



# Leukemia in Ohio, 2003-2007

## This Report on Leukemia Contains:

- Incidence and Mortality Rates in Ohio and the U.S.
- Incidence and Mortality Rates by Type, Age, Sex and Race
- Maps of Incidence Rates by County for Adults and Children
- Trends in Incidence for Adults and Children
- Survival Probability by Type, Age and Sex
- Risk Factors
- Signs and Symptoms
- Clinical Trials
- Sources of Data and Additional Information

## Leukemia Incidence and Mortality

Leukemia made up 2.3 percent of the incident (newly diagnosed) cancers reported to the Ohio Cancer Incidence Surveillance System (OCISS)<sup>1</sup> from 2003 through 2007 (Table 1). The average annual age-adjusted leukemia incidence rate during this time period was 11.1 cases per 100,000 persons, or an average of 1,351 cases per year (N). The 2003-2007 average annual age-adjusted U.S. (SEER<sup>2</sup>) incidence rate of 12.3 cases per 100,000 persons was 10.8 percent higher than the rate for Ohio. Estimated completeness of reporting for leukemia in Ohio was 84 percent in 2003-2007, which is less than the national standard of 95 percent for complete case ascertainment. Therefore, the leukemia incidence rates presented in this report may underestimate the true leukemia burden in Ohio. The Ohio leukemia mortality rate<sup>3</sup> of 7.7 deaths per 100,000 persons in 2003-2007 was 6.9 percent greater than the U.S. (NCHS<sup>4</sup>) mortality rate (7.2 per 100,000 persons).

**Table 1: Leading Sites/Types of Cancer and Esophageal Cancer: Average Annual Number (N), Percent (%) and Age-adjusted Rates of Invasive Cancer Cases and Cancer Deaths in Ohio with Comparison to the US (SEER and NCHS), 2003-2007<sup>1,2,3</sup>**

Incidence	N	%	Ohio Rate	U.S. Rate	Mortality	N	%	Ohio Rate	U.S. Rate
<b>All Sites/Types</b>	<b>58,136</b>		<b>470.0</b>	<b>461.1</b>	<b>All Sites/Types</b>	<b>24,917</b>		<b>199.6</b>	<b>183.8</b>
Lung and Bronchus	9,295	16.0%	75.0	62.5	Lung and Bronchus	7,411	29.7%	59.7	52.5
Breast (Female)*	8,073	28.3%	119.9	122.9	Colon and Rectum	2,456	9.9%	19.6	17.6
Prostate*	7,961	26.9%	145.5	156.9	Breast (Female)*	1,875	7.5%	26.5	24.0
Colon and Rectum	6,370	11.0%	51.1	47.9	Pancreas	1,381	5.5%	11.1	10.7
Bladder	2,691	4.6%	21.6	21.1	Prostate*	1,232	4.9%	26.2	24.7
Non-Hodgkin's Lymphoma	2,380	4.1%	19.3	19.6	Non-Hodgkin's Lymphoma	921	3.7%	7.4	6.9
⋮					⋮				
<b>Leukemia</b>	<b>1,351</b>	<b>2.3%</b>	<b>11.1</b>	<b>12.3</b>	<b>Leukemia</b>	<b>952</b>	<b>3.8%</b>	<b>7.7</b>	<b>7.2</b>

[1] Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.

[2] SEER: Surveillance, Epidemiology and End Results Program, National Cancer Institute, 2010.

[3] Vital Statistics Program, Ohio Department of Health, 2010.

[4] NCHS: National Center for Health Statistics, 2010.

\*The rates of breast (female) and prostate cancer are sex specific (i.e., the population denominator is females or males only).

### Technical Notes:

- Leukemia cases were defined as follows: International Classification of Diseases for Oncology, Third Edition (ICD-O-3), Types 9733; 9742; 9800; 9801; 9805; 9820; 9823 (sites C420, C421 and C424); 9826; 9827 (sites C420, C421 and C424); 9831; 9832-9834; 9835-9837; 9840; 9860; 9861; 9863; 9866; 9867; 9870; 9871-9874; 9875; 9876; 9891; 9895-9897; 9910; 9920; 9930; 9931; 9940; 9945; 9946; 9948; 9963; 9964. Leukemia deaths were defined as follows: International Statistical Classification of Diseases and Related Health Problems, Tenth Edition (ICD-10), codes C901; C910-C959.
- The 2003-2007 rates were calculated using vintage 2008 postcensal estimates for July 1, 2003-2007 (U.S. Census Bureau, 2009). Rates are direct age-adjusted to the U.S. 2000 standard population.
- N = Average number of cases per year rounded to the nearest integer.

## Leukemia Type

Leukemia is cancer that originates in the bone marrow and causes the production of abnormal blood cells, particularly white blood cells that help the body to fight infections and other diseases. Leukemia can be either acute or chronic. In acute leukemia, abnormal blood cells are unable to properly mature and cannot carry out normal functions. These abnormal cells accumulate more rapidly and the disease worsens more quickly. In chronic leukemia, the cells can mature, but are not completely normal and do not fight infection as well. Leukemia can arise in either of two main types of white blood cells – lymphoid cells or myeloid cells. The four primary types of leukemia are the following:

**Acute Lymphocytic (ALL):** Occurs when a bone marrow cell develops errors in its DNA, which causes the production of immature white blood cells called lymphoblasts. ALL is the most common type in young children, but also affects adults, mainly those ages 65 and older.

**Acute Myeloid (AML):** Caused by damage to the DNA of developing cells in bone marrow. AML occurs in both adults and children, but it is most common in adults age 65 and older.

**Chronic Lymphocytic (CLL):** Results from a genetic mutation in the DNA of blood-producing cells, leading to progressive accumulation of small, mature-appearing lymphocytes in blood lymph nodes, the spleen and bone marrow. Most often affects adults age 55 and older and is rare in children.

**Chronic Myeloid (CML):** Results from injury to the DNA of a stem cell in the bone marrow leading to uncontrolled growth of white cells. Occurs mainly in adults.

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## Leukemia Incidence by Age and Type

As seen in Table 2 and Figure 1, the incidence of leukemia in Ohio varied according to age group and type of leukemia. For ALL, the average age at diagnosis was 22.6 years; however, almost half (44 percent) of the cases occurred among children less than 10 years of age. The average ages at diagnosis of AML, CLL and CML were 62.0, 71.1, and 63.3 years, respectively. The incidence of CLL, AML and CML increased with advancing age, reaching a peak among adults 85 and older for CLL and 80-84 for AML and CML. Leukemia incidence in the U.S. follows patterns similar to those shown in Figure 1 for Ohio.

Figure 2 presents 1996-2007 average annual age-adjusted leukemia incidence rates by county of residence. As shown in Figure 2, county-specific leukemia incidence rates in Ohio ranged from 8.6 to 20.4 per 100,000 persons. To illustrate the concept that disease patterns do not abruptly change at county boundaries, Figure 3 displays the pattern of incidence after the county rates are smoothed—a statistical method in which rates are adjusted to consider the rates of neighboring geographical areas. Leukemia incidence rates are shown to be higher in the northwest, central and eastern areas of the state.

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## Leukemia Incidence by Age and Type

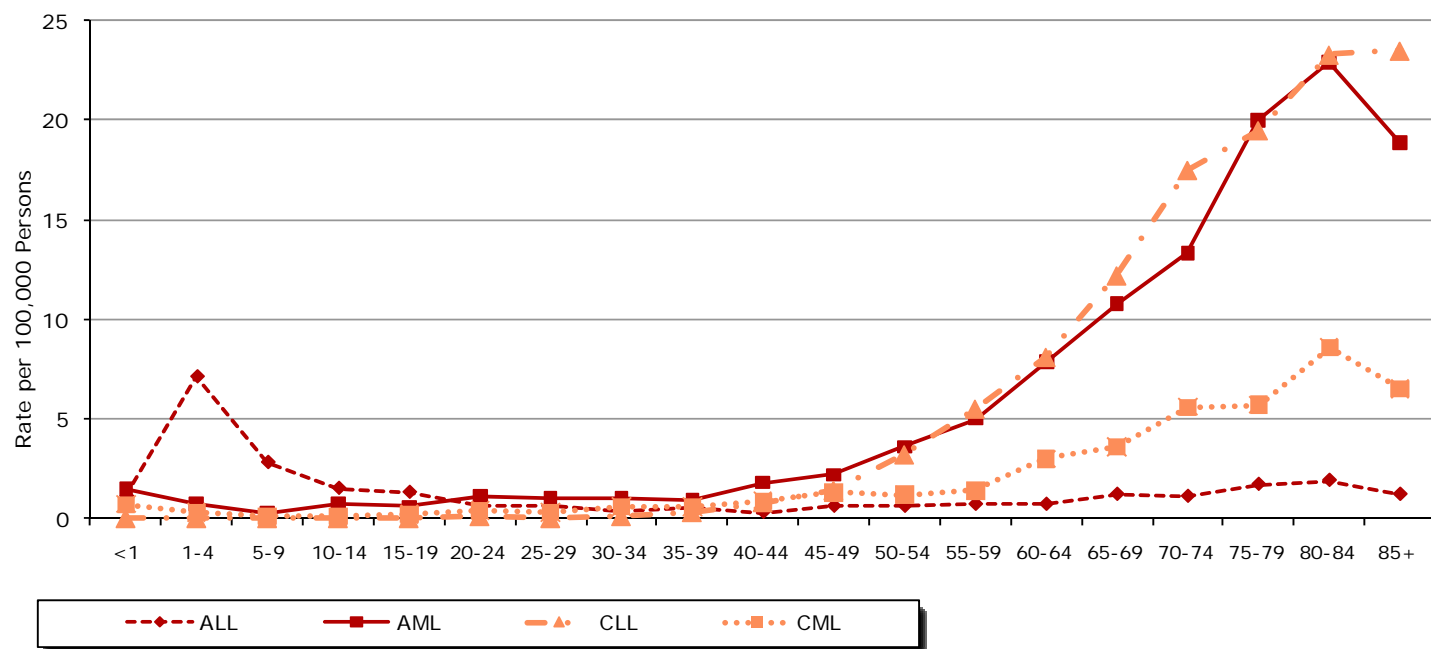
Table 2: Leukemia: Average Annual Number of Cases (N), Age-specific Incidence Rates per 100,000 Persons and Age-specific Percentages, by Type in Ohio, 2003-2007

Age Group	Leukemia Subtypes												All Leukemia		
	ALL			CLL			AML			CML			N	Rate	Percent
	N	Rate	Percent	N	Rate	Percent	N	Rate	Percent	N	Rate	Percent	N	Rate	Percent
<1	2	1.1	1.1%	0	*	0.0%	2	1.5	0.5%	1	0.7	0.6%	5	3.6	0.4%
1-4	42	7.1	28.4%	0	*	0.0%	4	0.7	1.0%	2	0.3	1.0%	50	8.4	3.7%
5-9	21	2.8	14.5%	0	*	0.0%	3	0.3	0.6%	<1	*	0.2%	26	3.4	1.9%
10-14	12	1.5	8.4%	0	*	0.0%	5	0.7	1.2%	1	0.1	0.6%	20	2.5	1.5%
15-19	11	1.3	7.3%	0	*	0.0%	5	0.6	1.1%	2	0.2	1.1%	19	2.4	1.4%
20-24	5	0.6	3.3%	<1	*	0.1%	9	1.1	2.0%	3	0.4	1.7%	18	2.4	1.4%
25-29	5	0.6	3.1%	<1	*	0.0%	8	1.0	1.7%	2	0.3	1.4%	18	2.5	1.4%
30-34	3	0.4	2.0%	1	0.1	0.2%	8	1.0	1.7%	4	0.6	2.5%	18	2.4	1.3%
35-39	4	0.5	2.8%	3	0.3	0.6%	7	0.9	1.6%	5	0.6	3.0%	24	3.1	1.8%
40-44	3	0.3	2.0%	7	0.8	1.7%	15	1.8	3.5%	8	0.9	5.0%	40	4.6	3.0%
45-49	5	0.6	3.4%	12	1.4	3.0%	20	2.2	4.5%	12	1.3	7.2%	56	6.3	4.2%
50-54	5	0.6	3.4%	26	3.2	6.4%	30	3.6	6.7%	10	1.2	6.2%	82	10.1	6.1%
55-59	5	0.7	3.4%	38	5.5	9.3%	34	5.0	7.8%	10	1.4	6.2%	99	14.3	7.3%
60-64	4	0.7	2.6%	42	8.1	10.3%	41	7.9	9.3%	16	3.0	9.8%	119	22.9	8.8%
65-69	5	1.2	3.4%	51	12.2	12.5%	45	10.8	10.2%	15	3.6	9.3%	128	30.8	9.5%
70-74	4	1.1	2.7%	62	17.5	15.1%	47	13.3	10.7%	20	5.6	12.3%	154	43.7	11.4%
75-79	5	1.7	3.5%	61	19.5	15.0%	63	20.0	14.3%	18	5.7	11.0%	179	57.0	13.3%
80-84	4	1.9	3.0%	55	23.3	13.5%	54	22.9	12.3%	20	8.6	12.6%	158	66.9	11.7%
85+	2	1.2	1.6%	49	23.5	12.0%	39	18.9	9.0%	14	6.5	8.4%	135	64.8	10.0%

Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.

\* Rates may be unstable and are not presented when the case count for 2003-2007 is less than five (*i.e.*, N<1).

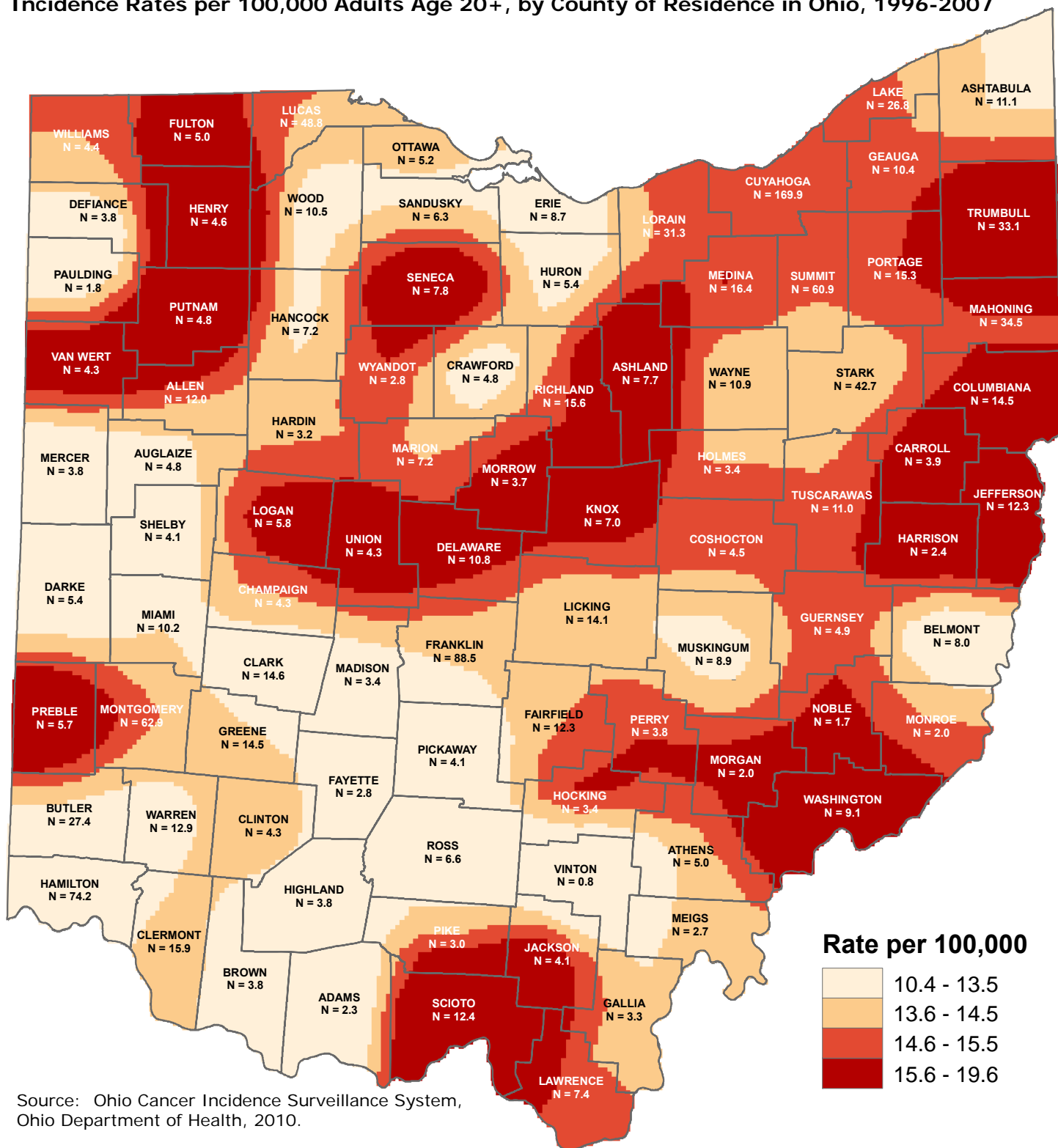
Figure 1: Leukemia: Age-specific Incidence Rates per 100,000 Persons, by Leukemia Type in Ohio, 2003-2007



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.



**Figure 3: Leukemia: Smoothed Pattern of Incidence, Based on Average Annual, Age-adjusted Incidence Rates per 100,000 Adults Age 20+, by County of Residence in Ohio, 1996-2007**



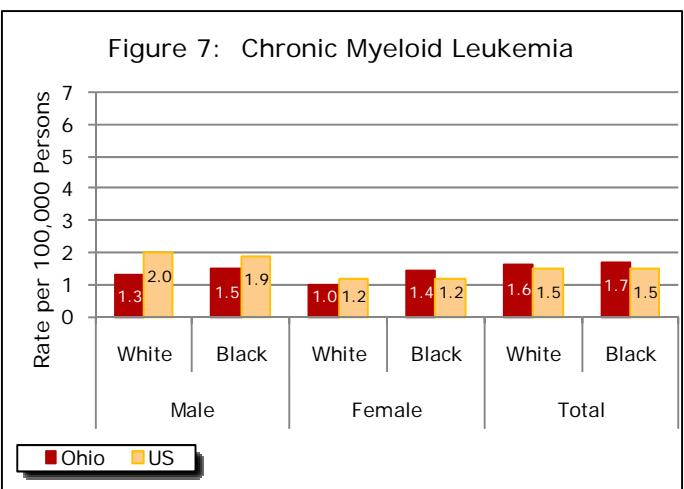
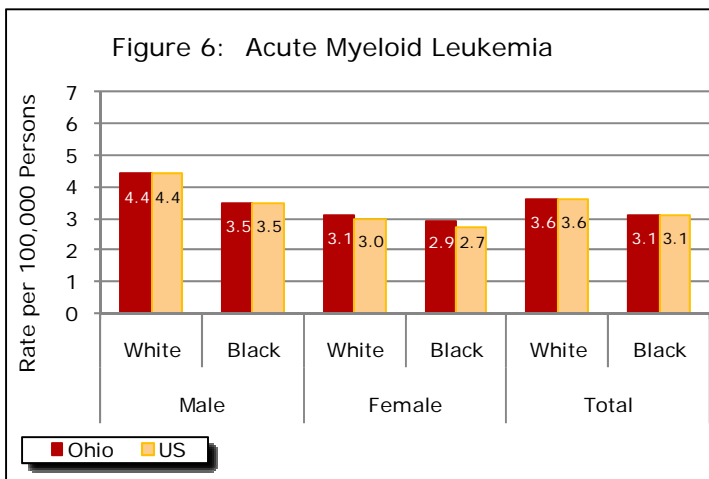
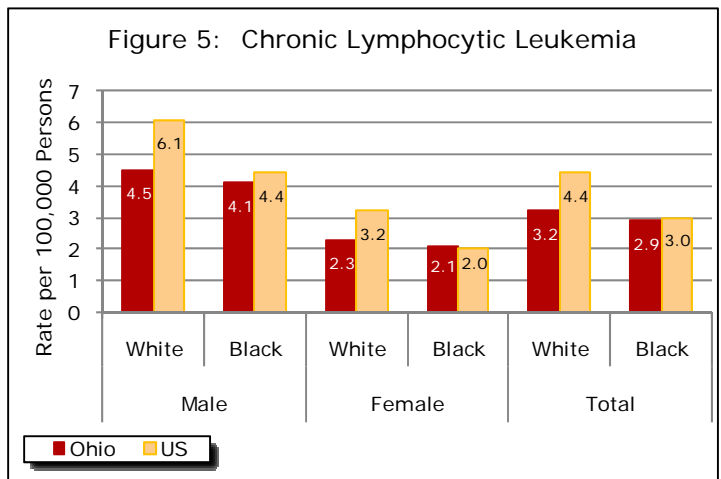
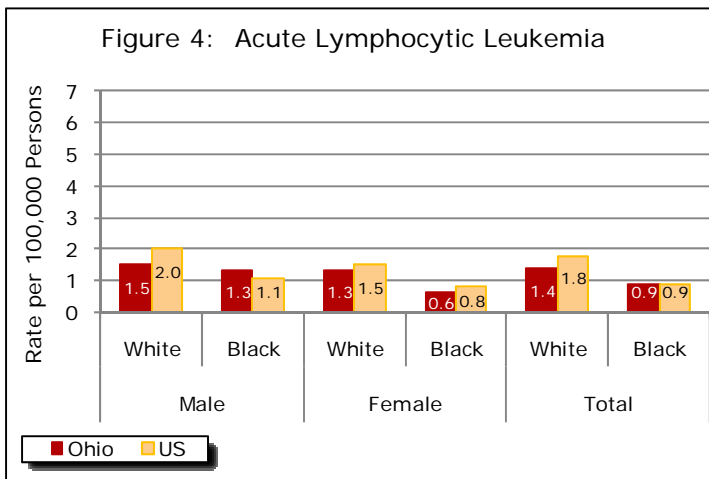
Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.

- N = Average number of cases *per year* (= Total cases in 1996-2007 ÷ 12 years).
- Each category represents approximately 25% of the 88 Ohio counties.

## Incidence of Leukemia by Type, Sex and Race

As shown in Figures 4-7, the incidence of leukemia varied according to sex, race and the type of leukemia. In both Ohio and the U.S. (SEER), the incidence rates of CLL and AML were greater than those for ALL and CML. In both Ohio and the U.S., the leukemia type that was greatest for white and black males was CLL, and the leukemia type that was greatest for white and black females was AML, with the exception of U.S. white females, for which CLL was greatest. For each type of leukemia, in both Ohio and the U.S., incidence rates for whites and blacks were greater for males, compared to females. Incidence rates of ALL, CLL and AML were greater for whites (both sexes combined) compared to blacks in both Ohio and the U.S., but the incidence rates of CML were similar for whites and blacks. For most of the race- and sex-specific comparisons, incidence rates were lower or identical in Ohio compared to the U.S.. However, it should be noted that the 2003-2007 estimated completeness of reporting for leukemia is 84 percent (lower than the national standard of 95 percent complete), which may be responsible for the lower incidence rates in Ohio.

**Figures 4-7: Average Annual Age-adjusted Incidence Rates per 100,000 Persons, by Type of Leukemia, Sex and Race in Ohio with Comparison to the US, 2003-2007<sup>1,2</sup>**



[1] Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.

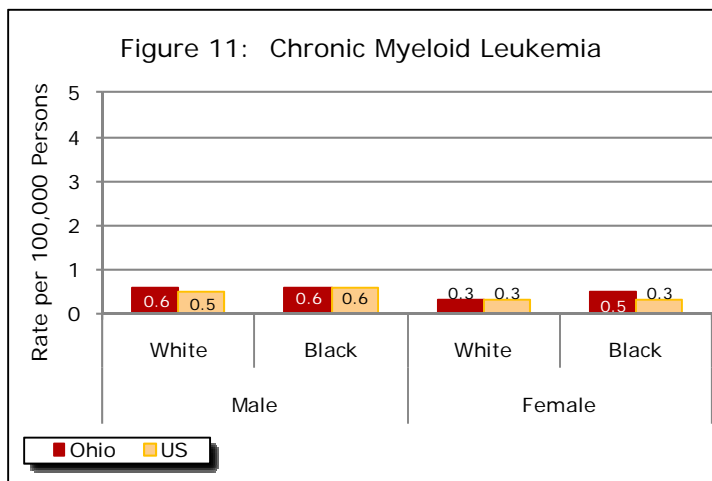
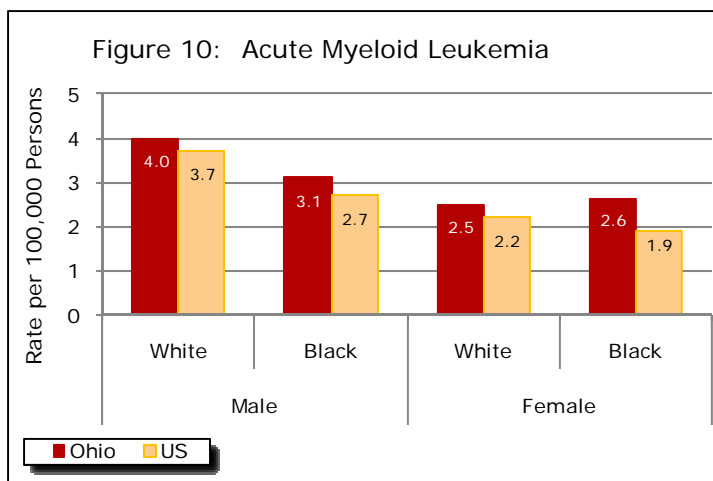
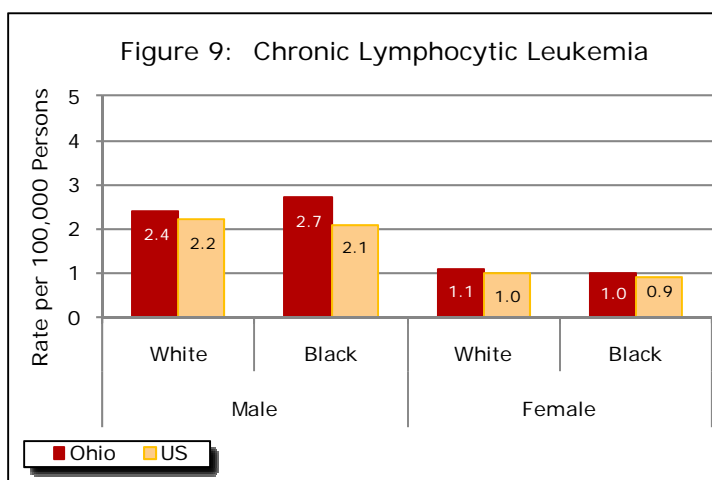
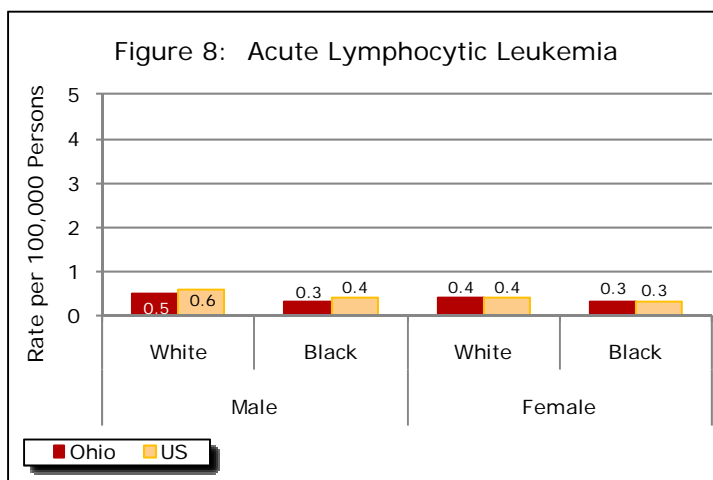
[2] SEER: Surveillance, Epidemiology and End Results Program, National Cancer Institute, 2010.

Note: Rates in Ohio may be lower because of underreporting.

## Mortality of Leukemia by Type, Sex and Race

As shown in Figures 8-11, leukemia mortality rates varied according to sex, race and the type of leukemia. In both Ohio and the U.S. (NCHS), the mortality rates of CLL and AML were higher than those of ALL and CML. For each leukemia type, in both Ohio and the U.S., mortality rates for whites and blacks were greater or identical for males, compared to females. Race- and sex-specific CLL and AML mortality rates were higher in Ohio, compared to the U.S., while ALL and CML mortality rates in Ohio and the U.S. were similar. The CLL mortality rate for black males was 29 percent higher in Ohio, and the AML mortality rate for black females was 37 percent higher in Ohio, compared to the U.S..

**Figures 8-11: Average Annual Age-adjusted Mortality Rates per 100,000 Persons, by Type of Leukemia, Sex and Race in Ohio with Comparison to the US, 2003-2007<sup>1,2</sup>**

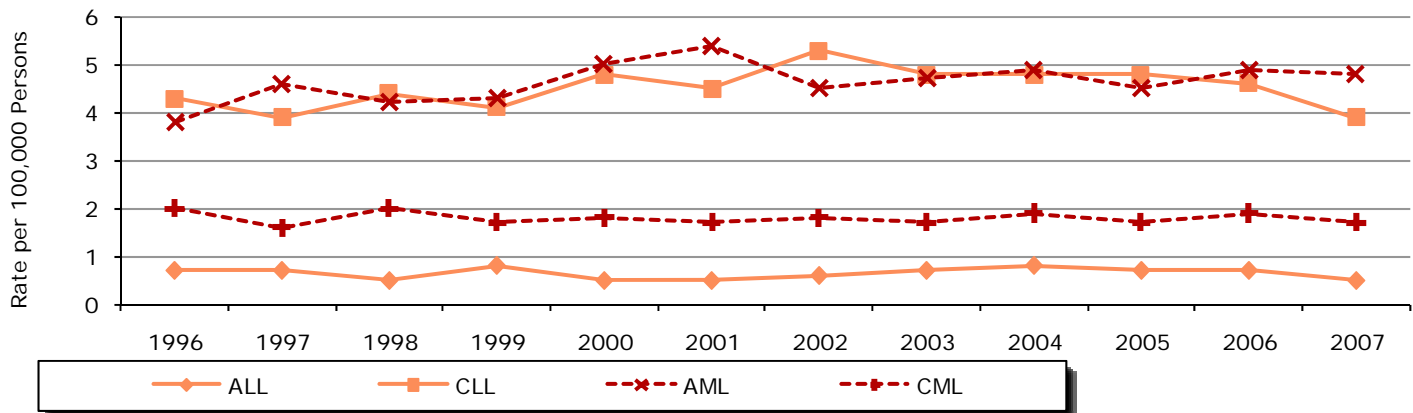


[1] Vital Statistics Program, Ohio Department of Health, 2010.

[2] NCHS: National Center for Health Statistics, 2010.

## Leukemia Incidence Trends

**Figure 12: Leukemia: Trends in Average Annual Age-adjusted Incidence Rates per 100,000 Persons Age 20 and Older, by Subtype in Ohio, 1996-2007**



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.

Figure 12 shows incidence rates of leukemia in Ohio adults (age 20+) according to year of diagnosis (1996 through 2007) by leukemia type. For each year, incidence rates of CLL and AML were greater than those for ALL and CML. From 1996 to 2007, the incidence rates for ALL, CLL, AML and CML did not increase or decrease over time, although the rates for CLL and AML were more variable.

## Childhood Leukemia

Leukemia is the most common type of cancer among children, making up about one-third of childhood cancers. Figure 13 shows the incidence of leukemia in Ohio and the U.S. among those age 19 and younger according to sex and race. In Ohio and the U.S., incidence rates were greater for males, compared to females and for whites, compared to blacks. For both males and females, the incidence rates among whites in Ohio were lower than those among whites in the U.S., while Ohio rates among blacks were greater than those for blacks in the U.S..

Figure 14 shows incidence rates of leukemia in Ohio among those age 19 and younger according to year of diagnosis (1996 through 2007) by leukemia type. Similar to the U.S. (not shown), for each year, the incidence rate was highest for ALL, followed by AML and CML. From 1996 to 2007, the incidence rates for ALL, AML and CML were relatively stable, with the exception of a spike in the incidence rate of CML in 2007 (0.5 per 100,000).

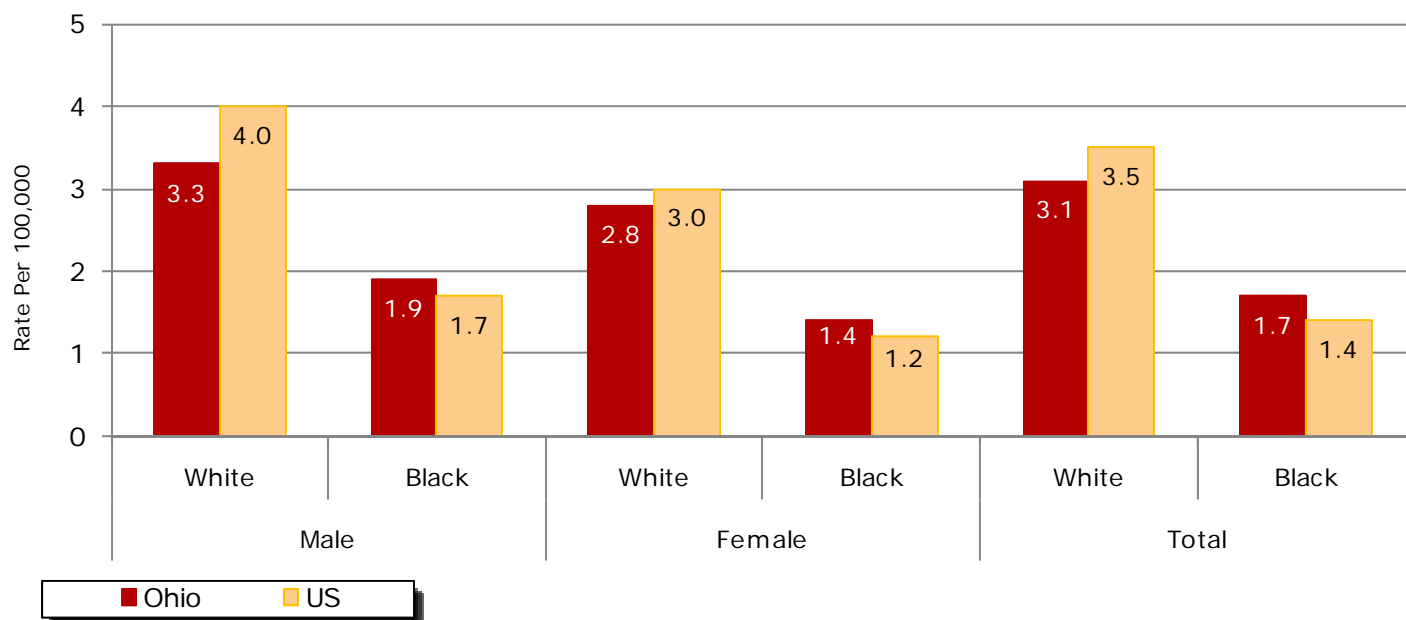
### Childhood Acute Lymphocytic Leukemia (ALL)

ALL is the most common type of childhood leukemia. Other than genetic diseases/syndromes and radiation exposure, little is known about the causes of childhood ALL. Groups with higher ALL incidence rates include males, whites, those ages two to six, and those with higher socioeconomic status. Due to improvements in treatment, five-year survival probability for childhood ALL has greatly increased over the past 40, years from less than 10 percent to about 80 percent.



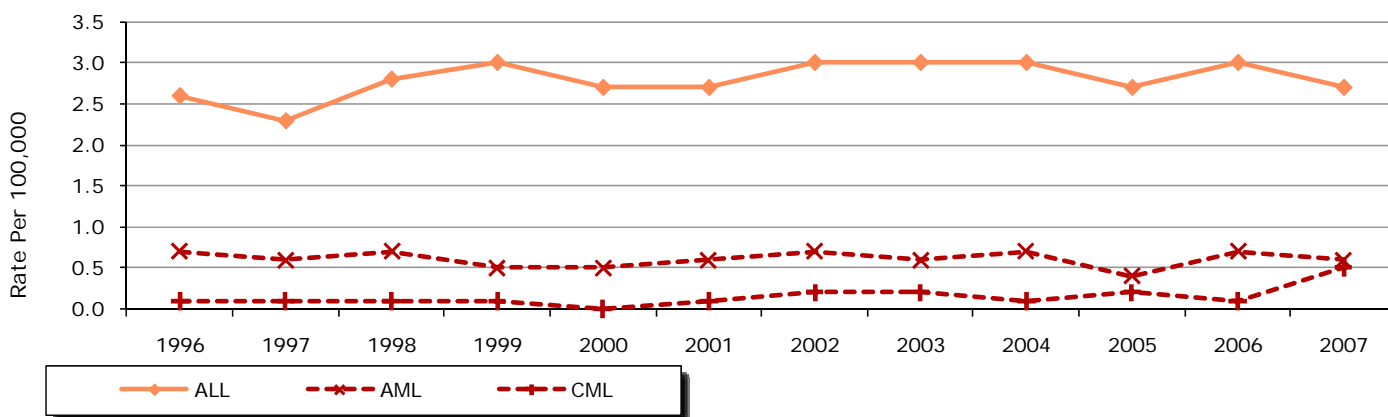
## Childhood Leukemia

Figure 13: ALL: Average Annual Age-adjusted Incidence Rates per 100,000 Persons Age 19 and Younger, by Race and Sex in Ohio with Comparison to the US, 2003-2007<sup>1,2</sup>



[1] Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.  
 [2] Surveillance, Epidemiology and End Results Program, National Cancer Institute, 2010.

Figure 14: Leukemia: Trends in Average Annual Age-adjusted Incidence Rates per 100,000 Persons Age 19 and Younger, by Type in Ohio, 1996-2007



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2010.

Figure 15 presents 1996-2007 average annual age-adjusted leukemia incidence rates in children (age 0–19) by county of residence. County-specific leukemia incidence rates in Ohio ranged from 2.6 to 13.5 per 100,000 children. To illustrate the concept that disease patterns do not abruptly change at county boundaries, Figure 16 displays the pattern of incidence after the county rates are smoothed—a statistical method in which rates are adjusted to consider the rates of neighboring geographical areas. Due to the large number of unstable rates at the county level, it is difficult to draw conclusions regarding the geographic distribution of childhood leukemia in Ohio.





## Leukemia Survival Probability

Table 3: Leukemia: Five-year Survival Probability (%) by Age Group, Sex and Leukemia Type in the US (SEER), 1999-2006

Five-year Survival Probability (%)															
Age	All Leukemia			ALL			CLL			AML			CML		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
< 45	68.8%	68.0%	69.8%	75%	73.4%	77.2%	91.1%	89.2%	94.3%	52.1%	49.9%	54.6%	78.2%	76.7%	80.5%
45-54	61.5%	63.0%	59.2%	26.6%	25.8%	27.7%	88.8%	87.5%	91.5%	32.0%	31.5%	32.7%	77.4%	75.6%	79.7%
55-64	57.6%	57.6%	57.5%	18.1%	17.6%	18.7%	85.0%	82.3%	90.5%	19.7%	16.9%	23.3%	63.0%	62.2%	64.4%
65-74	47.8%	46.1%	50.2%	9.8%	8.6%	11.2%	80.7%	77.5%	85.5%	8.7%	6.8%	11.2%	39.5%	35.9%	45.3%
75+	33.9%	33.1%	34.7%	6.1%	5.6%	6.5%	65.2%	62.6%	67.8%	1.9%	1.8%	1.9%	24.7%	23.2%	26.1%

Source: Surveillance, Epidemiology and End Results Program, National Cancer Institute, 2010.

Table 3 shows that the U.S. (SEER) five-year leukemia survival probability in 1999-2006 for all leukemia types combined varied according to age, with 68.8 percent surviving five years among those less than 45 years and 33.9 percent surviving among those 75 years and older. For both males and females and for each leukemia type, survival probability decreased with advancing age group. Survival probability was highest for CLL for each category of age and sex. For each age group, the survival probability for persons diagnosed with acute leukemia (ALL and AML) was lower than the probability for those diagnosed with chronic leukemia (CLL and CML). For each leukemia type and for each age group, a higher proportion of females survived at least five years, compared to males.

### Did You Know?

Treatment for leukemia depends on many factors, including age, overall health, leukemia type, and whether it has spread to other parts of the body. Common treatments used to fight leukemia include:

- **Chemotherapy** is the major form of treatment for leukemia. This drug treatment uses chemicals to kill leukemia cells.
- **Biological therapy** works by helping the immune system recognize and attack leukemia cells.
- **Targeted therapy** uses drugs that attack specific vulnerabilities within cancer cells.
- **Radiation therapy** uses X-rays or other high-energy beams to damage leukemia cells and stop their growth.
- **Stem cell transplant** is a procedure to replace diseased bone marrow with healthy bone marrow.

## Leukemia Cancer Risk Factors

Risk factors are different for the different types of leukemia. Having one or more risk factors does not mean that a person will develop leukemia. Most people who have risk factors never develop leukemia. According to the National Cancer Institute, the following are leukemia risk factors:

- **Age:** ALL is most commonly diagnosed among children; whereas, AML, CLL and CML occur mainly in adults.
- **Sex:** Leukemia is more common among men, compared to women.
- **Race:** Whites have higher rates of leukemia, compared to African Americans.
- **Radiation:** People exposed to very high levels of radiation (such as that from atomic bomb explosions and radiation therapy) are much more likely than others to get AML, CML and ALL.
- **Smoking:** Smoking cigarettes increases the risk of AML.
- **Benzene:** Exposure to benzene in the workplace can cause AML. It may also cause CML or ALL.
- **Chemotherapy:** Cancer patients treated with certain types of cancer-fighting drugs sometimes later get AML or ALL.
- **Down Syndrome and certain other inherited diseases:** Down syndrome and certain other inherited diseases increase the risk of developing acute leukemia.
- **Myelodysplastic syndrome and certain other blood disorders:** People with certain blood disorders are at increased risk of AML.
- **Human T-cell leukemia virus (HTLV-I):** People with HTLV-I infection are at increased risk of a rare type of leukemia known as adult T-cell leukemia.
- **Family history of leukemia:** Family history of CLL increases risk of CLL.

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## Leukemia Signs and Symptoms

Although there are usually no early signs of leukemia, a number of symptoms may appear as the cancer grows:

- Fatigue and weakness
- Pale skin
- Weight loss
- Repeat infections
- Fever and night sweats
- Bruising easily
- Nosebleeds and hemorrhages
- Swollen lymph nodes, especially in the neck or armpit
- Swelling or discomfort in the abdomen

It is possible that one or more of these signs and symptoms may be the result of other health problems. If you have any of these symptoms, you should consult with your health care provider.

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## Clinical Trials Information

Clinical trials test many types of treatments including new drugs, surgical procedures, radiation therapy and combinations of these. The goal of conducting clinical trials is to find better ways to treat cancer. To obtain information concerning clinical trials for leukemia, please talk with your health care provider or visit one of the following web sites:

- **National Cancer Institute:**  
<http://www.cancer.gov/clinicaltrials>
- **American Cancer Society:**  
[http://www.cancer.org/docroot/ETO/ETO\\_6.asp?sitearea=ETO](http://www.cancer.org/docroot/ETO/ETO_6.asp?sitearea=ETO)
- **The Ohio State University Comprehensive Cancer Center—Arthur G. James Cancer Hospital and Richard J. Solove Research Institute:**  
[http://cancer.osu.edu/patientsandvisitors/cancerinfo/clinical\\_trials/Pages/index.aspx](http://cancer.osu.edu/patientsandvisitors/cancerinfo/clinical_trials/Pages/index.aspx)
- **The Cleveland Clinic:**  
[http://my.clevelandclinic.org/cancer/clinical\\_trials/default.aspx](http://my.clevelandclinic.org/cancer/clinical_trials/default.aspx)
- **Case Western Reserve University Comprehensive Cancer Center:**  
<http://cancer.case.edu/sharedresources/clinicaltrials>
- **University of Cincinnati:**  
<http://uccancer.com/PatientCare/ClinicalTrials/Overview.aspx>
- **Toledo Community Hospital Oncology Program:**  
<http://www.tchop.com/clinical/default.asp>
- **Dayton Clinical Oncology Program:**  
<http://www.med.wright.edu/dcop/Clinical%20Trials.htm>
- **Columbus Community Clinical Oncology Program:**  
<http://www.columbusccop.org>

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## Sources of Data and Additional Information

- **Ohio Cancer Incidence Surveillance System:**  
[http://www.odh.ohio.gov/odhPrograms/dis/ociss/ci\\_surv1.aspx](http://www.odh.ohio.gov/odhPrograms/dis/ociss/ci_surv1.aspx)
  - **National Cancer Institute:**  
<http://www.cancer.gov/cancertopics/types/leukemia>
  - **American Cancer Society:**  
<http://www.cancer.org/cancer/index> (Search by leukemia type under "Select a Cancer Type")
-

**To address comments and information requests:**

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Web site: [http://www.odh.ohio.gov/healthstats/ocisshs/ci\\_surv1.aspx](http://www.odh.ohio.gov/healthstats/ocisshs/ci_surv1.aspx)

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