches 3 mg/L NO_3-N in a county, state agencies in partnership with university experts should identify best management practices for agricultural operations to minimize nitrogen losses. If groundwater reaches 5 mg/L, state agencies should restrict fertilizer sales to actual crop nitrogen needs and require implementation of the identified best management practices for all cropland and manure application.

- **Reform agricultural tile drainage practices to reduce nitrate transport.** State law should require drainage district boards to account for environmental impacts in determining whether to install or make improvements to new drainage. Districts should also require installation of best management practices upon installation or improvement of tile drainage to minimize environmental impacts and be allowed to use drainage district funds for practices that reduce environmental impacts. Funding for additional best management practices could come from elimination of the sales tax exemption for drainage tile.

- **Reform siting of all new, large, and expanding animal confinements and open feedlots to achieve appropriate concentration of facilities and protect water resources from contamination.** Such reforms may include minimum standards for siting, local oversight, effective public processes, and monitoring requirements. Adopt regulations that limit the density and location of livestock to align with the capacity of croplands to use manure.

- **Adopt protective policies that address land application of manure, fertilizer, and pesticides.** Policies should align application timing with environmental risk conditions, reduce nutrient losses, and minimize human and ecological exposure to agricultural chemicals.

2 Regulatory Reform, continued

- **Require industries that manufacture or use PFAS to test and pre-treat PFAS waste.** Until Iowa adopts water quality standards for PFAS, industrial users may not have restrictions on PFAS discharges. This pushes responsibility to downstream public water providers. The legislature should require industries to pre-treat PFAS waste and monitor releases to avoid externalizing costs onto taxpayers.

- **Restrict high-risk pesticide application.** State law should establish appropriate no-spray buffer zones around schools, homes, and surface waters. These sensitive areas should receive enhanced protections, such as stricter application requirements and the use of technologies to minimize chemical drift and protect vulnerable populations.

- **Set a standard for radon-resistant new construction in all Iowa homes.** The cost of installing radon mitigation during initial construction of a home is minimal, especially compared to a later retrofit or the consequences of a cancer diagnosis. Radon mitigation should be made standard in Iowa for new home construction.

- **Prohibit the discharge of contaminated water from coal ash landfills into Iowa water bodies.** This would reduce the release of heavy metals into the environment, where they can later enter drinking water supplies or interact with other chemicals to increase risks to human health.

- **Require state and local governments to purchase PFAS-free alternatives for products and applications.** This is especially important where effective substitutes are available and occupational exposures are high and unavoidable.

3 Monitoring and Transparency

- **Expand Iowa's water monitoring network.** Robust water quality data has proven critical during times when pollution puts drinking water sources at risk. Comprehensive data provides a picture of whether rivers, streams, lakes, and groundwater sources meet water quality standards, and measurement shows whether pollution-reduction investments and research are working. Iowa needs to fund a complete water quality monitoring network — including monitoring groundwater — to understand the sources of pollution across the state.

- **Require electronic, geospatial manure management plans.** Most manure application is subject to management plans that could reduce nitrate pollution if properly monitored and enforced. State law encourages electronic plans, but the IDNR has no electronic, geospatial system for oversight. The legislature should fund the IDNR to develop a geospatial system for manure management plans that can reduce over-application of manure, guide conservation efforts, facilitate research, and reduce nitrates in drinking water sources. The legislature should also amend the law to make manure application records available to the public.

- **Create a centralized pesticide tracking system and provide public notice of application.** The Iowa legislature should establish a centralized pesticide use tracking system in the Iowa Department of Agriculture and Land Stewardship (IDALS). This system would require reporting by licensed pesticide retailers and applicators of detailed pesticide application data — currently retained privately for three years but not filed — to IDALS. IDALS should house the information in an anonymized, publicly accessible database to support research, regulatory oversight, and community awareness.

  State law should also require pesticide applicators to provide advance public notice of planned pesticide applications, including the chemicals used, timing, and locations to neighbors to allow them to act to reduce their exposure.

- **Expand PFAS monitoring in surface water and groundwater and make the data publicly available.** PFAS is a relatively new contaminant in Iowa, and researchers are still learning about its presence. Expanding monitoring across the state and testing for all types of PFAS, including ultrashort-chain PFAS compounds, will facilitate research and provide the public with a better understanding of the risks in their area.

- **Require monitoring of PFAS in biosolids.** Wastewater is a centralized collection point of PFAS, so testing the biosolids is an efficient way to establish exposure levels in communities around the state. Land-applying biosolids on cropland can expand the potential pathways of PFAS exposure. Monitoring will help identify the risks of biosolid application. Additionally, the state should initiate a pilot project to test for PFAS in manure to better understand this pathway of PFAS contamination to soil and food.

- **Expand the state air monitoring network to include additional ozone and PM2.5 monitors.** Additional air monitoring can help identify PM2.5 sources and inform the public about when poor air quality increases their risk of both short-term and long-term health effects.

- **Create a state "right to know" law.** Federal law requires disclosure of toxic pollution when covered by a federal law, but the law leaves gaps for some industries and types of pollution. A state "right to

3 Monitoring and Transparency, continued

know" law modeled on the federal law would allow the public to understand risks and collaborate to remediate them.

- **Develop a state dashboard, clearinghouse, and interactive map of information about toxic sites and the contaminants associated with them.** Although the state has substantial data on individual polluted sites, the information is not readily accessible to the public. A public dashboard and easy-to-understand website would facilitate engagement and cleanup actions.

4 Investments in Healthy Air, Water, and Soil

- **Fund the Natural Resources and Outdoor Recreation Trust Fund by raising the sales tax in Iowa to protect natural resources, support healthy families, and improve the quality of life.** In 2010, Iowans overwhelmingly voted to approve an increase in sales taxes to invest in the protection of water, soil, air, and other natural resources; however, the legislature has never acted to implement it. Funding should be tailored to support solutions that keep Iowans healthier, including preventing pollution from reaching waterways, restoring soil health, and protecting access to outdoor recreation opportunities. The funding should work toward meeting health-based standards and yield measurable results. The legislature should leverage this funding mechanism to reduce exposure to carcinogens in Iowa's water, air, and soil.

- **Fund and coordinate development of watershed-scale analyses to predict water quality, nutrient loads, and surface hydrology under different land management practices.** These tools would help analyze and forecast nonpoint source pollution and identify the source areas of nitrate and pesticide contamination so that conservation efforts could be placed where they will have the greatest impact for public health.

- **Provide state-funded technical assistance and engineering grants to help communities plan, upgrade, and maintain public water supply infrastructure, including treatment systems for nitrate and pesticide removal.** This support would help local systems secure funding and implement effective upgrades that protect public health and ensure safe, reliable drinking water.

- **Focus economic development programs and business recruitment on the creation of new markets and local food systems** to support diverse crop rotations and supply healthier foods to Iowans.

- **Create a state working group focused on cancer mitigation and agriculture to develop recommendations for Farm Bill reforms that prioritize public health, environmental protection, and farmers' economic security.** Current subsidy structures reward maximum production and drive excessive fertilizer and pesticide use, limiting farmer choice while increasing risks to human health. Federal funding should instead incentivize diversified cropping and animal systems and the development of new markets to grow healthier foods. Reforms should also incentivize the conservation of vulnerable lands and the utilization of best management practices proven to reduce nitrate and pesticide runoff, such as continuous living cover, restored wetlands, and riparian buffers, which will support long-term agricultural sustainability.

- **Fund, promote, and provide technical assistance for additional private well testing and solution implementation.** The Private Well Grants Program allows free annual water testing through county health departments. The state should provide sustained and increased funding to ensure long-term viability, expanded outreach, and broader participation. Households with nitrate levels above 5 mg/L should be allowed to retest quarterly to build a more comprehensive dataset on nitrate trends across locations and seasons. The Iowa Department of Health and Human Services should also establish a clear support mechanism to help residents determine the most effective course of action when contamination is detected. For households with

4 Investments in Healthy Air, Water, and Soil, continued

contaminated wells that meet income qualifications, the state should provide an alternative, safe water source and place them on a priority list for installation of a free or subsidized water treatment system.

- **Increase access to free and low-cost radon testing for Iowans and create a financial assistance mechanism to help Iowans pay for radon mitigation systems with a focus on people with a low income.** The Iowa legislature should build on the success of partnerships with local public health, modeled on the Private Well Grants Program, by offering a similar program for radon testing in homes and businesses. The state should work with advocates and local governments to create financial support for those who need it in the form of point-of-sale rebates with certified installers, refundable tax credits, or property-assessed mitigation financing to reduce up-front installation costs.

5 Research

- **Protect the independence of university researchers working to solve Iowa's cancer crisis.** Corporate funding for research is a reality at almost every university in the United States. However, transparency regarding funding sources and specific corporate involvement is essential, as these entities often have conflicts of interest when investing in research. Additionally, university researchers should be protected from retribution if the results of research conflict with the interests of corporate funders or other university donors.

- **Provide and pursue more funding for research on environmental risk factors of cancer in Iowa.** Each risk factor discussed in this report has aspects that need more research to fully understand its role in contributing to cancer incidence. In particular, there are serious gaps in our understanding of cumulative exposures to a "cocktail" of different chemicals and how the mix of substances being applied to agricultural and urban land in Iowa impacts people in both rural and urban areas. The legislature should provide additional funding for research, and state and academic institutions should pursue funding opportunities for further scientific research, including exposure assessments, biological plausibility, replication of studies, and research into more specific cancer subtypes and subpopulations.

- **Support research in PFAS removal techniques, including specialized and advanced water treatment technologies, as well as promising new, experimental methods.** This research would help communities identify effective, cost-efficient solutions to protect drinking water and public health.

PERSONAL ACTIONS TO REDUCE YOUR ENVIRONMENTAL EXPOSURES

SAFE AND INFORMED INDIVIDUAL PESTICIDE USE.

Individuals should understand the pesticides and chemicals they use around their homes and businesses. This includes reading product labels, reviewing safety and toxicity information, and using proper personal protective equipment during application. Whenever possible, individuals should minimize pesticide use both indoors and outdoors, with a preference for non-chemical or low-toxicity alternatives such as integrated pest management techniques.

TEST FOR AND MITIGATE NITRATE IN DRINKING WATER SUPPLIES.

Regular well testing and mitigation for private well owners will reduce exposures. If nitrate concerns are significant, the installation of a certified treatment technology, such as a reverse osmosis system, can help remove nitrate and other contaminants from water.

TEST FOR AND MITIGATE RADON AND OTHER CARCINOGENS INSIDE YOUR HOME.

Regular radon testing and awareness of lead paint, lead pipes, and other household contaminants will help reduce exposure. Once contamination has been identified, take action to stop the spread within the household and contact a remediation professional, if necessary.

UNDERSTAND YOUR EXPOSURE TO AIRBORNE CARCINOGENS AND FOLLOW OFFICIAL GUIDANCE.

Airborne carcinogens, including particulate matter, smoke, and smog, are found inside and outside homes. Adhere to public health advisories regarding poor air quality.

TRANSITION TO PFAS-FREE ALTERNATIVES

in household products, personal care items, consumer goods, and related applications where effective substitutes are available.

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SECTION 2: ENVIRONMENTAL RISK FACTORS ANALYSIS: PFAS

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SECTION 3: ENVIRONMENTAL RISK FACTORS ANALYSIS: NITRATE

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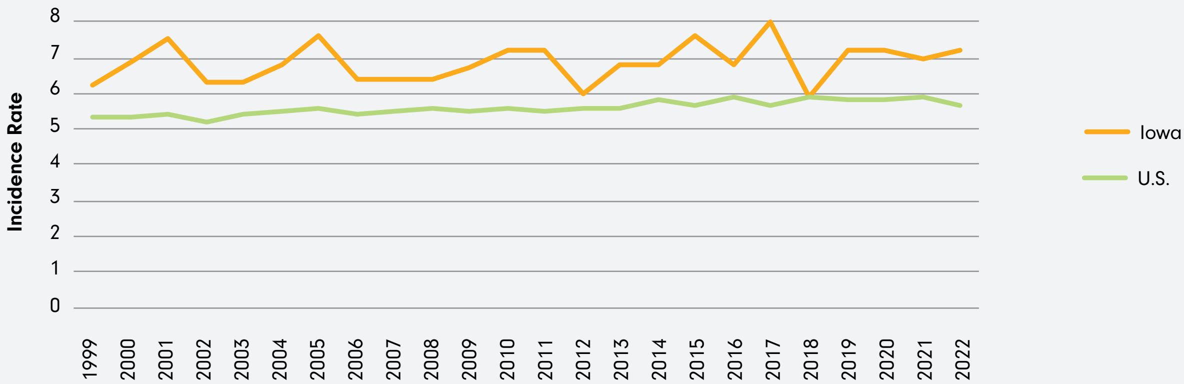
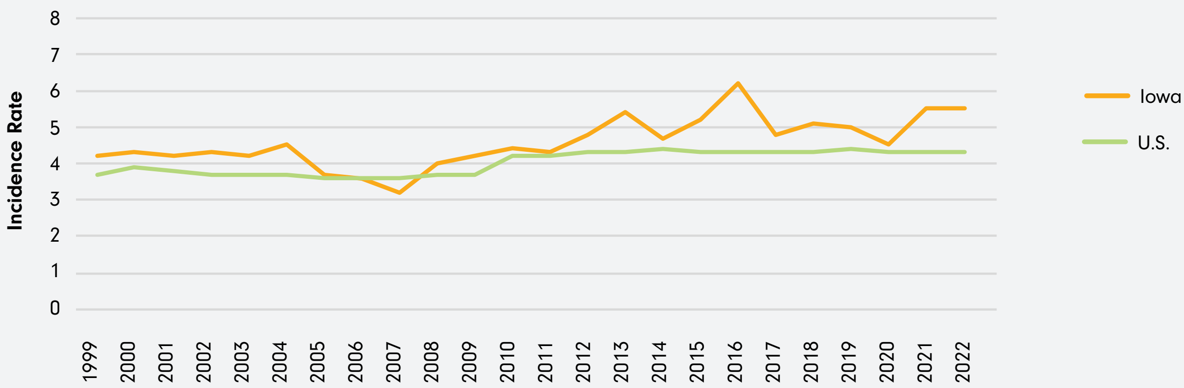
APPENDIX A

FIGURE A.1 **Testicular Cancer Incidence in Iowa per 100,000 Men (1999 – 2022)**



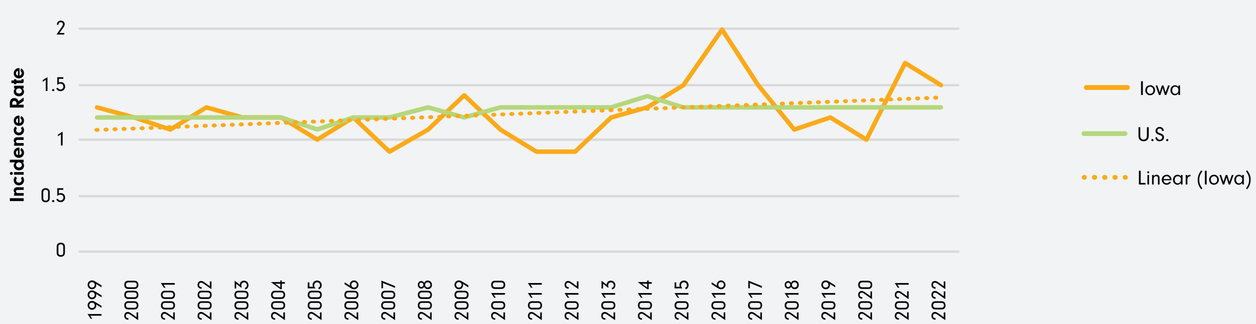
Source: Centers for Disease Control (CDC) Wonder database, 2025

FIGURE A.2 **Iowa and U.S. Acute Myeloid Leukemia Incidence per 100,000 People, All Population (1999 – 2022)**



Source: CDC Wonder database, 2026

FIGURE A.3 **Iowa and U.S. Acute Myeloid Leukemia Incidence per 100,000 People, Under 50 (1999 – 2022)**



Source: CDC Wonder database, 2026

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