August 2014

CHILD & ADOLESCENT CANCER IN OHIO, 1996-2011

Cancer is a group of diseases characterized by uncontrolled growth and spread of abnormal cells. If the spread is not controlled, it can result in death. Approximately 1 percent of all new cancers in the United States occur in children and adolescents. Cancer is the second leading cause of death in children ages 5-14.

The news of a cancer diagnosis is never easy but may be even more difficult when a child or adolescent is diagnosed. Cancer is much less common in children than adults; approximately 1 in 285 children in the United States will be diagnosed with cancer before the age of 20.

In this document, childhood cancer is defined as cancer diagnosed among persons ages 0-14 and adolescent cancer is among persons ages 15-19. The rates in this document are presented as the number of cases per 1,000,000 persons, whereas rates for adults are typically reported as the number of cases per 100,000 persons.

The types of cancer that develop in children and adolescents differ from those that develop in adults. Page 2 shows a list of the most common types of cancer in these age groups. While cancers occurring in adults are classified by the anatomical site of the primary tumor, cancers in children and adolescents are classified by histology (tissue type) into 12 major groups using the International Classification of Childhood Cancers (ICCC), available at: http://seer.cancer.gov/iccc/iccc-who2008.html.

In the United States in 2014, an estimated 10,450 new cancer cases and 1,350 cancer deaths are expected to occur among children and 5,330 new cases and 610 deaths are expected among adolescents. An estimated 379,112 survivors of child and adolescent cancer were alive in the United States as of January 1, 2010.

Key Findings

- Cancer incidence and mortality rates among both children and adolescents are lower in Ohio compared to the United States.
- Child and adolescent cancer incidence and mortality rates are higher among males compared to females, whites compared to blacks and adolescents compared to children in both Ohio and the United States.
- In Ohio, the leading cancer types among children are lymphoid leukemia (23 percent) and brain and other central nervous system (CNS) tumors (23 percent).
- The leading cancer types among adolescents in Ohio are Hodgkin lymphoma (17 percent) and germ cell tumors (13 percent).
- Incidence rates of child and adolescent cancer do not exhibit a clear geographic pattern in Ohio at the county level.
- Incidence rates for all cancer types combined in Ohio were relatively stable among children from 1996 to 2011; in contrast, incidence rates among adolescents increased slightly during this time period.
- Mortality rates of all child and adolescent cancers combined declined significantly from 1996 to 2011 in Ohio.
- The causes of cancer among children and adolescents are largely unknown. Certain chromosomes, genetic syndromes and ionizing radiation are known risk factors, but only explain a small percentage of cases.
- Signs and symptoms of child and adolescent cancer are similar to other common conditions in this age group; thus, early diagnosis is difficult.
- The U.S. five-year survival probability for all cancer types combined is 82.1 percent among children and 83.2 percent among adolescents.

Common Cancer Types among Children and Adolescents

The common types of cancer that develop in children and adolescents include:

Acute myeloid leukemia: Cancer of blood-forming cells arising in the bone marrow that starts from myeloid cells and grows quickly. Acute myeloid leukemia accounts for about 15 percent and 31 percent of leukemia cases in children and adolescents, respectively.

Bone tumors: Cancer that forms in cells of the bone. The most common types of bone cancer in children are osteosarcoma and Ewing sarcoma.

Brain and other CNS tumors: The growth of abnormal cells in the tissues of the brain and other CNS. The most common types of brain and other CNS tumors in children are medulloblastoma, astrocytoma, ependymoma and brain stem glioma. Brain and other CNS tumors account for 21 percent and 10 percent of the cancer cases among children and adolescents, respectively.

Germ cell tumors: A diverse group of tumors that arise from either the ovaries in girls or the testicles in boys. These tumors are most common in adolescents.

Hepatic tumors: Cancer that forms in the tissues of the liver.

Hodgkin lymphoma: Cancer of the lymphatic system that is marked by the presence of a type of cell called the Reed–Sternberg cell. Hodgkin lymphoma often starts in the lymph nodes in the chest, neck or abdomen. Hodgkin lymphoma is rare in children, but increases rapidly from age 10 through adolescence.

Lymphocytic leukemia: Cancer of blood-forming cells arising in the bone marrow that starts from lymphocytes. Lymphocytic leukemia may be acute and develop quickly or chronic and develop slowly. Acute lymphocytic leukemia accounts for about 80 percent of leukemia cases in children.

Melanoma of the skin: Cancer that begins in melanocytes (cells that make the pigment melanin) in the skin.

Neuroblastomas: Cancer that arises in immature nerve cells and affects mostly infants and children.

Non-Hodgkin lymphoma: Cancer of the lymphatic system, excluding Hodgkin lymphoma. The most common types of non-Hodgkin lymphoma in children are Burkitt lymphoma, lymphoblastic lymphoma and large cell lymphoma.

Renal tumors: Cancer of the kidney. The vast majority of kidney tumors in children are Wilms tumor.

Retinoblastomas: Cancer that forms in the tissues of the retina (the light-sensitive layers of nerve tissue at the back of the eye).

Soft tissue sarcomas: Cancer that begins in the muscle, fat, fibrous tissue, blood vessels or other supporting tissue of the body. The most common soft tissue sarcoma is rhabdomyosarcoma.

Thyroid cancer: Cancer that forms in the thyroid gland.

Risk of Cancer among Children and Adolescents

Table 1 shows the risk of being diagnosed with invasive cancer by age 20 for all types of cancer combined and selected types by sex in the United States. One in 270 males and one in 301 females will be diagnosed with invasive cancer by age 20. Risk of being diagnosed with each cancer type in Table 1 is greater among males compared to females and whites compared to blacks (race data not shown in Table 1).

Table 1: Risk of Being Diagnosed with Invasive Cancer by Age 20 for Selected Types by Sex in the United States, 2008-2010[1,2,3]

	Males	Females
All Cancer Types	1 in 270	1 in 301
Brain & Other CNS Tumors	1 in 1,570	1 in 1,717
Hodgkin Lymphoma	1 in 3,848	1 in 4,051
Leukemia (all types)	1 in 1,017	1 in 1,232
Lymphocytic Leukemia	1 in 1,355	1 in 1,718
Non-Hodgkin Lymphoma	1 in 3,325	1 in 6,505

1. Source: DevCan: Probability of Developing or Dying of Cancer Software, Version 6.7.0; Statistical Research and Applications Branch, National Cancer Institute, 2013.
2. Risk of developing cancer by age 20 for those free of cancer at birth, based on cancer cases diagnosed during 2008-2010.
3. Numbers are rounded to the nearest whole person.

One in 408 children and adolescents will develop invasive cancer by age 15 and one in 285 by age 20.

Cancer Clusters

A cancer cluster is a greater than expected number of cancer cases among a group of people in a geographic area over a defined period of time. True cancer clusters often involve:

- Multiple cases of one type of cancer or related cancers
- Unusual types of cancer in a particular population
- Unusual geographic or time distribution of cases
- Known exposure pathway to a cancer-causing agent

Cancer clusters are often not the result of environmental pollution; rather, clusters most often occur due to shared behaviors and lifestyle factors such as high rates of tobacco use, lack of access to preventive health care, increased rates of screening (which may identify previously undiagnosed cases), low socioeconomic status and chance, among other reasons. Because childhood cancer is rare and has a short latency period, childhood cancer clusters are particularly concerning and often warrant further investigation. However, only a small proportion of childhood cancers have known or preventable causes; thus, it is unlikely that one single factor can be identified as the cause of a childhood cancer cluster.

Cancer Incidence and Mortality among Children and Adolescents

In 2007-2011, an average of 505 new invasive cancer cases and 63 cancer deaths occurred each year among children and adolescents in Ohio (Table 2). The average annual age-adjusted incidence rate in Ohio was 163.4 cases per 1,000,000, which was 6.4 percent lower than the U.S. incidence rate of 174.6 per 1,000,000. The Ohio child and adolescent cancer mortality rate of 20.3 deaths per 1,000,000 in 2007-2011 was 15.4 percent lower than the U.S. mortality rate (24.0 per 1,000,000). In both Ohio and the United States, child and adolescent cancer incidence and mortality rates were greater for males, whites and those ages 15 to 19 years.

Table 2: All Cancer Types: Average Annual Number of New Invasive Cancer Cases and Age-adjusted Incidence Rates per 1,000,000, and Average Annual Number of Cancer Deaths and Age-adjusted Mortality Rates per 1,000,000, among Children and Adolescents (Ages 0-19), by Sex, Race and Age Group in Ohio and the United States, 2007-2011 (Incidence) and 2006-2010 (Mortality)

		Incidence			Mortality		
		Ohio		U.S.	Ohio		U.S.
		Cases	Rate	Rate	Deaths	Rate	Rate
Sex	Males	272	172.0	183.9	35	22.1	26.0
	Females	233	154.3	164.7	28	18.5	22.0
Race	White	416	167.2	187.7	52	20.7	25.0
	Black	64	120.4	129.8	9	17.7	23.0
Age Group	0-14	344	152.9	160.6	44	19.8	22.0
	15-19	161	194.4	216.3	18	21.8	30.0
Total		**505**	**163.4**	**174.6**	**63**	**20.3**	**24.0**

Source: Ohio Cancer Incidence Surveillance System, Chronic Disease and Behavioral Epidemiology Section and the Office of Vital Statistics, Ohio Department of Health, 2014; Surveillance, Epidemiology and End Results Program, National Cancer Institute, 2014; National Center for Health Statistics, 2013.

In 2007-2011, child and adolescent cancer incidence and mortality rates were lower in Ohio compared to the United States.

Leading Cancer Types among Children and Adolescents in Ohio

Figure 1: Leading Cancer Types: Average Annual Number and Proportion of New Invasive Cancer Cases in Children (Ages 0-14) and Adolescents (Ages 15-19) in Ohio, 2007-2011

Children (Ages 0-14)

Lymphoid leukemia
79 (23%)

Brain & other CNS tumors
79 (23%)

Soft tissue sarcomas
23 (7%)

Neuroblastomas
22 (6%)

Renal tumors
21 (6%)

Acute myeloid leukemia
18 (5%)

Bone tumors
13 (4%)

Non-Hodgkin lymphoma
12 (4%)

Hodgkin lymphoma
11 (3%)

Germ cell tumors
10 (3%)

Retinoblastomas
9 (3%)

All types
343

Adolescents (Ages 15-19)

Hodgkin lymphoma
27 (17%)

Germ cell tumors
21 (13%)

Thyroid cancer
16 (10%)

Brain & other CNS tumors
15 (9%)

Non-Hodgkin lymphoma
13 (8%)

Lymphoid leukemia
12 (7%)

Melanoma of the skin
12 (7%)

Soft tissue sarcomas
11 (7%)

Acute myeloid leukemia
7 (5%)

Bone tumors
7 (4%)

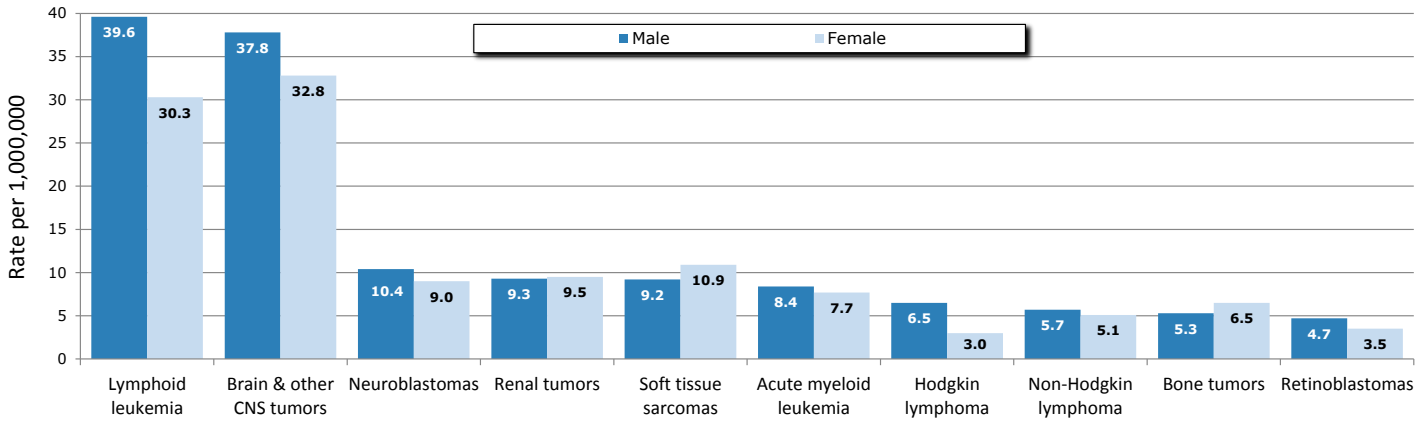
Hepatic tumors
2 (1%)

All types
161

Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Figure 1 shows the average annual number and proportion of new invasive cancer cases among children and adolescents in Ohio from 2007-2011 for the leading types of cancer in these age groups. Lymphoid leukemia (79 cases) and brain and other CNS tumors (79 cases) each accounted for 23 percent of the newly diagnosed cancers among children in this time frame. Hodgkin lymphoma was the leading cancer in adolescents (27 cases, 17 percent), followed by germ cell tumors (21 cases, 13 percent) and thyroid cancer (16 cases, 10 percent).

Figure 2: Leading Cancer Types among Children (Ages 0-14): Average Annual Age-adjusted Incidence Rates per 1,000,000, by Sex in Ohio, 2007-2011

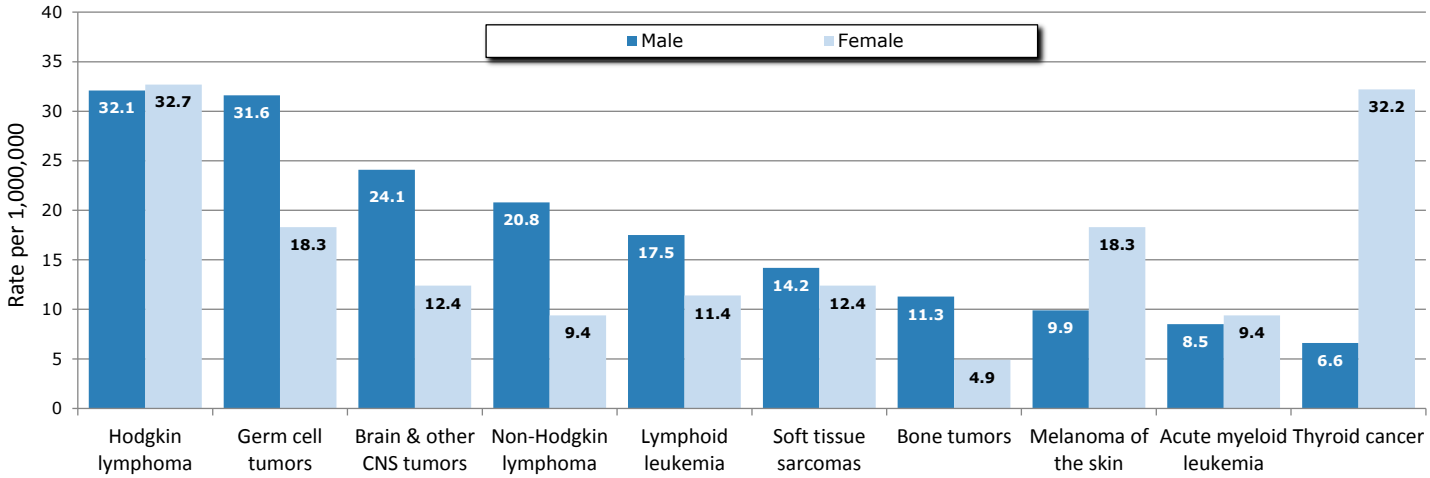


Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Figure 2 shows the 2007-2011 average annual age-adjusted incidence rates for the leading cancer types among children in Ohio by sex. The rates for males in this age group were slightly higher than the rates for females for most cancer types, with the exception of renal tumors, soft tissue sarcomas and bone tumors. The incidence rate of Hodgkin lymphoma was more than two times higher in males than females in this age group.

The average annual age-adjusted incidence rates for the leading cancer types among adolescents, by sex, are shown in Figure 3. The rates among males were approximately two times the rates among females for three of the four leading cancer types (germ cell tumors, brain and other CNS tumors, and non-Hodgkin lymphoma). Female incidence rates were higher than males for the following types: Hodgkin lymphoma, melanoma of the skin, acute myeloid leukemia and thyroid cancer. The thyroid cancer incidence rate for females was nearly five times higher than the rate for males (32.2 and 6.6 per 1,000,000, respectively).

Figure 3: Leading Cancer Types among Adolescents (Ages 15-19): Average Annual Age-adjusted Incidence Rates per 1,000,000, by Sex in Ohio, 2007-2011

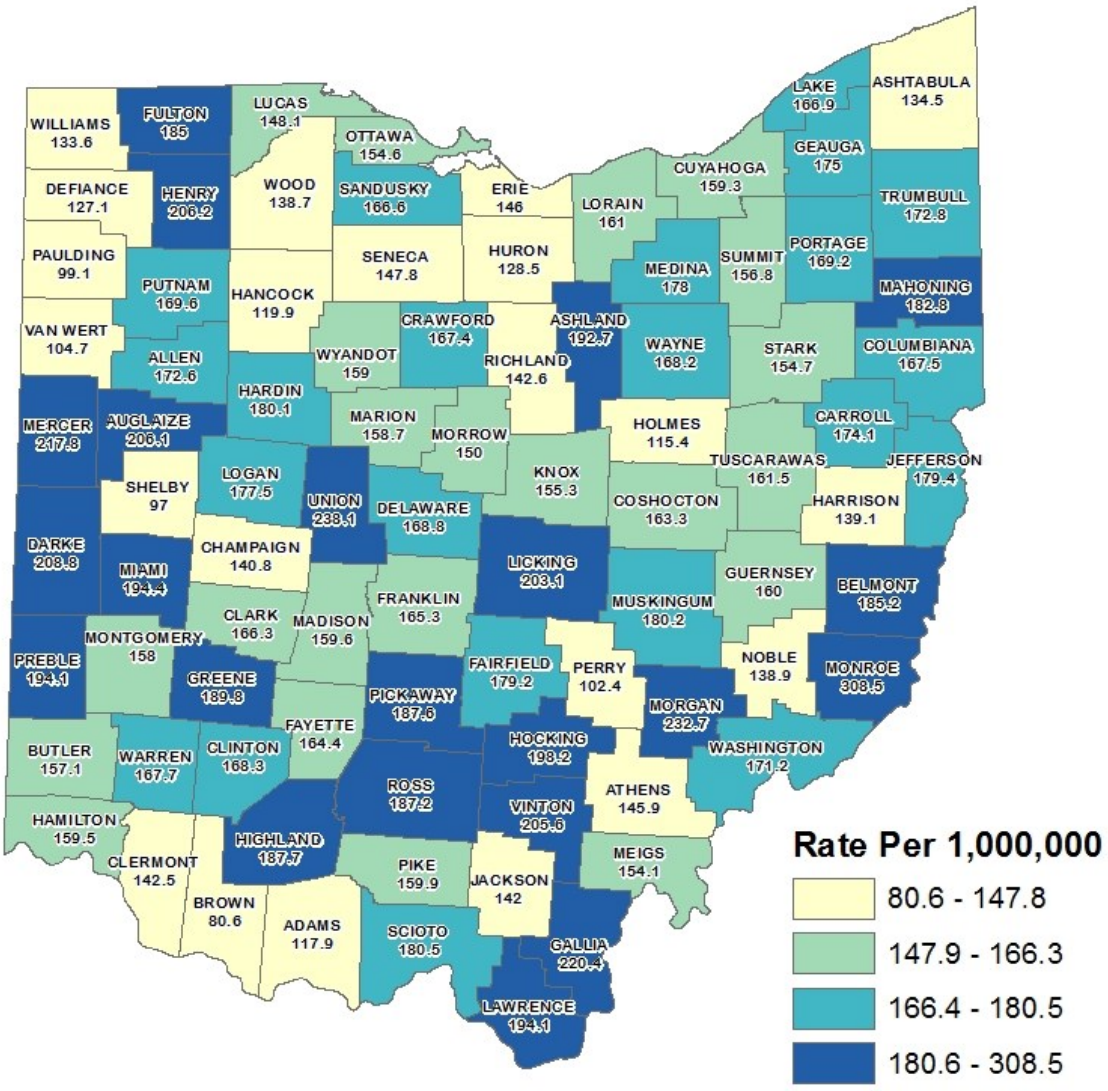


Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Cancer Incidence among Children and Adolescents by County

Maps of 1996-2011 average annual age-adjusted incidence rates among children and adolescents by Ohio county of residence are presented for all cancer types (Figure 4), leukemia (Figure 5) and brain and other CNS tumors (Figure 6). Because child and adolescent cancer is relatively rare, 16 years of data were combined to calculate county-level incidence rates; however, these rates may still be unstable due to small case counts and should be interpreted with caution. As shown in Figure 4, average annual age-adjusted incidence rates for all cancer types among children and adolescents do not exhibit a clear geographic pattern at the county level. Suppression of rates due to small counts makes it difficult to discern a geographic pattern by county for average annual age-adjusted incidence rates of leukemia (Figure 5) and brain and other CNS tumors (Figure 6). Data used to generate these maps can be found in Table 6 on page 19.

Figure 4: All Cancer Types: Average Annual Age-adjusted Incidence Rates per 1,000,000 Children and Adolescents (Ages 0-19), by County of Residence in Ohio, 1996-2011[1,2]



1. Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.
2. Each rate category represents approximately 25 percent of the 88 Ohio counties.

Figure 5: Leukemia: Average Annual Age-adjusted Incidence Rates per 1,000,000 Children and Adolescents (Ages 0-19), by County of Residence in Ohio, 1996-2011[1,2,3]

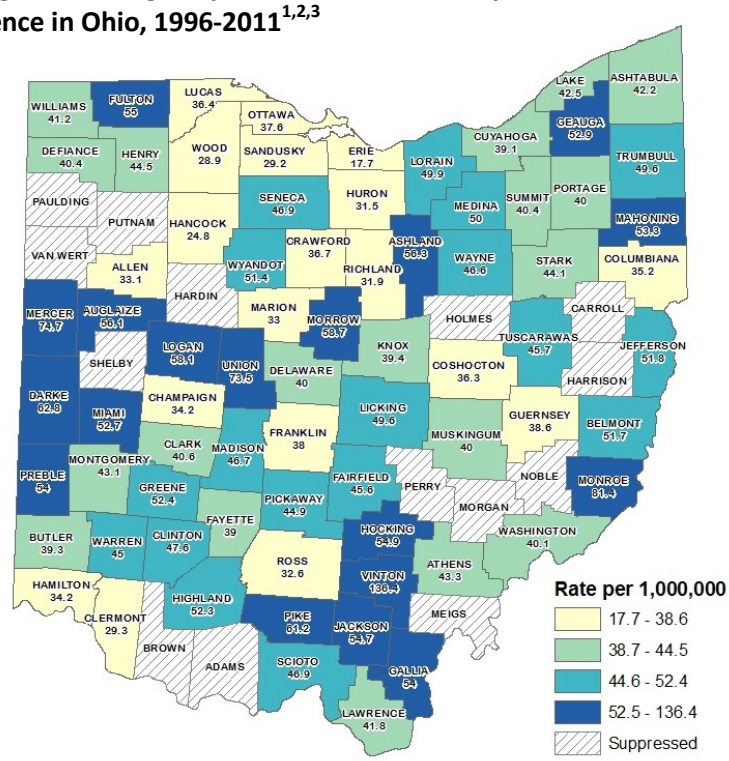
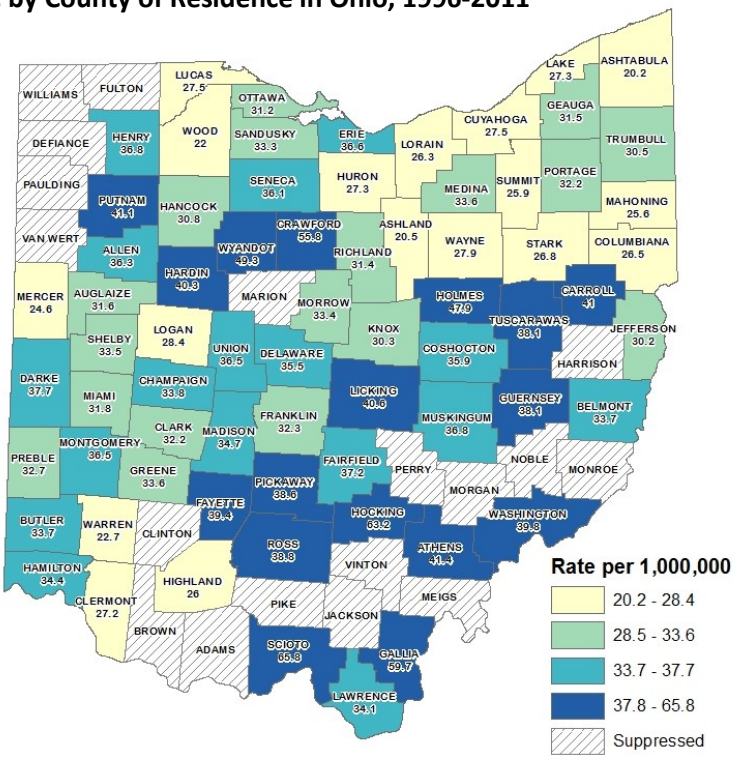


Figure 6: Brain and Other CNS Tumors: Average Annual Age-adjusted Incidence Rates per 1,000,000 Children and Adolescents (Ages 0-19), by County of Residence in Ohio, 1996-2011[1,2,3]



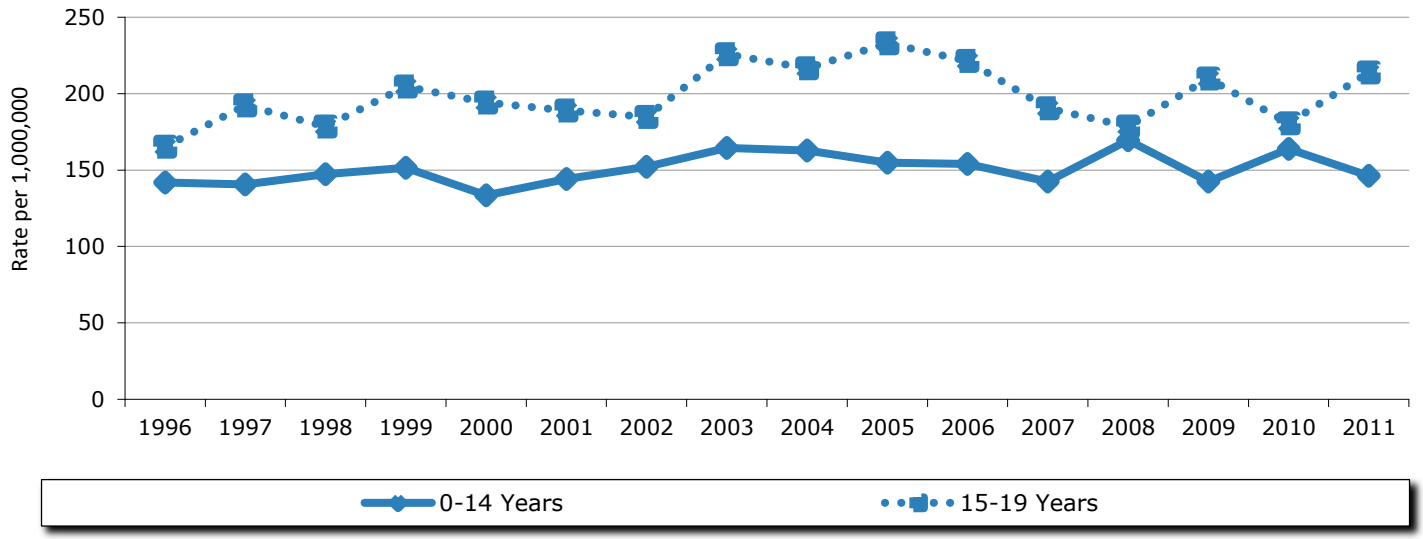
Figures 5 and 6:

1. Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.
2. Each rate category represents approximately 25 percent of the 88 Ohio counties.
3. Suppressed: Rates may be unstable and are not presented when the total case count for 1996-2011 was less than five.

Trends in Cancer Incidence and Mortality among Children and Adolescents

Figures 7-13 show trends in average annual age-adjusted child and adolescent cancer incidence rates per 1,000,000 for all cancer types combined; brain and other CNS tumors; leukemia; lymphoma (both Hodgkin lymphoma and non-Hodgkin lymphoma); thyroid cancer; and germ cell tumors, and mortality rates per 1,000,000 for all cancer types combined, according to year of diagnosis (1996 through 2011). Please use caution when comparing Figures 7 through 13 due to variation in scales of incidence and morality rates.

Figure 7: All Cancer Types: Trends in Annual Age-adjusted Incidence Rates per 1,000,000, by Age Group (Ages 0-14 and 15-19) in Ohio, 1996-2011



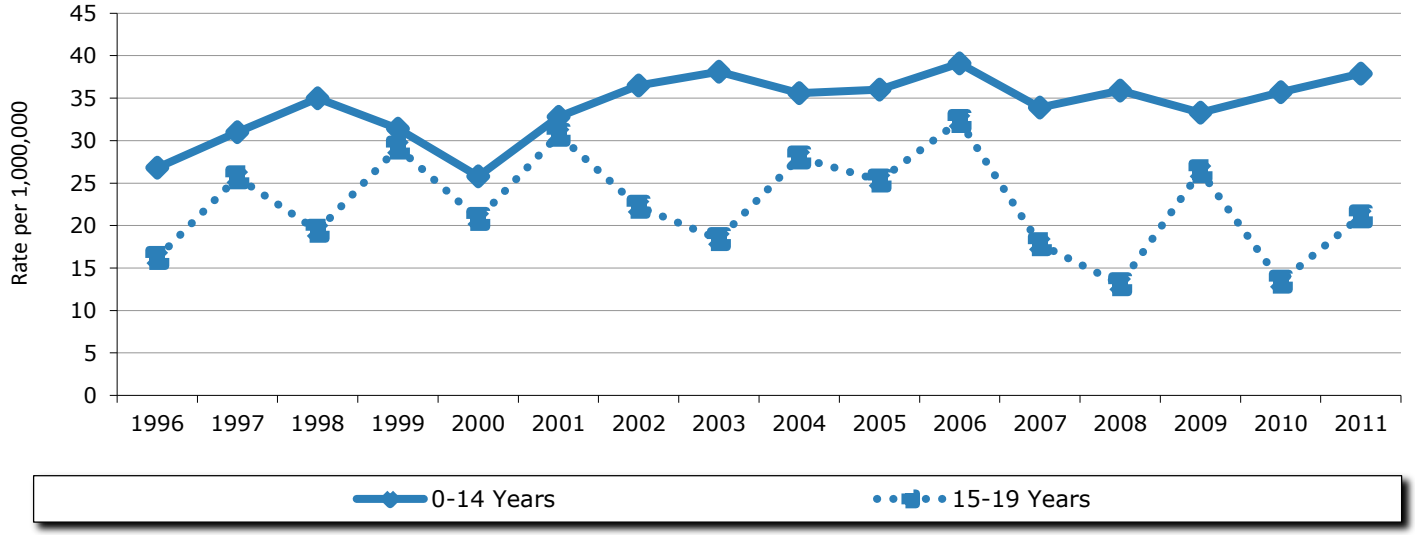
Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Incidence rates for all cancer types combined were higher among adolescents compared to children from 1996 to 2011. The rates were relatively stable among children but increased slightly from 1996-2011 among adolescents (Figure 7).

Did You Know?

In Ohio, thyroid cancer is the third most commonly diagnosed cancer among adolescents, and incidence rates of thyroid cancer among this age group have increased rapidly from 2007 to 2011. Much of this increase can be explained by improved detection methods. Thyroid cancer incidence rates among Ohio adolescents are nearly five times higher in females than in males.

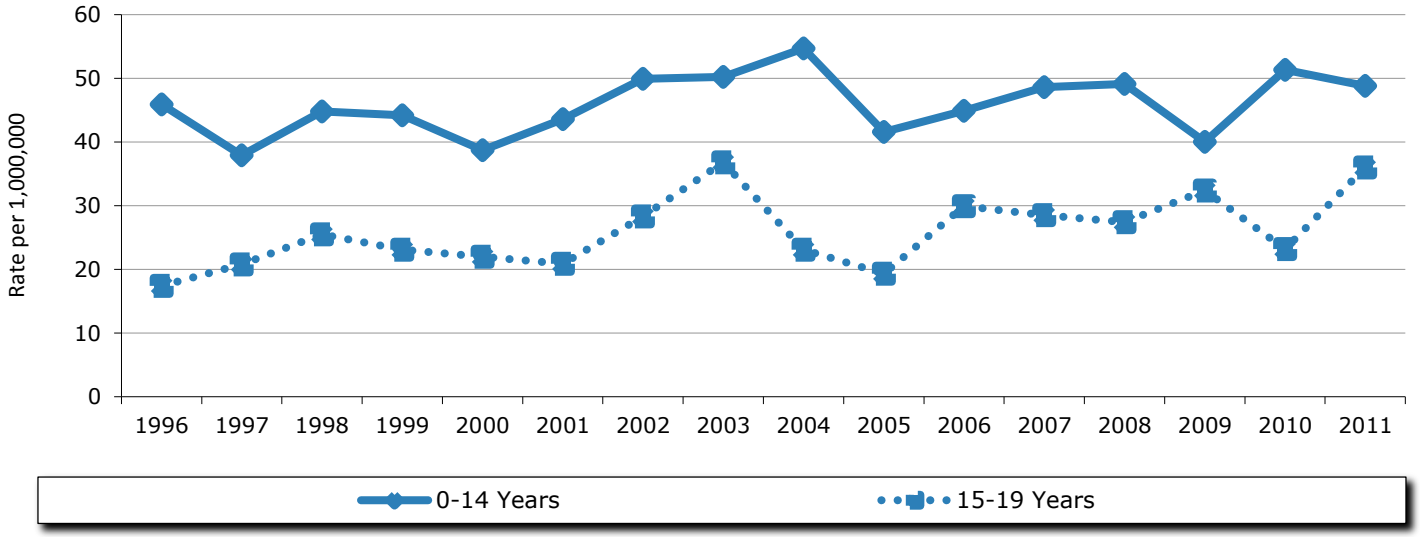
Figure 8: Brain and Other CNS Tumors: Trends in Annual Age-adjusted Incidence Rates per 1,000,000, by Age Group (Ages 0-14 and 15-19) in Ohio, 1996-2011



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Incidence rates for brain and other CNS tumors increased among children but were variable among adolescents from 1996 to 2011. The rates among children were higher than the rates among adolescents each year during the time period (Figure 8).

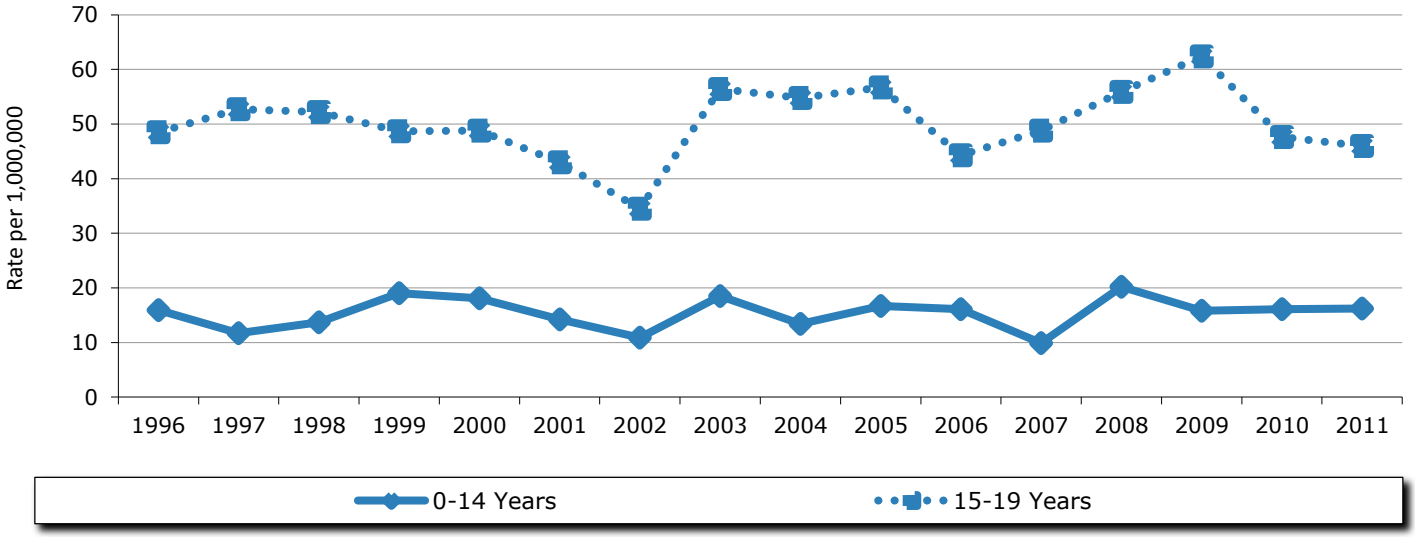
Figure 9: Leukemia: Trends in Annual Age-adjusted Incidence Rates per 1,000,000, by Age Group (Ages 0-14 and 15 -19) in Ohio, 1996-2011



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Figure 9 shows that incidence rates of leukemia in children were consistently higher than the rates among adolescents from 1996 to 2011. Leukemia rates among children were variable, whereas rates among adolescents increased slightly during the time period.

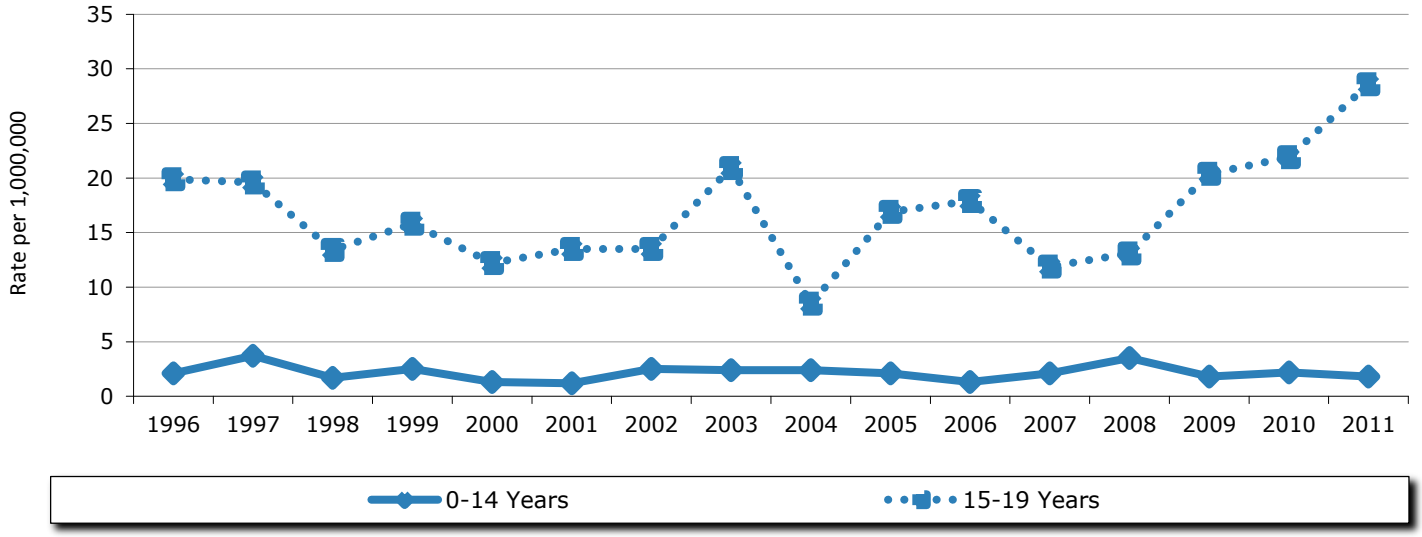
Figure 10: Lymphoma: Trends in Annual Age-adjusted Incidence Rates per 1,000,000, by Age Group (Ages 0-14 and 15-19) in Ohio, 1996-2011



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Incidence rates of lymphoma (both Hodgkin lymphoma and non-Hodgkin lymphoma) had periods of increase and decrease among adolescents but remained stable among children from 1996 to 2011. Lymphoma rates were two to three times higher among adolescents compared to children during this time period (Figure 10).

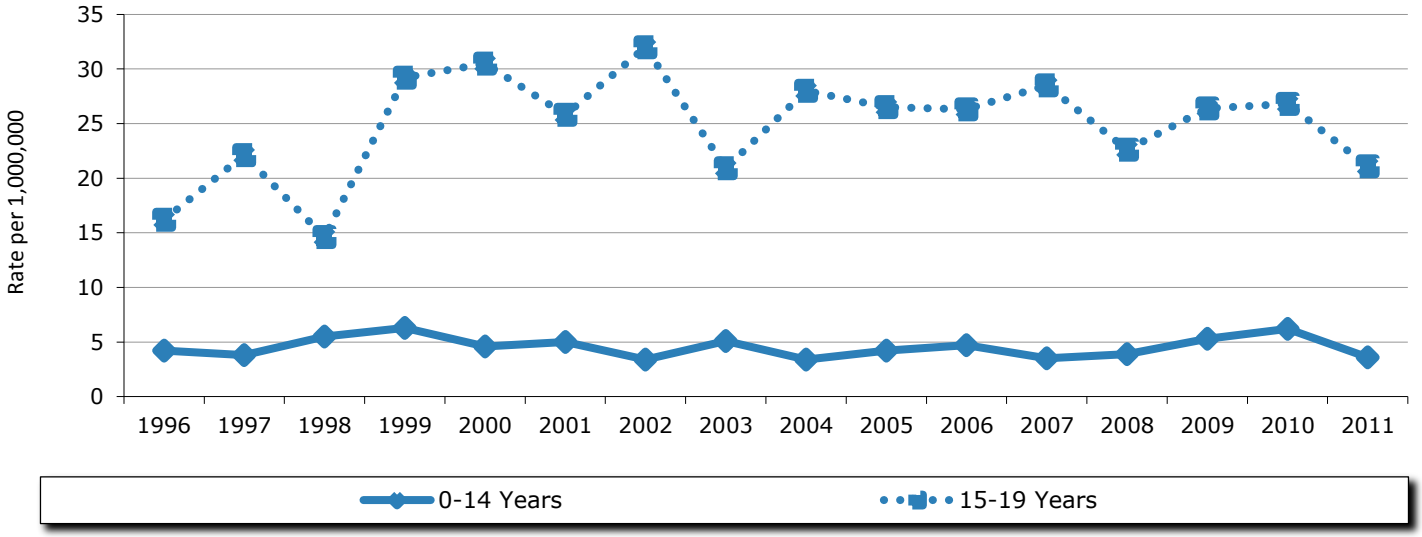
Figure 11: Thyroid Cancer: Trends in Annual Age-adjusted Incidence Rates per 1,000,000, by Age Group (Ages 0-14 and 15-19) in Ohio, 1996-2011



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

Incidence rates of thyroid cancer in children were very low (less than 5 per 1,000,000) and stable from 1996 to 2011. Thyroid cancer incidence rates in adolescents ranged from 8.5 per 1,000,000 in 2004 to 28.6 per 1,000,000 in 2011 (Figure 11).

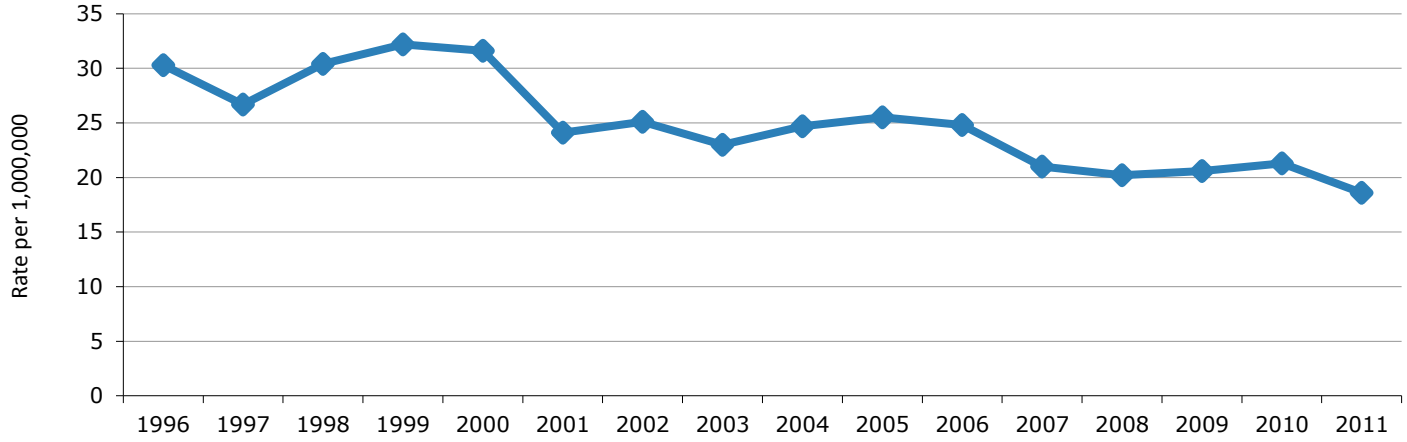
Figure 12: Germ Cell Tumors: Trends in Annual Age-adjusted Incidence Rates per 1,000,000, by Age Group (Ages 0-14 and 15-19) in Ohio, 1996-2011



Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014.

From 1996 to 2011, incidence rates of germ cell tumors were low and stable among children. Incidence rates of germ cell tumors among adolescents were more variable from 1996 to 2011 and three to six times higher compared to children (Figure 12).

Figure 13: All Cancer Types: Trends in Age-adjusted Mortality Rates per 1,000,000 Children and Adolescents (Ages 0-19) in Ohio, 1996-2011



Source: Chronic Disease and Behavioral Epidemiology Section and the Office of Vital Statistics, Ohio Department of Health, 2014.

Mortality rates of all child and adolescent cancers combined declined from 1996 to 2011 in Ohio. During this time period, the mortality rate was highest in 1999 (32.2 per 1,000,000) and fell to a low of 18.6 per 1,000,000 in 2011, a decline of 73 percent. Nationally, the largest declines in child and adolescent cancer mortality rates were observed for Hodgkin lymphoma, non-Hodgkin lymphoma and acute lymphocytic leukemia. These declines are largely due to advances in treatment (Figure 13).

Child and Adolescent Cancer Clinical Trials

Clinical trials are used to determine the most safe and effective treatment for a disease. Clinical trials aim to improve survival rates or reduce side effects or late effects of treatment. Clinical trials are standard practice in child and adolescent cancer treatment. While less than 5 percent of adults with cancer are enrolled in clinical trials, 60 percent of patients under age 29 diagnosed with cancer are enrolled in clinical trials.

Where to find child and adolescent cancer clinical trials:

National Cancer Institute, Cancer Trials Search: www.cancer.gov/clinicaltrials/search
Clinical Trials.gov: www.clinicaltrials.gov
TrialCheck.org: www.trialcheck.org

The Children's Oncology Group (COG) is the largest pediatric clinical trials group in the world, with more than 200 participating hospitals. For more information about childhood cancer clinical trials, visit: http://www.childrensoncologygroup.org/index.php/what-is-a-clinical-trial

Cancer Signs and Symptoms among Children and Adolescents

Signs and symptoms of child and adolescent cancer often look similar to other more common diseases in children, making early diagnosis difficult. Some common symptoms of child and adolescent cancer include an unusual mass or swelling; unexplained paleness or loss of energy; a sudden tendency to bruise; a persistent localized pain or limping; a prolonged unexplained fever or illness; frequent headaches, often with vomiting; sudden eye or vision changes; and excessive, rapid weight loss. Signs and symptoms for specific cancer types are shown in Table 3.

Table 3: Signs and Symptoms of Child and Adolescent (Ages 0-19) Cancer by Type

Cancer Type	Signs and Symptoms
Acute lymphocytic leukemia	• Anemia, which can lead to fatigue, irritability, sleepiness, paleness, shortness of breath and a rapid heartbeat • More easily bruising or bleeding from injuries • Frequent infections
Brain and other CNS tumors	• Varied, depending on the tumor location, the developmental stage and communication ability of the child or adolescent and whether intracranial pressure is raised
Osteosarcoma	• Sporadic pain in the affected bone that can worsen at night or with activity with progression to local swelling
Retinoblastoma	• "White pupil" in which the pupil of the eye appears white instead of red when light shines into it • Eye pain or redness • Vision problems
Testicular germ cell tumors	• Lump on the testicle
Wilms tumor	• An abdominal mass that is often noticed while dressing or bathing a child

Any of these signs and symptoms may be caused by cancer or by other, less serious health problems.
If you have any of these signs or symptoms, see your doctor.

Cancer Risk Factors among Children and Adolescents

Causes of child and adolescent cancer are largely unknown. Specific chromosomes, certain genetic syndromes and ionizing radiation explain a small percentage of cases. While environmental causes of child and adolescent cancer are often suspected, they are particularly difficult to directly link with the development of cancer. This is due to the complexity of identifying past exposure levels, the differing types of childhood cancer and the various ways in which cancers develop. Risk factors presented in Table 4 represent those with sufficient evidence to support an increased risk of developing child and adolescent cancer.

Table 4: Risk Factors For Child and Adolescent (Ages 0-19) Cancer by Type

Cancer Type	Risk Factors
Acute lymphocytic leukemia	• Inherited risk factors such as trisomy 21 (Down syndrome), certain genetic syndromes (Bloom syndrome, Fanconi anemia and Nijmegen breakage syndrome) and congenital immunodeficiency diseases • Accelerated fetal growth and higher birth weight • Radiation exposure
Acute myeloid leukemia	• Radiation exposure • Some specific chemicals such as benzene, and drugs used to treat cancer such as alkylating agents and topoisomerase II inhibitors • Lower birth weight
Brain and other CNS tumors	• Certain genetic syndromes (e.g., Turcot syndrome, Li-Fraumeni syndrome, neurofibromatosis type 2) • Ionizing radiation including high-dose therapeutic radiation
Hodgkin lymphoma	• Exposure to the Epstein Barr virus (EBV) or having a personal history of mononucleosis or human immunodeficiency virus (HIV) infection
Neuroblastoma	• Children who have siblings with neuroblastoma (tenfold increased risk)
Non-Hodgkin lymphoma	• EBV or malaria infection • Immunosuppression from a variety of causes, including inherited immunodeficiency disorders, HIV infection and post-transplantation immune suppression • Accelerated fetal growth and higher birth weight
Osteosarcoma	• Prior radiation treatment for another tumor • Hereditary form of retinoblastoma, Li-Fraumeni syndrome and several other genetic syndromes
Ovarian germ cell tumors	• Genetic syndromes involving sex chromosomes such as Turner and Swyer syndromes
Retinoblastoma	• Genetic mutation in the retinoblastoma 1 gene (approximately one-third of cases)
Rhabdomyosarcoma	• Genetic syndromes, including Li-Fraumeni syndrome and neurofibromatosis type 1 • Accelerated fetal growth and higher birth weight
Testicular germ cell tumors	• Family history of testicular cancer • History of an undescended testicle
Wilms tumor	• Birth defects such as urogenital tract abnormalities (approximately 10 percent of cases) • Accelerated fetal growth and higher birth weight

Late Effects of Child and Adolescent Cancer

Over the past several decades, improved cancer treatments and supportive care have resulted in more children surviving and recovering from cancer. However, they are at risk for developing long-term side effects, also called late effects, from cancer treatment. Late effects can involve more than one part of the body and can range from mild to severe. They can occur months or years after cancer treatment ends. Any cancer treatment may cause late effects, including chemotherapy, radiation therapy, surgery and bone marrow/stem cell transplantation. Risk of developing late effects depends on many factors, including cancer type and location, age at diagnosis, general health, area of the body treated, type and dose of treatment, genetics and family history. Late effects are a major concern for all childhood cancer survivors. Researchers continue to search for ways to reduce long-term effects. Careful follow-up after cancer treatment allows doctors to find and treat late effects as early as possible. Symptoms potentially related to these late effects should be discussed with your healthcare provider. Below is a listing of specific late effects of child and adolescent cancer.

Emotional difficulties: Anxiety, depression and fear of recurrence are among the most common late effects.

Second cancers: Survivors of childhood cancer have a slightly increased risk of developing a second cancer. For example, children treated for Hodgkin lymphoma have higher breast and thyroid cancer risks. Causes include radiation therapy and chemotherapy.

Reproductive and sexual development problems: In boys, radiation therapy to the brain, testicles or abdomen may cause infertility, as can chemotherapy. These treatments may also change levels of testosterone, which can affect puberty and sexual functioning. In girls, particularly those who have begun menstruation, chemotherapy and radiation therapy to the abdomen, pelvis, lower spine or head can affect the ovaries, causing infertility, irregular menstruation and premature menopause.

Growth, development and hormone problems: Cancer treatments may affect the endocrine system, impacting growth, energy and puberty. Radiation therapy near the brain, eyes or ears can impact the pituitary gland, which helps control growth. Pituitary gland radiation increases risk of becoming overweight or obese. Radiation therapy given to bone can lead to reduced or uneven growth and conditions such as scoliosis.

Learning and memory problems: Children treated for cancer have higher risk of learning difficulties (especially if school is missed), learning disabilities and memory problems.

Heart problems: Women and younger children are at increased risk of heart-related late effects. Chemotherapy drugs called anthracyclines may cause heart problems, such as abnormal heartbeat, disease of the heart muscle and congestive heart failure. Radiation therapy to the chest, spine or upper abdomen and bone marrow/stem cell transplantation may increase risk of heart-related late effects.

Lung and breathing problems: Children who are younger at the time of treatment have a greater risk of breathing problems. Certain types of chemotherapy may cause lung damage. Chest radiation and surgery to the chest or lungs may also cause lung problems.

Digestive system problems: The gastrointestinal system can be affected by abdominal or pelvic surgery and radiation therapy to the neck, chest, abdomen or pelvis.

Dental problems: Radiation therapy to the mouth, head or neck may cause problems such as dry mouth and cavities. Chemotherapy, especially when given to a child whose adult teeth have not formed, may cause tooth development problems.

Hearing problems: Radiation therapy to the head or brain and some chemotherapy may cause hearing loss, especially among younger children.

Eye problems: High doses of radiation to the eye or brain may cause eye problems such as cataracts. Radioiodine treatment for thyroid cancer and bone marrow/stem cell transplants may also cause eye problems such as tearing.

Cancer Survival Probability among Children and Adolescents

Table 5: U.S. Five-Year Relative Survival Probabilities for Child (Ages 0-14) and Adolescent (Ages 15-19) Cancer by Type, Sex and Race, 2004-2010 [1,2]

	Children (Ages 0-14)					Adolescents (Ages 15-19)				
Cancer Site/Type	Total	Male	Female	White	Black	Total	Male	Female	White	Black
All cancer types	82.1%	81.9%	82.3%	83.2%	76.3%	83.2%	80.8%	85.9%	84.0%	76.5%
Acute myeloid leukemia	64.2%	63.2%	65.4%	67.7%	49.7%	57.6%	58.7%	56.6%	58.6%	48.2%
Bone tumors	73.0%	72.6%	73.3%	73.8%	73.0%	64.7%	62.3%	69.0%	62.4%	70.4%
Brain & other CNS tumors	72.3%	73.2%	71.3%	73.6%	64.4%	77.4%	74.2%	81.3%	78.6%	75.9%
Germ cell tumors	93.4%	93.4%	93.3%	93.4%	91.4%	91.6%	91.6%	91.7%	91.8%	92.8%
Hepatic tumors	74.1%	73.9%	74.1%	74.1%	70.0%	49.6%	54.4%	42.7%	45.4%	55.8%
Hodgkin lymphoma	97.4%	97.9%	96.7%	97.9%	95.5%	95.8%	96.0%	95.6%	96.4%	93.6%
Lymphoid leukemia	89.2%	88.4%	90.3%	89.4%	86.8%	73.8%	73.8%	73.8%	74.2%	65.2%
Melanoma of the skin	94.5%	95.7%	93.4%	95.8%	~	95.3%	91.1%	98.2%	95.5%	71.5%
Neuroblastoma	78.5%	77.3%	79.8%	81.4%	66.5%	80.1%	75.6%	86.6%	88.6%	60.1%
Non-Hodgkin lymphoma	86.7%	88.3%	84.0%	87.8%	82.2%	84.1%	82.6%	86.2%	83.9%	82.4%
Renal tumors	88.9%	88.8%	89.2%	89.7%	84.6%	84.6%	72.9%	91.5%	92.0%	66.0%
Retinoblastoma	96.5%	96.0%	96.9%	96.3%	94.0%	~	~	~	~	~
Soft tissue sarcomas	72.7%	71.9%	73.5%	73.3%	74.7%	68.7%	67.7%	69.6%	69.9%	61.3%
Thyroid cancer	99.7%	100.0%	99.5%	100.0%	91.7%	99.4%	97.3%	99.7%	99.3%	97.8%

1. Source: Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Incidence - SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2013 Sub (1973-2011 varying) - Linked To County Attributes - Total U.S., 1969-2012 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch, released April 2014 (updated 5/7/2014), based on the November 2013 submission.
2. Percentages are adjusted for normal life expectancy and are based on cases diagnosed in the SEER 18 areas from 2004-2010, followed into 2011.

~ Statistics could not be calculated due to small case counts.

Table 5 shows five-year relative survival probabilities in the United States for common cancer types among children and adolescents. Survival probability is greater than 80 percent (four out of five) and is slightly higher among adolescents, as compared to children. Among children and adolescents, females and whites have higher survival probabilities, as compared to males and blacks, respectively. Survival probability among children is lowest among those diagnosed with acute myeloid leukemia, brain and other CNS tumors, bone tumors and soft tissue sarcomas. Among adolescents, survival probability is lowest among those diagnosed with lymphoid leukemia, acute myeloid leukemia, hepatic tumors, bone tumors and soft tissue sarcomas.

Technical Notes

Age-Adjusted Rate: A summary rate that is a weighted average of age-specific rates, where the weights represent the age distribution of a standard population (direct adjustment). The incidence and mortality rates presented in this report were standardized to the age distribution of the 2000 U.S. Standard Population. Under the direct method, the population was first divided into five five-year age groups, i.e., <1, 1-4, 5-9, 10-14, 15-19, and the age-specific rate was calculated for each age group. Each age-specific rate was then multiplied by the standard population proportion for the respective age group. For children, the first four standardized age-specific rates were summed to give an overall age-adjusted rate. For adolescents, the standardized age-specific rate for the 15-19 age group served as the overall rate. Age adjustment allows for the comparison of rates between populations with different age distributions.

Average Annual Number: The number of cases or deaths diagnosed per year, on average, for the time period of interest (e.g., 2007-2011). Average annual numbers are calculated by summing the number of cases or deaths for a given time period, dividing by the number of years that comprise the time period and rounding to the nearest whole number.

International Classification of Childhood Cancer (ICCC): Cancers in children and adolescents are classified by histology (tissue type) into 12 major groups using the International Classification of Childhood Cancers (ICCC), available at: http://seer.cancer.gov/iccc/iccc-who2008.html.

Cancer Cluster: A greater than expected number of cancer cases among a group of people in a geographic area over a defined period of time.

Census Data: The 1996-2011 rates were calculated using bridged-race intercensal population estimates for July 1, 1996-July 1, 1999 (U.S. Census Bureau and National Center for Health Statistics, 2004); revised bridged-race intercensal population estimates for July 1, 2000-July 1, 2009 (U.S. Census Bureau and National Center for Health Statistics, 2012); and vintage 2012 bridged-race postcensal population estimates for April 1, 2010-July 1, 2011 (U.S. Census Bureau and National Center for Health Statistics, 2013).

Incidence: The number of cases diagnosed during a specified time period (e.g., 2007-2011).

Invasive Cancer: A malignant tumor that has infiltrated the organ in which the tumor originated. Invasive cancers consist of those diagnosed at the localized, regional, distant and unstaged/missing stages. Only invasive cancers were included in the calculation of incidence rates in this document.

Late Effects: Long-term side effects from cancer treatment.

Mortality: The number of deaths during a specified time period (e.g., 2007-2011).

Rate: The number of cases or deaths per unit of population (e.g., per 1,000,000 persons), durin a specified time period (e.g., 2007-2011). Child and adolescent cancer rates in this document are presented as the number of cases per 1,000,000 persons per year. Rates may be unstable and are not presented when the case count is less than five.

Survival Probability: The probability that an individual will survive a given number of years after diagnosis. Five-year relative survival probabilities are from the SEER 18 areas for diagnosis years 2004-2010. Probabilities are based on follow-up of patients into 2011.

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Appendix

Table 6: Total Number of Invasive Cancer Cases and Average Annual Age-adjusted Incidence Rates per 1,000,000 Children and Adolescents (Ages 0-19) by County of Residence in Ohio, 1996-2011[1,2]

	All Types		Leukemia		Brain & Other CNS	
	Cases	Rate	Cases	Rate	Cases	Rate
Ohio	**8,215**	**162.7**	**2,043**	**40.8**	**1,560**	**31.1**
U.S.		**166.4**		**41.2**		**30.4**
Adams	15	117.9	4	*	3	*
Allen	86	172.6	16	33.1	18	36.3
Ashland	46	192.7	13	56.3	5	20.5
Ashtabula	61	134.5	19	42.2	9	20.2
Athens	32	145.9	9	43.3	8	41.4
Auglaize	45	206.1	12	56.1	7	31.6
Belmont	49	185.2	13	51.7	9	33.7
Brown	16	80.6	2	*	4	*
Butler	255	157.1	63	39.3	54	33.7
Carroll	21	174.1	3	*	5	41.0
Champaign	25	140.8	6	34.2	6	33.8
Clark	104	166.3	25	40.6	20	32.2
Clermont	124	142.5	26	29.3	24	27.2
Clinton	32	168.3	9	47.6	4	*
Columbiana	77	167.5	16	35.2	12	26.5
Coshocton	27	163.3	6	36.3	6	35.9
Crawford	33	167.4	7	36.7	11	55.8
Cuyahoga	913	159.3	223	39.1	157	27.5
Darke	50	208.8	15	62.8	9	37.7
Defiance	23	127.1	7	40.4	2	*
Delaware	112	168.8	28	40.0	24	35.5
Erie	48	146.0	6	17.7	12	36.6
Fairfield	110	179.2	28	45.6	23	37.2
Fayette	21	164.4	5	39.0	5	39.4
Franklin	815	165.3	189	38.0	158	32.3
Fulton	37	185.0	11	55.0	3	*
Gallia	30	220.4	7	54.0	8	59.7
Geauga	75	175.0	22	52.9	14	31.5
Greene	130	189.8	34	52.4	23	33.6
Guernsey	29	160.0	7	38.6	7	38.1
Hamilton	588	159.5	125	34.2	125	34.4
Hancock	39	119.9	8	24.8	10	30.8
Hardin	26	180.1	4	*	6	40.3
Harrison	9	139.1	0	*	0	*
Henry	28	206.2	6	44.5	5	36.8
Highland	36	187.7	10	52.3	5	26.0
Hocking	25	198.2	7	54.9	8	63.2
Holmes	28	115.4	3	*	12	47.9
Huron	37	128.5	9	31.5	8	27.3
Jackson	21	142.0	8	54.7	4	*
Jefferson	50	179.4	14	51.8	8	30.2
Knox	41	155.3	10	39.4	8	30.3
Lake	156	166.9	39	42.5	26	27.3
Lawrence	52	194.1	11	41.8	9	34.1
Licking	141	203.1	34	49.6	28	40.6
Logan	37	177.5	12	58.1	6	28.4
Lorain	210	161.0	65	49.9	34	26.3
Lucas	304	148.1	74	36.4	56	27.5
Madison	28	159.6	8	46.7	6	34.7
Mahoning	187	182.8	54	53.3	26	25.6
Marion	44	158.7	9	33.0	4	*
Medina	130	178.0	36	50.0	25	33.6
Meigs	15	154.1	3	*	3	*
Mercer	44	217.8	15	74.7	5	24.6
Miami	86	194.4	23	52.7	14	31.8
Monroe	19	308.5	5	81.4	3	*
Montgomery	375	158.0	102	43.1	86	36.5
Morgan	15	232.7	1	*	4	*
Morrow	23	150.0	9	58.7	5	33.4
Muskingum	69	180.2	15	40.0	14	36.8
Noble	8	138.9	3	*	4	*
Ottawa	25	154.6	6	37.6	5	31.2
Paulding	9	99.1	3	*	2	*
Perry	17	102.4	4	*	2	*
Pickaway	43	187.6	10	44.9	9	38.6
Pike	21	159.9	8	61.2	3	*
Portage	115	169.2	26	40.0	20	32.2
Preble	36	194.1	10	54.0	6	32.7
Putnam	29	169.6	4	*	7	41.1
Richland	77	142.6	17	31.9	17	31.4
Ross	58	187.2	10	32.6	12	38.8
Sandusky	46	166.6	8	29.2	9	33.3
Scioto	61	180.5	16	46.9	22	65.8
Seneca	39	147.8	12	46.9	9	36.1
Shelby	23	97.0	2	*	8	33.5
Stark	249	154.7	70	44.1	43	26.8
Summit	362	156.8	93	40.4	60	25.9
Trumbull	156	172.8	44	49.6	28	30.5
Tuscarawas	64	161.5	18	45.7	15	38.1
Union	51	238.1	16	73.5	8	36.5
Van Wert	14	104.7	3	*	3	*
Vinton	12	205.6	8	136.4	0	*
Warren	145	167.7	40	45.0	20	22.7
Washington	44	171.2	10	40.1	10	39.8
Wayne	91	168.2	25	46.6	15	27.9
Williams	23	133.6	7	41.2	4	*
Wood	77	138.7	15	28.9	11	22.0
Wyandot	16	159.0	5	51.4	5	49.3

1. Source: Ohio Cancer Incidence Surveillance System, Ohio Department of Health, 2014; Surveillance, Epidemiology and End Results Program, National Cancer Institute, 2014
2. Total count is for 1996-2011 data combined.

* Rates are suppressed when the total count is less than five.

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