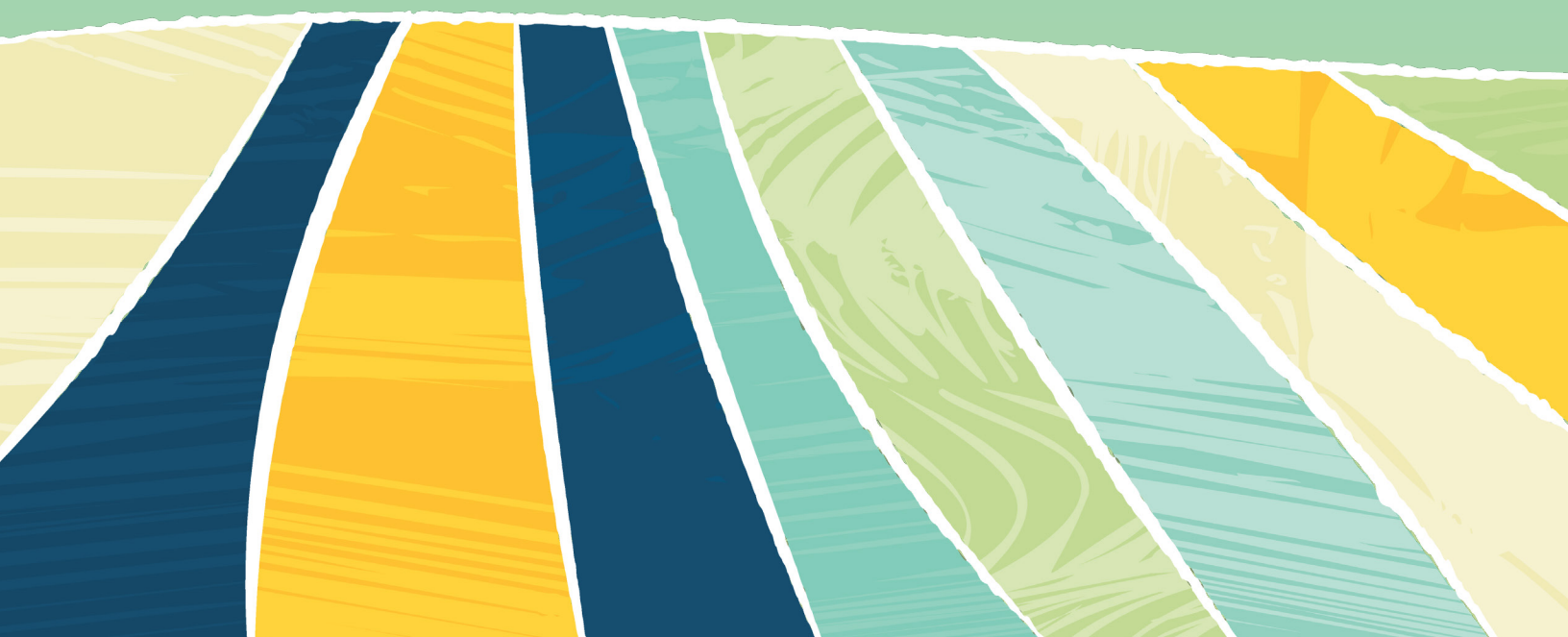
IOWA CANCER REGISTRY

# CANCER IN IOWA

2026



# Iowa Cancer Registry

The Cancer in Iowa report is produced by the Iowa Cancer Registry. The Iowa Cancer Registry is Iowa's statewide cancer registry, meaning that data are collected on all Iowa residents who are diagnosed with cancer. Given that cancer is a significant public health concern in Iowa and throughout the U.S., cancer is a reportable disease in all fifty states. The Iowa Administrative Code has designated the Iowa Cancer Registry to collect data on Iowans with cancer, including patient demographic characteristics, tumor characteristics, stage at diagnosis, first course of treatment, and length of survival. Oncology Data Specialists at the Iowa Cancer Registry, as well as those working in cancer centers and hospitals across Iowa, collect this detailed information beginning with the date of diagnosis for each patient with cancer.

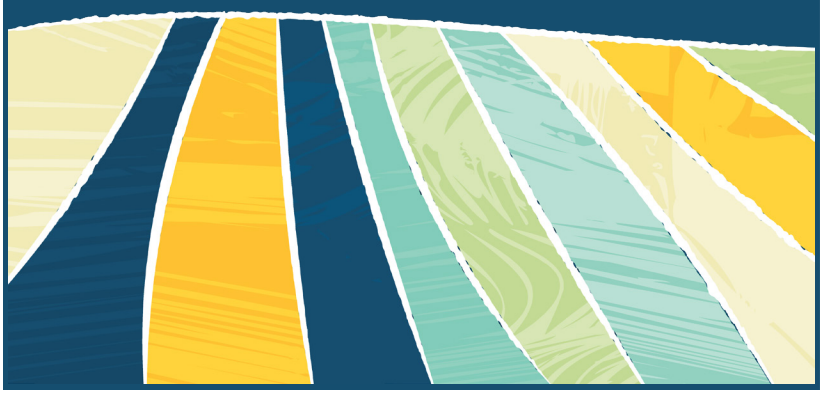
The Iowa Cancer Registry is funded by the National Cancer Institute through the Surveillance, Epidemiology, and End Results (SEER) Program, as well as the University of Iowa and the State of Iowa. The Registry is primarily a surveillance organization, and the data collected by the Registry are made available to researchers and public health professionals to facilitate cancer research and support initiatives to reduce the burden of cancer. Research studies using Iowa Cancer Registry data have been funded by many other federal agencies and foundations and include renowned studies such as the Agricultural Health Study. Iowa represents rural and Midwestern populations, and our data are included in many publications, national estimates, and projections of the impact of cancer.

Confidentiality is critically important to the Iowa Cancer Registry. It is the responsibility of the Iowa Cancer Registry to balance the need to protect its data and the privacy of those included in the Registry and provide researchers the information needed to conduct studies to help reduce the burden of cancer. To meet this goal, the Iowa Cancer Registry has policies around research, reporting, and release of data to safeguard the confidentiality of patients, providers, and hospitals.

**The 2026 Cancer in Iowa report provides information on the status of cancer in our state.**

**Key takeaways include:**

- **An estimated 21,700 new, invasive cancers will be diagnosed among Iowans in 2026.**
- **An estimated 6,400 Iowans will die from cancer in 2026.**
- **The number of cancer survivors is increasing, with an estimated 175,290 survivors currently living in Iowa.**
- **The rate of new cancers in children and adolescents in Iowa is similar to the U.S., but the rate in young adults in Iowa is significantly higher than the U.S.**
- **Cancer in Iowa's farming population is the featured topic of this year's report, made possible by research from the Agricultural Health Study.**

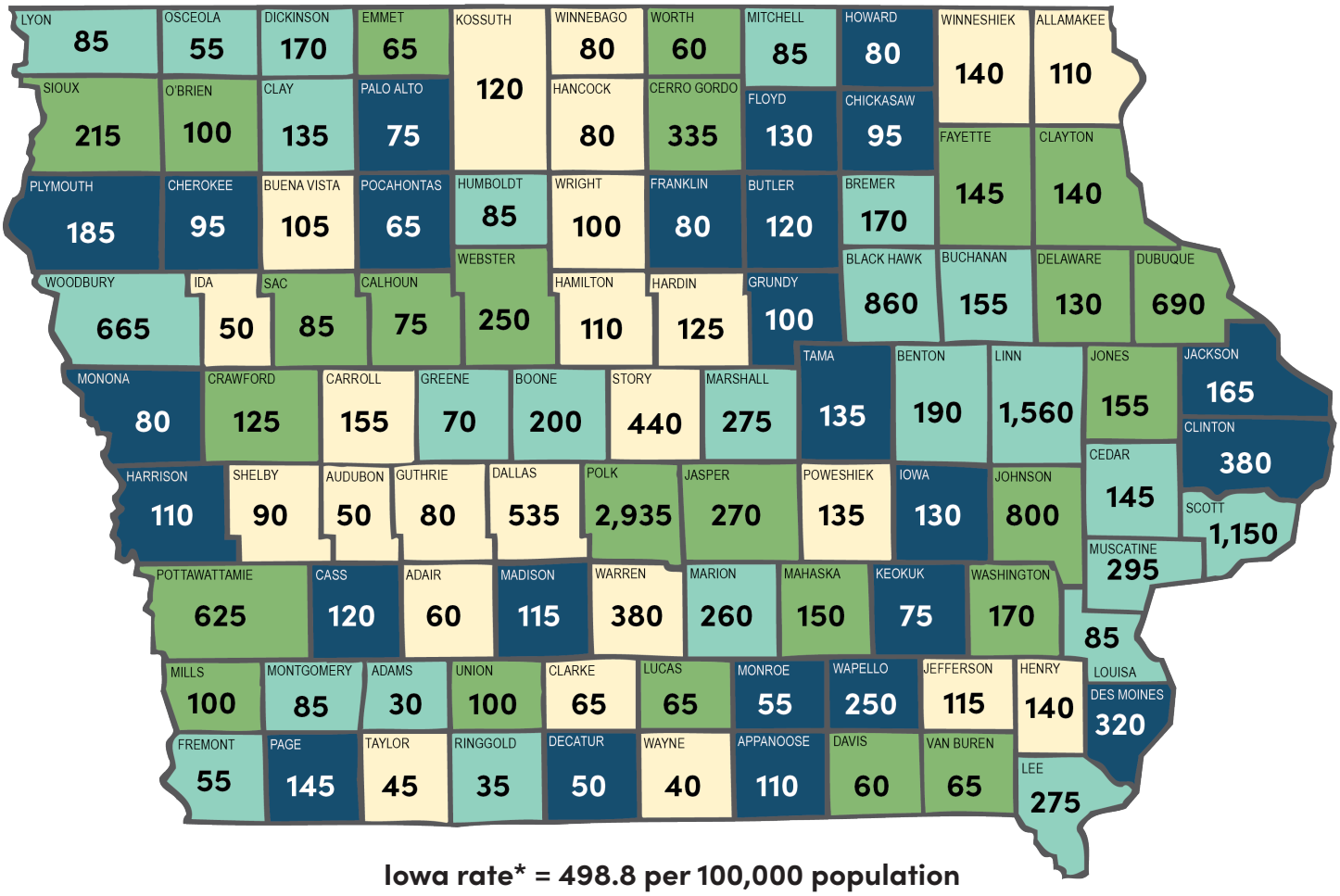


**This report can also be found online: https://shri.public-health.uiowa.edu/cancer-data/iowa-cancer-reports/**

If you are a representative of the media and have questions about this report, please email: **ICR-Media@uiowa.edu**

# Estimates for New Cancers for 2026

The numbers in each of the counties represent the estimated counts of new cancer cases for 2026 (meaning cancers that were diagnosed as stages 1-4, as well as in situ or stage 0 bladder cancers). The populations of each county vary widely in terms of size and age, so when comparing new cancers across counties it is important to focus on age-adjusted rates. The color of the county represents the age-adjusted rate of new cancers based on the most recent five-year time period (2018-2022) with the counties with the lowest rates shaded light yellow and highest rates shaded dark blue.




**Iowa rate* = 498.8 per 100,000 population**

406.8–479.3 (lowest rates in state)

480.0–499.3 (includes state rate)

500.3–520.0 (greater than state rate)

520.1–581.9 (highest rates in state)

*Rates are age-adjusted and per 100,000 population, 2018–2022

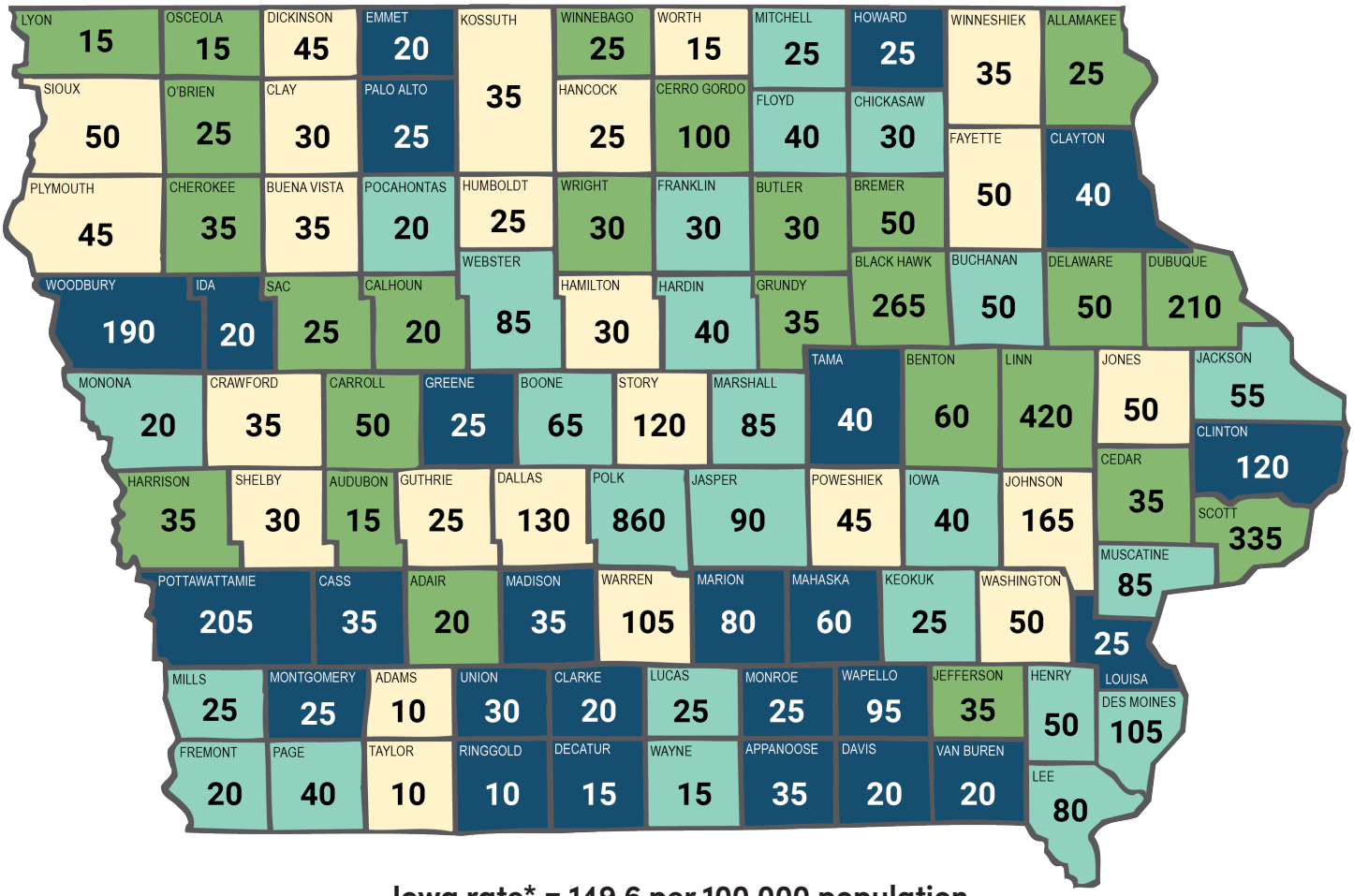
**ESTIMATED NEW CANCERS AMONG IOWA RESIDENTS, ALL AGES, 2026**

| TYPE | COUNT | % OF TOTAL | TYPE | COUNT | % OF TOTAL |
|---|---|---|---|---|---|
| Prostate | 3,100 | 14.3 | Leukemia | 720 | 3.3 |
| Breast | 3,050 | 14.1 | Uterus | 680 | 3.1 |
| Lung | 2,600 | 12.0 | Pancreas | 630 | 2.9 |
| Colon and rectum | 1,630 | 7.5 | Oral cavity and pharynx | 620 | 2.9 |
| Skin melanoma | 1,500 | 6.9 | Thyroid | 550 | 2.5 |
| Kidney and renal pelvis | 950 | 4.4 | Liver and intrahepatic bile duct | 370 | 1.7 |
| Bladder | 900 | 4.1 | Myeloma | 300 | 1.4 |
| Non-Hodgkin lymphoma | 870 | 4.0 | All others | 3,230 | 14.9 |

**TOTAL COUNT: 21,700**

# Estimates for Cancer Deaths for 2026

The numbers in each of the counties represent the estimated counts of cancer deaths for 2026. The populations of each county vary widely in terms of size and age, so when comparing deaths across counties it is important to focus on age-adjusted rates. The color of the county represents the age-adjusted rate of cancer deaths based on the most recent five-year time period (2018-2022), with the counties with the lowest rates shaded light yellow and highest rates shaded dark blue.




**Iowa rate* = 149.6 per 100,000 population**

- 106.5 - 138.7 (lowest rates in state)
- 139.0 - 151.9 (includes state rate)
- 152.6 - 164.2 (greater than state rate)
- 164.8 - 203.5 (highest rates in state)

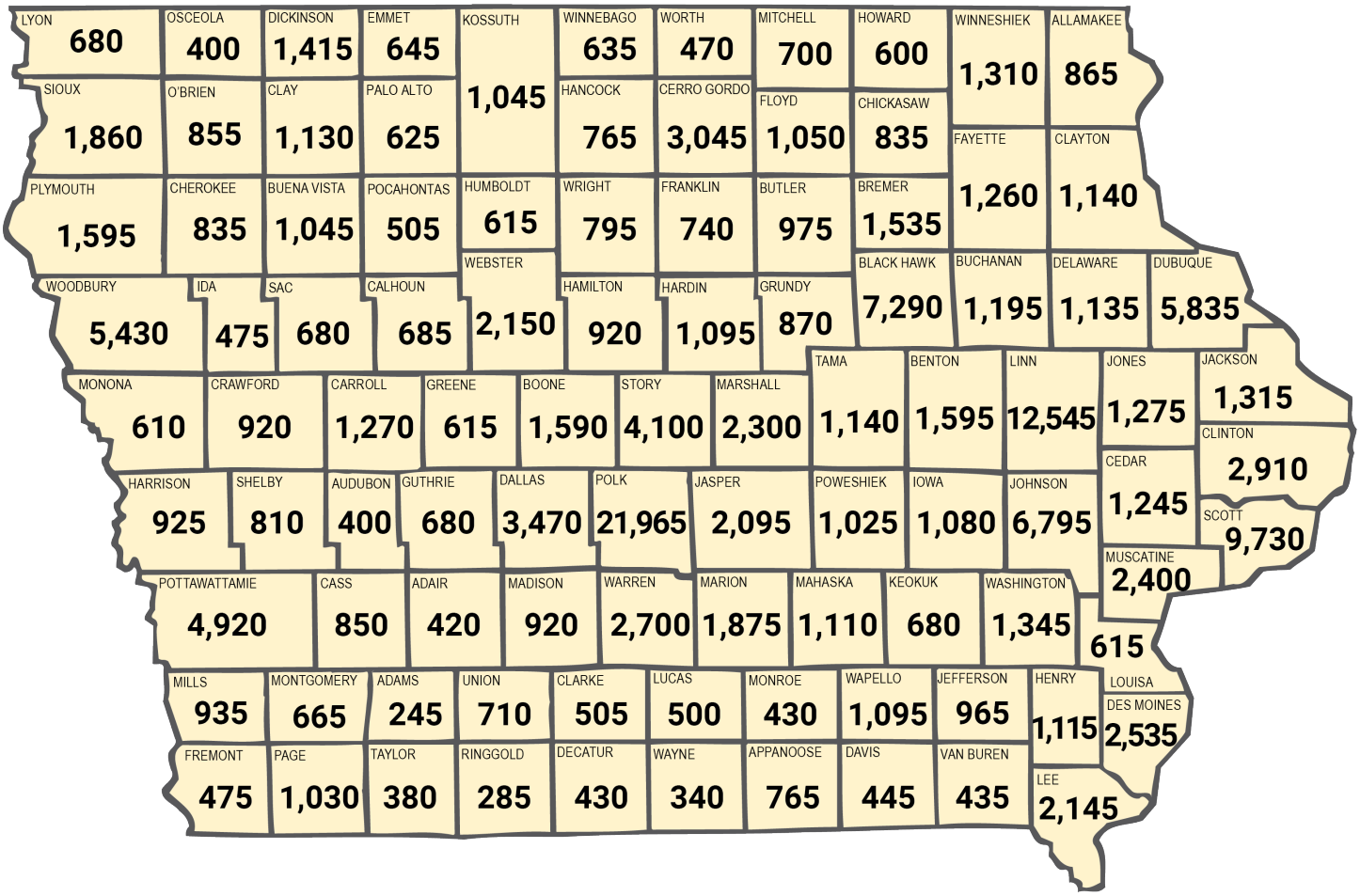
*Rates are age-adjusted and per 100,000 population, 2018-2022

**ESTIMATED CANCER DEATHS AMONG IOWA RESIDENTS, ALL AGES, 2026**

| TYPE | COUNT | % OF TOTAL | TYPE | COUNT | % OF TOTAL |
|---|---|---|---|---|---|
| Lung | 1,460 | 22.8 | Esophagus | 200 | 3.1 |
| Colon and rectum | 550 | 8.6 | Kidney and renal pelvis | 200 | 3.1 |
| Pancreas | 530 | 8.3 | Bladder | 170 | 2.7 |
| Breast | 380 | 5.9 | Brain | 170 | 2.7 |
| Prostate | 370 | 5.8 | Uterus | 130 | 2.0 |
| Liver and intraheptic bile duct | 270 | 4.2 | Myeloma | 110 | 1.7 |
| Leukemia | 250 | 3.9 | Ovary | 110 | 1.7 |
| Non-Hodgkin lymphoma | 240 | 3.8 | All others | 1,260 | 19.7 |
| **TOTAL COUNT: 6,400** | | | | | |

# Living with Cancer

The number of cancer survivors is growing in Iowa, and nationwide. The Iowa Cancer Registry has tracked the vital status of more than 98 percent of cancer survivors diagnosed since 1973. According to Iowa Cancer Registry incidence and survival data for 1973-2021, there are an estimated 175,290 cancer survivors living in Iowa (defined as people who are currently living with or having had cancer).




**TOP 16 CANCER TYPES WITH THE MOST SURVIVORS IN IOWA**

| TYPE | COUNT | % OF TOTAL CANCERS | TYPE | COUNT | % OF TOTAL CANCERS |
|---|---|---|---|---|---|
| Breast | 38,200 | 19.9 | Kidney and renal pelvis | 7,500 | 3.9 |
| Prostate | 32,750 | 17.1 | Lung | 7,490 | 3.9 |
| Colon and rectum | 15,475 | 8.1 | Leukemia | 5,870 | 3.1 |
| Skin melanoma | 14,670 | 7.6 | Oral cavity and pharynx | 5,065 | 2.6 |
| Uterus | 9,210 | 4.8 | Testis | 3,005 | 1.6 |
| Thyroid | 8,925 | 4.7 | Cervix | 2,530 | 1.3 |
| Non-Hodgkin lymphoma | 8,340 | 4.4 | Hodgkin lymphoma | 2,280 | 1.2 |
| Bladder | 8,250 | 4.3 | Ovary | 2,225 | 1.2 |

**175,290 CANCER SURVIVORS WITH 191,560 TOTAL CANCERS**

# Childhood, Adolescent, and Young Adult Cancer in Iowa

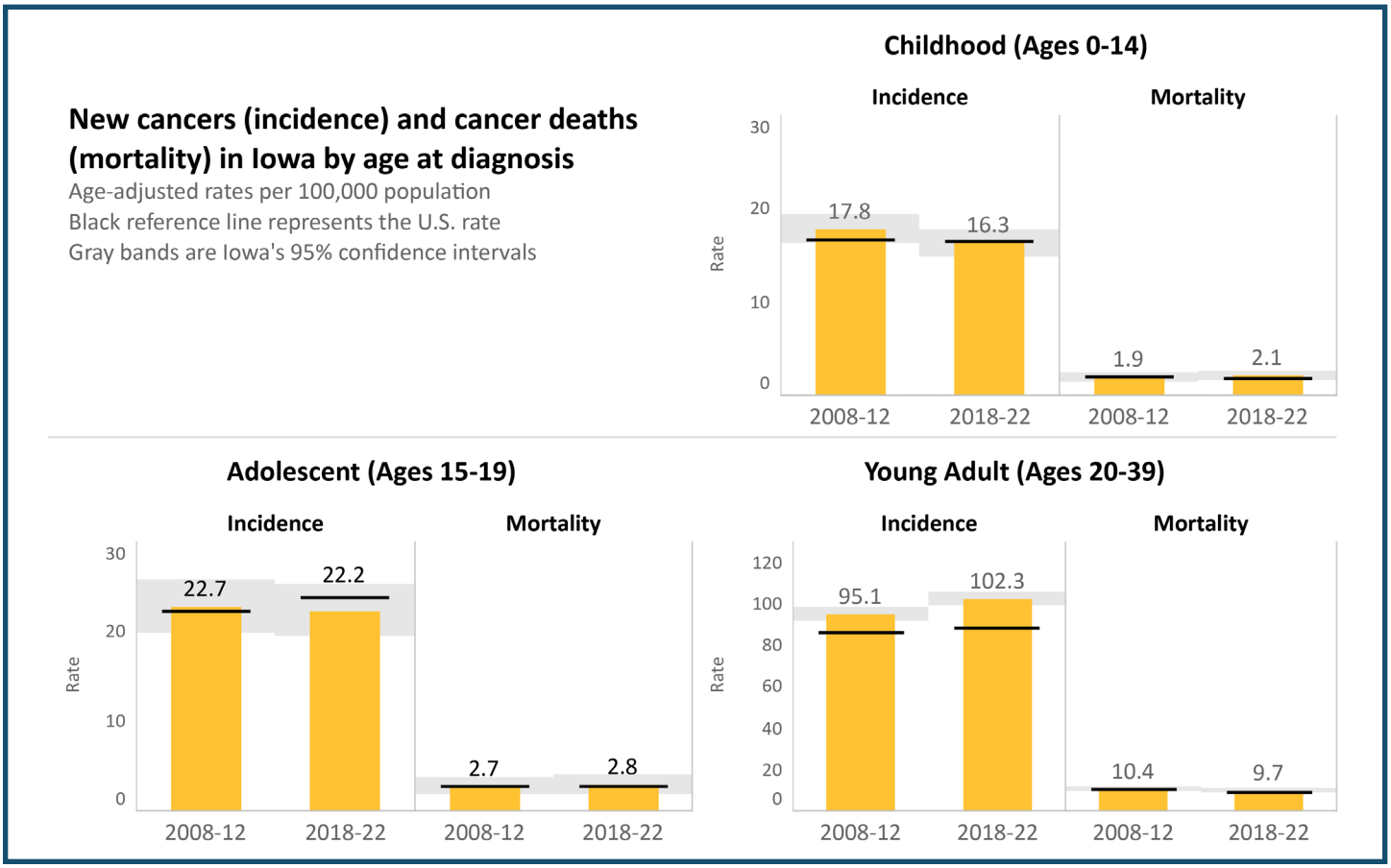
Cancers that affect children from birth through age 14 are known as childhood cancers. For diagnosis years 2018-2022, there were 497 new cancers diagnosed among children in Iowa, about 100 cases per year, with 53% diagnosed among males and 47% among females. The most common childhood cancers were leukemia (28%), brain (20%), lymphoma (9%), bones and joints (6%), and soft tissue including heart (6%). Over this same five-year period, there were 63 childhood cancer deaths (13 per year), with brain (38%) and leukemia (21%) as the most common.

Adolescent cancers affect those ages 15-19 years. For diagnosis years 2018-2022, there were 245 new cancers diagnosed among adolescents in Iowa, averaging 49 cases per year, with 52% diagnosed among males and 48% among females. The most common adolescent cancers were leukemia (16%), Hodgkin lymphoma (14%), thyroid (13%), and brain (12%). Over this same five-year period, there were 31 adolescent cancer deaths (6 per year), with numbers too small to present by cancer type.

Young adult cancers affect those ages 20-39 years. For diagnosis years 2018-2022, there were 4,006 new cancers diagnosed among young adults in Iowa, averaging 801 cases per year, with 62% diagnosed among females and 38% in males. The most common young adult cancers were skin melanoma (14%), breast (14%), thyroid (14%), and testis (8%). Over this same five-year period, there were 374 cancer deaths among young adults (75 per year), with brain (14%), colon and rectum (13%), breast (11%), leukemia (7%), and soft tissue (7%) as the most common.

The figure below compares the rate of new cancers (incidence) and the rate of cancer deaths (mortality) between Iowa and the U.S. from 2008-2012 and 2018-2022 (most recent five-year time period). The yellow bars represent the Iowa rates, the gray bands represent the 95% confidence intervals for the Iowa rates, and the black lines represent the U.S. rates. The childhood and adolescent cancer incidence rates in Iowa were similar to the U.S. rates, as the gray bands overlap the black lines, and there was no significant increase from 2008-2012 to 2018-2022. However, the incidence rate for young adult cancer in Iowa was higher than the U.S. rate for both 2008-2012 and 2018-2022, and it increased significantly from 2008-2012 to 2018-2022. Iowa's rate for young adult cancer ranks the second highest in the U.S.

The mortality rates for childhood, adolescent, and young adult cancer in Iowa were all similar to the U.S. rates and similar to Iowa rates from 2008-2012. While young adults in Iowa were diagnosed with more cancers, they were not dying more often from cancer. This may reflect that 57% of young adults in Iowa were diagnosed with localized disease in 2018-2022, meaning the cancer had not spread and therefore easier to treat, compared to 51% with localized disease in the U.S.



# The Iowa Cancer Registry and the Agricultural Health Study (AHS): Cancer in Iowa's Farming Population

Each year, the Iowa Cancer Registry selects a different topic to feature in the Cancer in Iowa report, with the goal of educating Iowans about specific kinds of cancer, cancer in special populations, or risk factors for cancer. This year, we are using information from the Agricultural Health Study (AHS) to feature the topic of cancer in Iowa's farming population.

## KEY POINTS:

### Background of the AHS

- The AHS is an ongoing research study that plays a critical role in identifying health risks among farmers, as it is one of the most rigorous and comprehensive studies in the world focused on how agricultural, lifestyle, and genetic factors affect the health of farming populations. The Iowa Cancer Registry regularly contributes data to the AHS so that investigators can evaluate cancer risk among the participating Iowa farmers and their spouses.
- More than 89,000 farmers and their spouses in Iowa and North Carolina were enrolled in the AHS in the mid-1990s. In Iowa, the study recruited more than 31,000 private pesticide applicators (mostly male farmers), about 4,900 commercial pesticide applicators, and nearly 21,000 spouses of the private pesticide applicators (mostly females).
- Farmers who apply pesticides are considered to be 'highly exposed' to pesticides compared to the general population, so studying this population makes it more likely that researchers will be able to detect relationships between pesticide exposures and cancer risk when they exist.

### Cancer Among Iowa Participants in the AHS

- Iowa farmers in the AHS had 13% fewer cancers overall than expected compared to the general population in Iowa from 1994-2015. Among farmers, there were fewer cases than expected for cancers of the colon and rectum, lung, bladder, oral cavity and pharynx, pancreas, esophagus, larynx, liver, and tongue. However, farmers experienced more cases than expected of prostate and lip cancers.
- Iowa spouses in the AHS had 10% fewer cancers than expected compared to the general population in Iowa. There were fewer cases among Iowa spouses for cancers of the colon and rectum, lung, bladder, pancreas, and cervix. However, Iowa spouses experienced more cases than expected of melanoma and thyroid cancer.
- While the AHS has identified several pesticides that are associated with a higher risk of cancer in the most highly exposed farmers and spouses, lower rates of smoking and alcohol consumption among AHS farmers and their spouses likely contributed to a lower burden of many cancers. Cancer is complex; lifestyle is critical, but more work needs to be done to better understand other contributing factors, including the environment.

### AHS Contributions to Understanding Cancer Risk from Pesticides

- There are many agencies in the U.S. and around the world that conduct risk assessments or hazard identifications to determine if an agent (e.g., substance, chemical, or exposure) causes cancer. For agencies that make these determinations, it is usually not enough for one study to find an association.
- The International Agency for Research on Cancer (IARC) is one such agency that convenes experts from around the world to review studies of agents to decide if they are carcinogenic (cancer causing). Their classification is based on the strength and consistency of evidence from all studies, including epidemiologic studies of humans such as the AHS, and studies in laboratory animals, toxicology studies, and other mechanistic studies.
- Findings from the AHS have been considered by IARC when deciding that eight pesticides, with residential or agricultural use, should be classified as known or probable causes of cancer.

### Ongoing Research on Nitrate in Drinking Water in the AHS

- 71% of AHS participants reported using private well water for drinking, which is not regulated under the U.S. Safe Drinking Water Act. Using models created to predict nitrate levels in private wells and using water quality data for Iowa public water supply systems, potential nitrate exposure in drinking water (from nitrogen fertilizers or animal waste) and cancer risk and other health outcomes in AHS participants can be evaluated.
- An AHS analysis showed that drinking water nitrate-nitrogen exposure at average levels >10 mg/L, the current maximum contaminant level for public water supplies, was associated with increased risk of prostate cancer, particularly aggressive disease. Another AHS analysis suggested that risk of ovarian cancer increased with higher average nitrate levels in drinking water.

# The Iowa Cancer Registry and the Agricultural Health Study: Cancer in Iowa's Farming Population

Each year, the Iowa Cancer Registry selects a topic to feature in the Cancer in Iowa report, with the goal of educating Iowans about specific types of cancer, populations that may have unique cancer patterns, or risk factors for certain types of cancer. This year, the Registry used information from the Agricultural Health Study (AHS) to feature cancer in Iowa's farming population. The landmark AHS study is one of the largest and longest running studies of agricultural exposures and health outcomes in the world and includes farmers and their spouses from Iowa and North Carolina. The AHS has relied on data from the Iowa Cancer Registry since it began. This report focuses on Iowa participants in the AHS.

The AHS continues to be funded by the National Cancer Institute (NCI) and the National Institute of Environmental Health Sciences (NIEHS) and has received funding from the U.S. Environmental Protection Agency (EPA) and the National Institute for Occupational Safety and Health (NIOSH) for specific projects.

The AHS is a prospective study, meaning participants are followed over time to observe their health outcomes. In Iowa, the study includes more than 31,000 private pesticide applicators (mostly male farmers), about 4,900 commercial pesticide applicators (most often employed by pest control companies or businesses that apply pesticides, such as warehouse operators or grain mills), and nearly 21,000 spouses of the private pesticide applicators (mostly females). Applicators were invited to join the study in 1993-1997 when they obtained or renewed their Iowa restricted-use pesticide licenses. If the private pesticide applicators were married, their spouses were also invited to participate. Because over 80% of Iowa's pesticide applicators chose to enroll in the study, the study population closely reflects the broader population of pesticide applicators in the state of Iowa during that time.

When AHS participants enrolled in the study, they provided information on their farming and pesticide application practices, lifestyle characteristics, medical histories, and other factors that might impact health outcomes. Throughout the study, the participants provided updated information on these topics in four follow-up questionnaires, including a detailed dietary history. Some participants provided a cheek cell sample or blood sample to help researchers explore how genes may affect cancer risk. Over the years, the AHS has conducted studies on cancer in applicators, spouses, and children. In addition to cancer, they have studied other outcomes such as reproductive health, respiratory health, neurological symptoms and disease, diabetes, thyroid disease, rheumatoid arthritis and other autoimmune diseases, injury, and mortality, among other topics. They have examined a wide range of agricultural exposures including solvents, engine exhaust, and grain dust. The AHS has contributed to more than 400 peer-reviewed publications in the scientific literature.

Farmers are particularly important to study because they can accurately report the pesticides they use[1] and are exposed to much higher levels than most people through mixing, loading, and applying these products. In contrast, the general public is usually exposed only to very small amounts of pesticides, mainly through food, drinking water, or drift from nearby fields. Studying a population with higher and more frequent exposure makes it easier for researchers to detect whether certain pesticides are linked to cancer. Including spouses in the AHS is also valuable because some of them work on the farm and apply pesticides themselves, and most are women, allowing researchers to examine possible connections to female-specific cancers. Spouses may also be exposed indirectly, through pesticide residues brought home on clothing or skin, or by living close to where pesticides are applied, giving researchers a more complete picture of how pesticides may affect health within farm families.

Along with lifetime pesticide use, the AHS has collected information on:

- Pesticide application practices including use of personal protective equipment
- Machinery used
- Types of crops and animals
- Farming methods and tasks
- Solvents
- Fuels and oils
- Engine exhaust
- Grain handling
- Dust-generating tasks
- Detailed diet questionnaire and cooking methods
- Medical history
- Type of drinking water source

Questionnaires used in the study, survey details, and publications can be found at https://aghealth.nih.gov/.

A major focus of the AHS is investigating how pesticides, including insecticides, herbicides, fungicides, and fumigants, affect cancer risk (see **Table 2** on page 12 for definitions). Researchers use information provided by AHS participants about their pesticide usage over time, while also taking into account important individual factors (e.g., age, sex, and smoking status) that might impact cancer risk. The AHS regularly links the study population to the cancer data in the Iowa Cancer Registry. This linkage tells researchers which AHS participants have been diagnosed with cancer and provides details about each cancer case. AHS researchers then use this information to study possible links between cancer and specific pesticides or other factors.

Since the study began, 11,347 cancers have been diagnosed in the farmers (6,478 in Iowa) and 5,254 in the spouses (3,436 in Iowa). These large numbers give researchers enough cases to study common cancers and even some rare ones, and the ability to learn more as additional cancers are diagnosed over time.

# Characteristics of Iowa Farmers and Their Spouses in the Agricultural Health Study

Most of the farmers who joined the AHS were men (99%), which is similar to the 1997 Census of Agriculture showing that about 95% of Iowa farmers at that time were men.[2] However, AHS farmers and their spouses differed from the general Iowa population in several ways as shown in **Table 1**. They tended to be middle-aged when they enrolled: about 40% of both farmers and spouses were between ages 45 and 64, and fewer than 10% were 65 or older. In the Iowa adult population overall, a smaller proportion was in the 45-64 age group and a larger proportion was 65 or older. Education levels also differed—a smaller proportion of men in the AHS attended some college compared to Iowa men overall (43% vs. 49%), while a larger proportion of women in the AHS attended some college compared to Iowa women overall (60% vs. 51%). Nearly all AHS farmers and spouses were white.

Iowa AHS farmers and spouses were less likely to smoke compared to the general Iowa population: farmers (11% vs. 25% of Iowa males at that time) and spouses (8% vs. 22% of Iowa females). Farmers and spouses were also less likely to drink alcohol at least once per month: farmers (61% vs. 68% of Iowa males at that time) and spouses (36% vs. 48% of Iowa females). A higher proportion of farmers used smokeless tobacco, though this question was asked differently in the farmers than the general population assessed.[3] More farmers and spouses were overweight or obese compared to males and females, respectively, in the general population. Of note, Iowa's current obesity rate of 38% has almost doubled compared to what it was in 1995 (~20%).

**Table 1.** Characteristics of the Iowa Agricultural Health Study participants at enrollment (1993-1997) compared to the general population of males and females ages 18+ in Iowa using Census Data from 1995 and 2000 and 1995 Behavioral Risk Factor Surveillance System data

| | Iowa AHS | State of Iowa | Iowa AHS | State of Iowa |
|---|---|---|---|---|
| | Male Farmers | Males | Female Spouses & Farmers | Females |
| **Number of People** | **N=31,433** | **N=1,010,480♦** | **N=22,145** | **N=1,107,437♦** |
| **Age at Enrollment**** | | | | |
| 18-44 years | 50% | 55%♦ | 50% | 50%♦ |
| 45-64 years | 41% | 28%♦ | 44% | 27%♦ |
| 65+ years | 8% | 17%♦ | 6% | 23%♦ |
| Race** | | | | |
| White | 99% | 96%♦ | 98% | 97%♦ |
| Black/Other | <1% | 4%♦ | <1% | 3%♦ |
| Education** | | | | |
| Less than high school | 5% | 15%♦ | 3% | 13%♦ |
| High school or equivalent | 50% | 36%♦ | 35% | 36%♦ |
| Some college or more | 43% | 49%♦ | 60% | 51%♦ |
| Smoking status at enrollment** | | | | |
| Never | 59% | 45%* | 75% | 61%* |
| Former | 29% | 31%* | 16% | 18%* |
| Current | 11% | 25%* | 8% | 22%* |
| Smokeless tobacco (snuff, chewing) at enrollment | 14% | 8%^ | <1% | unknown |
| Alcohol use at enrollment** | | | | |
| Never | 22% | 32%* | 32% | 52%* |
| Less than once per month | 14% | | 29% | |
| At least once per month | 61% | 68%* | 36% | 48%* |
| Body Mass Index | | | | |
| Underweight: <18.5 | <1% | 1%* | 1% | 3%* |
| Healthy weight: 18.5 - <25 | 25% | 34%* | 48% | 49%* |
| Overweight: 25 - <30 | 52% | 47%* | 32% | 28%* |
| Obese: ≥30 | 23% | 18%* | 19% | 20%* |

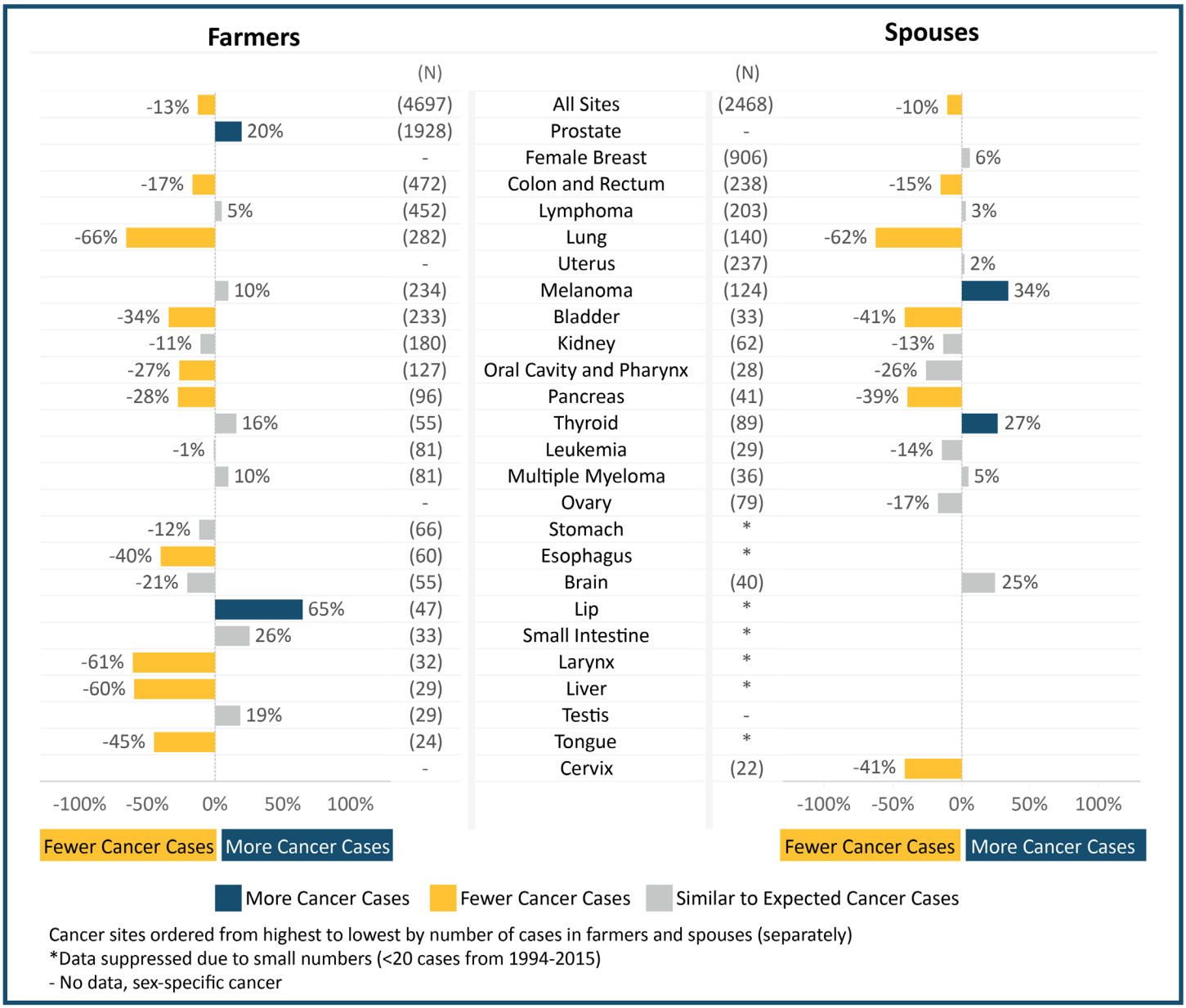
♦Number of Iowans and age from 1995 census; race and education from 2000 census; *smoking status, alcohol use, and BMI data from 1995 Iowa BRFSS
^ AHS asked about use for 6 months or more in their lifetime and Iowa data were based on a question about current use for 1992 and 1993[3]
**Percents may not add to 100% when there were missing data

# Cancer Experience in Farmers and Their Spouses in the Agricultural Health Study

Researchers compared cancer rates in the AHS to those in the overall Iowa population using a method called a "standardized incidence ratio." This method estimates how many cancer cases would be expected among AHS farmers and spouses if they developed cancer at the same rates as other Iowans. It then compares that expected number to the number of cancers actually found in the AHS group. Although the AHS group has a different mix of ages and includes far more men than the general population, this method adjusts for those differences. This allows researchers to determine whether cancer is more or less common among AHS participants than in Iowa overall.

**Figure 1** shows how the number of cancer cases in Iowa farmers and their spouses compared to the number that would be expected based on cancer rates in the overall Iowa population from 1994 to 2015.[4] In this figure, blue bars indicate cancers that occurred significantly more often than expected, yellow bars indicate cancers that occurred significantly less often than expected, and gray bars represent cancers that occurred at about the same rate as expected (not significantly different). Although the AHS originally included both private and commercial pesticide applicators, the results shown here focus only on farmers (private pesticide applicators) and their spouses.

**Figure 1.** Percent difference of cancer cases by cancer sites evaluated in Iowa farmers and spouses, 1994-2015




Iowa specific data are found in supplemental table 2 [https://pmc.ncbi.nlm.nih.gov/articles/PMC6459699/#SM1]

**Cancers That Occurred Less Often in AHS Participants**

Farmers had 13% fewer cancer cases overall than expected based on rates in the Iowa general population. Cancers that occurred less often in farmers included: colon and rectum, lung, bladder, oral cavity and pharynx, pancreas, esophagus, larynx, liver, and tongue.

Spouses had 10% fewer cancers overall than expected. Among spouses, cancers that occurred less often included: colon and rectum, lung, bladder, pancreas, and cervix.

AHS researchers suggested that possible reasons for the lower cancer burden include the following:

- The "healthy worker effect", which means that people who are working—especially in physically demanding jobs like farming—tend to be healthier than the general population because they must be well enough to continue working.
- Many of the cancers that were less common in the AHS are linked to behaviors people can change, like smoking and drinking alcohol.[4] Farmers and their spouses in the study reported smoking and drinking less often than the general Iowa population when they joined the study, which may help explain their lower rates of these cancers.

**Cancers That Occurred More Often in AHS Participants**

Prostate Cancer

Farmers were diagnosed with 20% more cases of prostate cancer than expected. Over the 22-year follow-up period, 1,928 farmers were diagnosed with prostate cancer (about 88 cases per year). Risk factors for prostate cancer include age, family history (such as BRCA2), and African American race. While less is known about modifiable risk factors in the general population, AHS analyses have found that high exposure to certain organophosphate insecticides (such as dimethoate, fonofos, malathion, terbufos, and aldrin) may increase the risk of aggressive prostate cancer.[5,6] "Aggressive" cancers include distant stage, poorly differentiated grade, high Gleason score, or fatal prostate cancer. AHS researchers have also studied other possible risk factors, including:

- How genetic susceptibility interacts with pesticide exposure[7]
- Arsenic and selenium levels measured in toenails[8]
- Dietary factors, such as omega-3 fatty acid intake from fish, seeds, and nuts[9]
- Nitrate in drinking water (more information can be found on Page 15)

These studies show how multiple factors—genetic, environmental, and lifestyle-related—may work together to influence prostate cancer risk. In addition, potential differences in screening practices and healthcare access may also be contributors to observed differences in prostate cancer.

Lip Cancer

Farmers were diagnosed with 65% more cases of lip cancer than expected. There were 47 lip cancer cases (excluding melanoma) diagnosed among farmers over 22 years—about two cases per year. Most of the excess were cancers of the external lip, suggesting that sun exposure (UV radiation) played a major role. Farmers also reported higher rates of smokeless tobacco use, which may contribute.

Melanoma

Spouses were diagnosed with 34% more cases of melanoma than expected. There were 124 spouses diagnosed with melanoma over the 22-year follow-up period (an average of 6 cases per year). Sunlight, primarily from UV radiation, is the main risk factor for melanoma. The risk of melanoma increases with increased sun exposure and severe sunburns.[10]

Thyroid Cancer

Spouses were diagnosed with 27% more cases of thyroid cancer than expected. There were 89 spouses diagnosed with thyroid cancer over the 22-year follow-up period (an average of 4 cases per year). Thyroid cancer most commonly occurs among women ages 30-60. Known risk factors include some hereditary conditions and family history, as well as radiation exposure, excess body weight, and diets low in iodine. AHS analyses reported that greater exposure to malathion (an insecticide) was associated with increased risk of thyroid cancer among spouses.[11]

Cancer often takes a long time to develop. Many years can pass between being exposed to something that increases cancer risk and actually showing symptoms or receiving a diagnosis. Because of this long delay, the exposure information collected from farmers and spouses in the mid-1990s is still very important for understanding cancers that appear many years later. AHS participants will continue to be followed over time, and an updated comparison of their cancer rates with those of the Iowa population is expected in the coming years.

# Common Exposures Among Farmers and Their Spouses in the Agricultural Health Study

The AHS collected detailed information on each participant's exposure to specific pesticides. Farmers provided information about which pesticides they used, including how they mixed and applied them, their use of personal protective equipment, and if they repaired their own pesticide equipment. Spouses reported their own personal use of specific pesticides and general household pesticide use.

This information was used to estimate participants' lifetime exposure to commonly used pesticides. For example, those who did not report using personal protective equipment were estimated to have higher exposure levels than those who did. These estimates were supported by field studies conducted by the EPA and NIOSH.

Researchers have also combined information collected by the AHS with information from other studies to estimate exposure to pesticides brought home on clothing, use of pesticides around the home, and agricultural drift (when pesticide dust or droplets are carried by the wind to unintended areas).

When examining potential cancer risk factors among farmers and spouses, AHS researchers focused on chemicals commonly encountered in the workplace and the environment. Data collected at the start of the study showed that over 90% of farmers and 40% of spouses reported lifetime mixing or application of at least one herbicide or insecticide, the most common classes of pesticides (**Table 2**).

**Table 2.** Common pesticide exposures among Iowa Agricultural Health Study participants at enrollment, 1993–1997

| | | Percent Reporting Use | |
|---|---|---|---|
| **Class of Pesticide*** | **Definition** | **Farmers** | **Spouses** |
| Herbicides | Control unwanted plants or weeds that compete with crops for nutrients, water, and sunlight | 97% | 40% |
| Insecticides | Specifically target insects that damage crops, stored products, or spread diseases | 92% | 40% |
| Fungicides | Protect plants from fungal diseases that can cause significant crop losses | 18% | 3% |
| Fumigants | Pesticides that, when applied to soil, form a gas to control pests that live in the soil and can disrupt plant growth and crop production | 9% | 1% |

*Report lifetime ever use of at least one of 50 pesticides (18 herbicides, 22 insecticides, 6 fungicides, 4 fumigants)

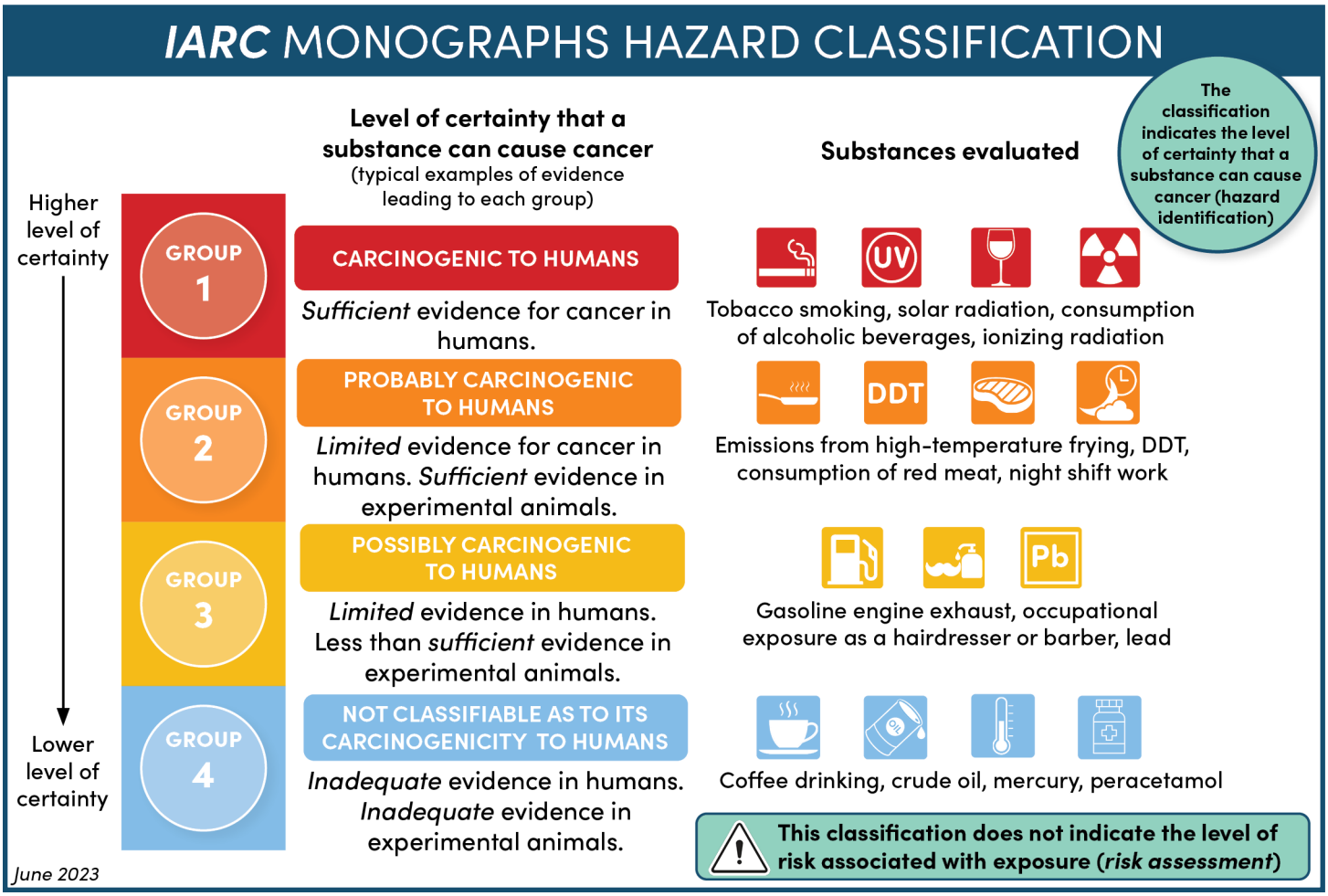
# How the Agricultural Health Study has Contributed to Classification of Pesticides as Cancer-Causing Agents

Since its beginning, AHS researchers have published more than 60 scientific papers that examined potential associations between numerous pesticides and various types of cancer. Results from these studies have suggested increased risk of certain types of cancer with specific pesticides. Some of the studies represent the first time that a specific pesticide-cancer relationship has been investigated. However, it takes multiple research studies and strong evidence to determine that an agent (e.g., substance, chemical, or exposure) causes cancer. As are all studies of pesticides conducted in humans, the AHS is an observational epidemiological study, meaning that researchers document events that occur rather than conducting experiments by giving people doses of chemicals. Because of this, it is always important to try to replicate any findings from an epidemiological study in other populations. In addition to other epidemiological evidence, it is also important to have supporting evidence from other types of studies, such as toxicological studies, which can provide insight into mechanisms by which a pesticide or other agent might cause cancer.

The Monographs Programme of the International Agency for Research on Cancer (IARC) is an organization that identifies agents that can cause cancer in humans. IARC convenes Working Groups of scientists with a range of expertise to review all pertinent studies of a particular agent in humans, animals, and in laboratory studies to determine whether the strength of evidence is enough to categorize the agent as a carcinogen. The agent is then classified based on its cancer-causing potential (shown in **Figure 2**). Classifications can change over time as more studies are conducted. Since it began in 1971, IARC has evaluated over 1,000 agents.

IARC does not recommend regulations, legislation, or public health interventions, which remain the responsibility of individual governments and other international organizations. In the U.S., the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the federal statute that governs the registration, distribution, sale, and use of pesticides and is overseen by the EPA. EPA's Office of Pesticide Programs evaluates pesticides as part of FIFRA, and its risk evaluation considers hazard and exposure- how people come into contact with the chemical and the expected conditions of use.

**Figure 2.** IARC monographs hazard classification




https://www.iarc.who.int/

While IARC assesses the strength of evidence that an agent can cause cancer in humans, the primary goal of EPA's Office of Pesticide Programs Review Registration Process is to ensure that, when applied as instructed, a pesticide will not cause unreasonable risk to human health or the environment. The EPA uses an independent review of animal and other studies, with dose, duration, route, and real-world exposure context as part of the estimated risk assessment.

Once a pesticide is registered by the EPA, there are two primary ways that a pesticide registration may be canceled: 1) the company may request cancellation or 2) the EPA could re-evaluate the product and remove some or all uses based on current scientific knowledge of the risks to human health or the environment. The EPA can also classify pesticides as 'Restricted Use', which must be labeled as such, and can only be purchased and/or used by certified pesticide applicators who undergo required training, testing, and continuing education. More information on the EPA and pesticide registration and regulation can be found at https://www.epa.gov/pesticides.

**Table 3** lists the ten pesticides with residential or agricultural use classified by IARC with sufficient evidence that the pesticide can cause cancer in humans (**Group 1** agents) or with limited evidence that the pesticide causes cancer in humans and either convincing evidence it causes cancer in laboratory animals or strong evidence that the pesticide has key characteristics of causing cancer in humans (**Group 2A** agents). **Table 3** also contains the EPA cancer classification, as well as the registration status for use in the U.S.

AHS findings were considered in the IARC hazard classifications for one **Group 1** (lindane) and all seven **Group 2A** pesticides (alachlor, atrazine, dichlorodiphenyltrichloroethane [DDT], diazinon, dieldrin, glyphosate, and malathion). Published findings from the AHS were among the studies considered in the ruling for those agents in the rows shaded yellow; the evaluation for arsenic occurred before the beginning of the AHS and AHS did not collect information on pentachlorophenol as its primary use is as an industrial wood preservative.

**Table 3.** Group 1 (carcinogenic hazard to humans) and Group 2A (probably carcinogenic hazard to humans) pesticide classifications (for pesticides with residential or agricultural use) by IARC and classification and status by the U.S. EPA

Published findings from the AHS were among the studies considered in the ruling for those agents in the rows shaded yellow

| Agent | Cancer Type Caused (Strongest Evidence) | EPA Cancer Classification | U.S. EPA Registration Status | IARC Monograph |
|---|---|---|---|---|
| **IARC Group 1 – Carcinogenic Hazard to Humans** | | | | |
| Arsenic and inorganic arsenic compounds (including arsenical insecticides) | Lung, urinary bladder, skin; possibly kidney, liver, prostate | Carcinogenic to humans | Many registrations for specific chemicals canceled or severely restricted in U.S. | 23 |
| Lindane (Hexachlorocyclo-hexanes) | Non-Hodgkin lymphoma | Likely to be carcinogenic | Use severely restricted in U.S.; no agricultural use | 113 |
| Pentachlorophenol (PCP) | Non-Hodgkin lymphoma | Likely to be carcinogenic | All registrations canceled in U.S. | 117 |
| **IARC Group 2A – Probably Carcinogenic Hazard to Humans** | | | | |
| Alachlor | Larynx | Likely to be carcinogenic | No active registrations in U.S. | 140 |
| Atrazine | Non-Hodgkin lymphoma | Suggestive evidence of carcinogenicity | Still registered for some agricultural use | 140 |
| DDT (4,4'-dichlorodiphenyl-trichloroethane) | Liver, testis, non-Hodgkin lymphoma | Likely to be carcinogenic | All registrations canceled in U.S. | 113 |
| Diazinon | Non-Hodgkin lymphoma, leukemia, lung | Suggestive evidence of carcinogenicity | Residential use banned in 2004, still registered for some agricultural use | 112 |
| Dieldrin, and aldrin metabolized to dieldrin | Breast | Likely to be carcinogenic | All registrations canceled in U.S. | 117 |
| Glyphosate | Non-Hodgkin lymphoma | Not likely to be carcinogenic | Residential products ceased by manufacturer in 2023; still registered for agricultural use | 112 |
| Malathion | Non-Hodgkin lymphoma, prostate | Suggestive evidence of carcinogenicity | Registered for some residential and agricultural use | 112 |

# Research on Nitrate in Drinking Water in the Agricultural Health Study

Nitrate and nitrite are chemicals that are naturally found in soil, water, and some foods, especially green leafy vegetables and root vegetables. Dietary nitrate ingestion from vegetables is associated with beneficial health effects likely due to the presence of antioxidants, whereas nitrate and nitrite ingested from drinking water are often consumed without antioxidants and therefore can react with other substances to form toxic N-nitroso compounds (NOCs). Notably, nitrite reacts directly with hemoglobin to form methemoglobin, which can lead to methemoglobinemia (often referred to as "blue baby syndrome"). NOC formation is the hypothesized mechanism for cancer and birth defects. The U.S. EPA drinking water maximum contaminant level (MCL) for nitrate (10 mg/L $NO_3$-N) was set to protect against blue baby syndrome and did not consider other adverse health outcomes such as cancer.

Public water supply systems are required to deliver a Consumer Confidence Report (annual drinking water quality report) to their customers (see Resources section). Unlike public water supplies, which are regulated by the U.S. EPA under the Safe Drinking Water Act, it is the responsibility of the private well owner to test for and remove nitrate and other chemicals from their water. The highest nitrate levels are often found in shallow wells and surface water near farms, where fertilizer and animal waste can run off into the water. Thus, private wells or springs can be important sources of nitrate contamination in drinking water. Approximately 282,000 Iowans obtain their water from a private water supply.[12]

AHS participants were asked about their source of drinking water, with 71% reporting that they used a private well or spring. The AHS did not collect well water samples directly from these participants; rather they developed models[13] to estimate nitrate levels in their wells using 34,084 available measurements of wells in Iowa that were collected from 1980-2011. Samples were collected and compiled through several studies by agencies (not specific to AHS participants) including Iowa Department of Natural Resources (IDNR), U.S. Geological Survey, and Center for Health Effects of Environmental Contamination (CHEEC) at the University of Iowa. CHEEC and IDNR maintain historic water quality datasets available to the public such as Iowa Trust Your Tap (https://trustyourtap.org/), the Iowa Well Forecasting System (https://igs.iihr.uiowa.edu/igs/wellforecasting/), and the Drinking Water Portal (https://programs.iowadnr.gov/iowadrinkingwater).

For those AHS participants who did not report using a private well for their drinking water, their address was linked to public water supply data, including rural water supplies.[14] Water quality monitoring data for Iowa public water supply systems were obtained from CHEEC at the University of Iowa.[15] Researchers found that nitrate concentrations in private wells were higher than those in public water supplies; 12% of Iowa private well users had nitrate estimates above the U.S. EPA MCL of 10 mg/L.[14] It has been estimated that about 79% of AHS farmers in Iowa with private wells have ever tested their wells for nitrate.[16]

Once the AHS investigators were able to establish estimates of nitrate levels for most AHS participants, they began studying the relationship between elevated nitrate levels and cancer. Two studies have been published so far:

- A recently published study using AHS data focusing on prostate cancer, showed that those with drinking water nitrate-nitrogen exposure at average levels >10 mg/L had increased risk for prostate cancer, particularly aggressive disease, compared to those with average levels <1 mg/L.[15] This analysis was the first prospective study to evaluate drinking water nitrate exposures and prostate cancer risk.
- Another recent AHS study suggested that the risk of ovarian cancer was elevated with increasing levels of drinking water nitrate, though this association was not statistically significant.[17]

Further investigation is needed to determine if these relationships are found in other populations.

# Contributions from the Agricultural Health Study

The AHS is one of the only large, long-term studies in the world designed to understand how agricultural, lifestyle, and genetic factors influence the health of farming families. The contributions of the thousands of Iowa farmers and their spouses has made this possible. Since the 1990s, the AHS has greatly expanded our understanding of cancer risks linked to certain pesticides and other agricultural exposures. The study has also shown that lifestyle factors are important. For example, the lower rates of smoking and alcohol use in the farmers and their spouses likely contributed to their lower overall rate of cancer compared to the general Iowa population. However, cancer is extremely complex, and many other factors may influence why study participants have fewer cancers overall. While we have learned a great deal from AHS research, there is still much to be done to understand the complex ways that agricultural environments interact with people's work practices and other daily habits to influence their risk of cancer and other chronic diseases.

# Resources Related to Pesticide Exposure

While the AHS focused exclusively on the farming population, there are many resources available for anyone concerned about exposure to pesticides or drinking water contaminants such as nitrate.

According to the U.S. EPA, the most effective way to reduce risks posed by pesticides is to use non-chemical control methods to reduce or eliminate pest problems.[18] The U.S. EPA provides guidance on Integrated Pest Management Principles that can be applied to both agricultural and non-agricultural settings: https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles.

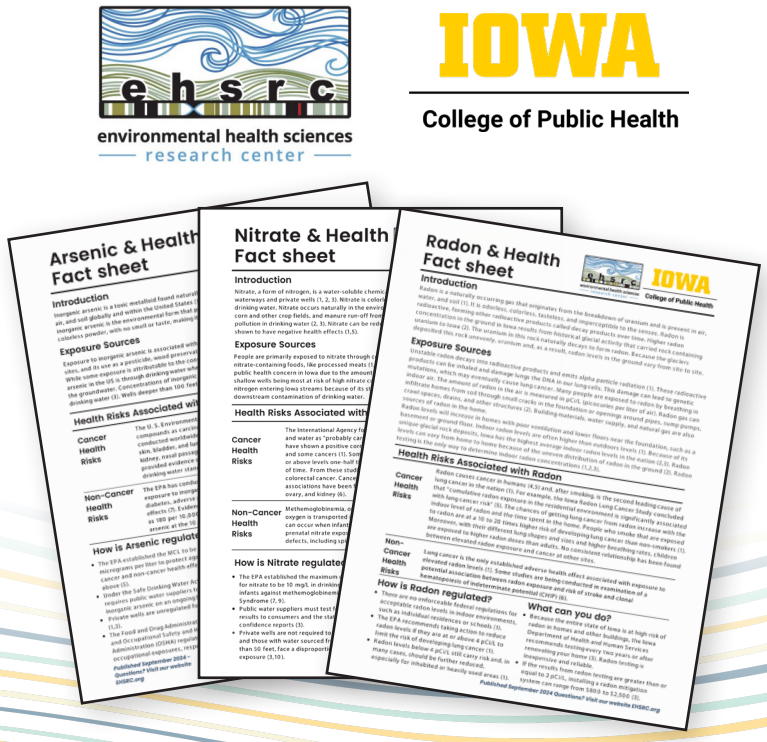
Pesticide safety tips are available from the U.S. EPA at https://www.epa.gov/pesticide-incidents/pesticide-safety-tips or the National Pesticide Information Center at https://npic.orst.edu/.

If using pesticides, follow the label as directed, including using the appropriate personal protective equipment.

- Consumer product labels contain valuable use instructions and precautions that can help you keep your family, pets, and community safe. By reading the label first, you can prevent accidents from occurring.
- Labels tell you how to use a product safely and effectively, how to store the product safely, how to give first aid, and where to call for help or more information.

The Center for Energy & Environmental Education housed at the University of Northern Iowa (https://ceee.uni.edu/) is focused on empowering Iowans with the knowledge, experiences, tools, and inspiration needed to create a sustainable and desirable future for our communities. They offer technical assistance and services, educational programs, and leadership in energy and environmental conservation, community-based agriculture, and environmental health.

The Environmental Health Sciences Research Center housed at the University of Iowa (https://ehsrc.public-health.uiowa.edu/) has a mission to continually advance knowledge and awareness of environmental health science that improves quality of life among rural and agricultural populations. They have created Environmental Exposures and Health Risks Fact Sheets in response to concerns from community members about the connections between contaminants in the environment and health outcomes such as cancer and other diseases. Topics covered include arsenic, atrazine, glyphosate, nitrate and radon and can be found at https://ehsrc.public-health.uiowa.edu/wp-content/uploads/2024/10/Environmental-Health-and-Cancer-Fact-Sheets-1.pdf



# Resources Related to Drinking Water Contaminants

If you use private well water, learn how to get your water tested and information on the Private Well Grant Program at https://www.iowadnr.gov/environmental-protection/water-quality/private-well-program.

If you are on a public water supply, the U.S. EPA requires community water systems to deliver a Consumer Confidence Report, also known as an annual drinking water quality report, to their customers by July 1st of each year. The report includes:

- The lake, river, aquifer, or other source of the drinking water
- A brief summary of the risk of contamination of the local drinking water source
- The regulated contaminant(s) found in local drinking water
- The potential health effects of any contaminant detected in violation of an EPA health standard
- The system's actions to restore safe drinking water

If you did not receive a report, you can call your local water supplier or find your report at http://ofmpub.epa.gov/apex/safewater/f?p=136:102.

If you need help on how to read a Consumer Confidence Report, please see the video at https://www.youtube.com/watch?v=OAbr9uAJecA.

The Center for Health Effects of Environmental Contamination housed at the University of Iowa (https://cheec.uiowa.edu/about) supports and conducts research to identify, measure, and study adverse health outcomes related to exposure to environmental toxins. The center was established through the 1987 Iowa Groundwater Protection Act and has focused its efforts mainly on drinking water contaminants.

CENTER FOR HEALTH EFFECTS OF ENVIRONMENTAL CONTAMINATION

**Understanding Cancer and Environmental Risk Factors in Iowa**

A New Initiative from the Iowa Environmental Council and The Harkin Institute

The Harkin Institute

Iowa Environmental Council

The Harkin Institute and the Iowa Environmental Council have embarked on an initiative that explores the relationship between environmental risk factors and cancer rates in Iowa. The initiative is the first of its kind to combine a rigorous review of existing academic research about environmental risk factors and their sources with a statewide campaign to listen to, understand, and amplify Iowans' own lived experiences with cancer. For more Information, see https://www.iaenvironment.org/.

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For a list of all AHS publications see https://aghealth.nih.gov/news/publications.html

# Acknowledgements

This publication is a product of the Iowa Cancer Registry. We would also like to acknowledge and thank the many organizations who provided expert review of this report.

- Center for Health Effects of Environmental Contamination
- Environmental Health Sciences Research Center
- Heartland Center for Occupational Health and Safety
- Holden Comprehensive Cancer Center
- Iowa Cancer Consortium
- Iowa Department of Health and Human Services
- The University of Iowa College of Public Health

**We offer our deepest gratitude to the thousands of Iowa farmers and their family members who have generously agreed to participate in this ongoing study and share their information to help us learn about exposures that might impact cancer risk in farmers.**

This report has been funded in part with federal funds from the National Cancer Institute, National Institutes of Health, and the Department of Health and Human Services under Contract No. HHSN261201800012I_ HHSN26100001.

Published March 2026
Design by:
Ann Armstrong
Design Center, The University of Iowa
uiowa.edu/designcenter



Iowa CANCER REGISTRY ICR

STATE HEALTH REGISTRY OF IOWA

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PUBLIC HEALTH