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# Childhood Leukemia Early Detection, Diagnosis, and Types

## Detection and Diagnosis

Catching cancer early often allows for more treatment options. Some early cancers may have signs and symptoms that can be noticed, but that is not always the case.

- [Can Childhood Leukemia Be Found Early?](#)
- [Signs and Symptoms of Childhood Leukemia](#)
- [Tests for Childhood Leukemia](#)

## Subtypes and Outlook (Prognosis)

Learn how childhood leukemia is classified and how this may affect treatment options.

- [Childhood Leukemia Subtypes](#)
- [Prognostic Factors in Childhood Leukemia \(ALL or AML\)](#)
- [Survival Rates for Childhood Leukemias](#)

## Questions to Ask about Childhood Leukemia

Here are some questions to ask your cancer care team to help you better understand a childhood leukemia diagnosis and treatment options.

- [Questions to Ask About Childhood Leukemia](#)

# Can Childhood Leukemia Be Found Early?

At this time there are no widely recommended blood tests or other screening tests for most children to look for leukemia before it starts to cause symptoms. Childhood leukemia is often found because a child has [signs or symptoms](#)<sup>1</sup> that prompt a visit to the doctor. The doctor then orders [blood tests](#)<sup>2</sup>, which might point to leukemia as the cause. The best way to find these leukemias early is to pay attention to the possible signs and symptoms of this disease.

## For children at increased risk

For children known to be at [increased risk of leukemia](#)<sup>3</sup> (because of a genetic condition such as Li-Fraumeni syndrome or Down syndrome, for example), most doctors recommend careful, regular medical checkups and possibly other tests. The same is true for children who have been treated with chemotherapy and/or radiation therapy for other cancers, and for children who have had organ transplants and are taking immune system-suppressing drugs. The risk of leukemia in these children, although higher than in the general population, is still small.

## Hyperlinks

1. [www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/signs-and-symptoms.html](http://www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/signs-and-symptoms.html)
2. [www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/how-diagnosed.html](http://www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/how-diagnosed.html)
3. [www.cancer.org/cancer/leukemia-in-children/causes-risks-prevention/risk-factors.html](http://www.cancer.org/cancer/leukemia-in-children/causes-risks-prevention/risk-factors.html)

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## Signs and Symptoms of Childhood Leukemia

Many of the symptoms of childhood leukemia can have other causes as well, and most often these symptoms are not caused by leukemia. Still, if your child has any of them, it's important to have your child seen by a doctor so the cause can be found and treated, if needed.

Leukemia begins in the bone marrow, which is where new blood cells are made. The symptoms of leukemia are often caused by problems in the bone marrow. As leukemia cells build up in the marrow, they can crowd out the normal blood cells. As a result, a child may not have enough normal red blood cells, white blood cells, and blood platelets. These shortages show up on blood tests, but they can also cause symptoms. The leukemia cells might also invade other areas of the body, which can also cause symptoms.

**Symptoms from low red blood cell counts (anemia):** Red blood cells carry oxygen to all of the cells in the body. A shortage of red blood cells can cause symptoms such as:

- Feeling tired (fatigue)
- Feeling weak
- Feeling cold
- Feeling dizzy or lightheaded
- Shortness of breath
- Paler skin

**Symptoms from a lack of normal white blood cells:** White blood cells help the body fight off germs. Children with leukemia often have high white blood cell counts, but most of these are leukemia cells that don't protect against infection, and there aren't enough normal white blood cells. This can lead to:

- **Infections**, which can occur because of a shortage of normal white blood cells. Children with leukemia can get infections that don't seem to go away, or they may get one infection after another.
- **Fever**, which is often the main sign of infection. But some children might have a fever without having an infection.

**Symptoms from low blood platelet counts:** Platelets in the blood normally help stop bleeding. A shortage of platelets can lead to:

- Easy bruising and bleeding
- Frequent or severe nosebleeds
- Bleeding gums

**Bone or joint pain:** This pain is caused by the buildup of leukemia cells near the surface of the bone or inside the joint.

**Swelling of the abdomen (belly):** Leukemia cells can collect in the liver and spleen, making these organs bigger. This might be noticed as a fullness or swelling of the belly. The lower ribs usually cover these organs, but when they are enlarged the doctor can often feel them.

**Loss of appetite and weight loss:** If the spleen and/or liver get big enough, they can press against other organs like the stomach. This can make the child feel full after eating only a small amount of food, leading to a loss of appetite and weight loss over time.

**Swollen lymph nodes:** Some leukemias spread to lymph nodes, which are normally small (bean-sized) collections of immune cells in the body. Swollen nodes may be seen or felt as lumps under the skin in certain parts of the body (such as on the sides of the neck, in underarm areas, above the collarbone, or in the groin). Lymph nodes inside the chest or abdomen can also swell, but these can only be seen on [imaging tests](#)<sup>1</sup>, such as CT or MRI scans.

In infants and children, lymph nodes often get bigger when they are fighting an infection. An enlarged lymph node in a child is much more often a sign of infection than leukemia, but it should be checked by a doctor and followed closely.

**Coughing or trouble breathing:** Some types of leukemia can affect structures in the middle of the chest, such as lymph nodes or the thymus (a small organ in front of the trachea, the breathing tube that leads to the lungs). An enlarged thymus or lymph nodes

in the chest can press on the trachea, causing coughing or trouble breathing.

In some cases where the white blood cell count is very high, the leukemia cells can build up in the small blood vessels of the lungs, which can also cause trouble breathing.

**Swelling of the face and arms:** An enlarged thymus might press on the superior vena cava (SVC), which is a large vein that carries blood from the head and arms back to the heart. This can cause the blood to “back up” in the veins. This is known as **SVC syndrome**. It can result in swelling in the face, neck, arms, and upper chest (sometimes with a bluish-red skin color). Symptoms can also include headaches, dizziness, and a change in consciousness if it affects the brain. The SVC syndrome can be life-threatening, so it needs to be treated right away.

**Headaches, seizures, vomiting:** A small number of children have leukemia that has already spread to the brain and spinal cord when it is first found. This can lead to symptoms such as headaches, trouble concentrating, weakness, seizures, vomiting, problems with balance, and blurred vision.

**Rashes or gum problems:** In children with acute myeloid leukemia (AML), leukemia cells may spread to the gums, causing swelling, pain, and bleeding.

If AML spreads to the skin, it can cause small, dark spots that look like common rashes. A collection of AML cells under the skin or in other parts of the body is called a **chloroma** or **granulocytic sarcoma**.

**Extreme fatigue and weakness:** A rare but very serious consequence of AML is extreme tiredness, weakness, and slurring of speech. This can occur when very high numbers of leukemia cells thicken the blood and slow the circulation through small blood vessels of the brain.

Again, most of the symptoms above are more likely to be caused by something other than leukemia. Still, it's important to have these symptoms checked by a doctor so the cause can be found and treated, if needed.

## Hyperlinks

1. [www.cancer.org/treatment/understanding-your-diagnosis/tests/imaging-radiology-tests-for-cancer.html](http://www.cancer.org/treatment/understanding-your-diagnosis/tests/imaging-radiology-tests-for-cancer.html)

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## Tests for Childhood Leukemia

Most of the [signs and symptoms](#)<sup>1</sup> of childhood leukemia are more likely to have other causes, such as infections. Still, it's important to let your child's doctor know about such symptoms right away so that the cause can be found and treated, if needed.

Exams and tests will be done to determine the cause of the symptoms. If leukemia is found, further tests will be needed to find out the type and [subtype](#)<sup>2</sup> of leukemia and decide how it should be treated.

It's important to diagnose childhood leukemia as early as possible and to determine what type of leukemia it is so that treatment can be tailored to provide the best chance of success.

## Medical history and physical exam

If your child has signs and symptoms that suggest they might have leukemia, the doctor will want to get a thorough **medical history** to learn about the symptoms and how long your child has had them. The doctor may also ask about exposure to possible [risk factors](#)<sup>3</sup>. A family history of cancer, especially leukemia, may also be important.

During the **physical exam**, the doctor will look for any enlarged lymph nodes, areas of bleeding or bruising, or possible signs of infection. The eyes, mouth, and skin will be looked at carefully, and a nervous system exam may be done. The child's abdomen (belly) will be felt for signs of an enlarged spleen or liver.

## Tests to look for leukemia in children

If the doctor thinks your child might have leukemia, blood and bone marrow samples will need to be checked to be sure. Your child's doctor may refer you to a **pediatric oncologist**, a doctor who specializes in childhood cancers (including leukemias), to have some of these tests done. If leukemia is found, other types of tests may also be done to help guide treatment.

### Blood tests

The first tests done to look for leukemia are blood tests. The blood samples are usually taken from a vein in the arm, but in infants and younger children they may be taken from other veins (such as in the feet or scalp) or from a "finger stick."

**Blood counts** and **blood smears** are the usual tests done on these samples. A [complete blood count](#)<sup>4</sup> (CBC) is done to determine how many blood cells of each type are in the blood. For a blood smear, a small sample of blood is spread on a glass slide and looked at under a microscope. Abnormal numbers of blood cells and changes in the way these cells look may make the doctor suspect leukemia.

Most children with leukemia will have too many white blood cells and not enough red blood cells and/or platelets. Many of the white blood cells in the blood will be **blasts**, an early type of blood cell normally found only in the bone marrow. Even though these findings may make a doctor suspect that a child has leukemia, usually the disease can't

be diagnosed for sure without looking at a sample of bone marrow cells.

### **Bone marrow aspiration and biopsy**

A bone marrow aspiration and bone marrow biopsy are tests that are usually done at the same time. The samples are usually taken from the back of the pelvic (hip) bones, but sometimes they may be taken from the front of the pelvic bones or from other bones.

Before the tests, the skin over the hip bone is cleaned and numbed by injecting a local anesthetic or applying a numbing cream. In most cases, the child is also given other medicines to make them drowsy or even go to sleep during the tests.

- For a **bone marrow aspiration**, a thin, hollow needle is then inserted into the bone, and a syringe is used to suck out (aspirate) a small amount of liquid bone marrow.
- A **bone marrow biopsy** is usually done just after the aspiration. A small piece of bone and marrow is removed with a slightly larger needle that is pushed down into the bone. Once the biopsy is done, pressure will be applied to the site to help stop any bleeding.

The bone marrow samples are then sent to a lab for testing.

Bone marrow tests are used to diagnose leukemia, but they may also be repeated later to find out if the leukemia is responding to treatment.

### **Lumbar puncture (spinal tap)**

This test is used to look for leukemia cells in the cerebrospinal fluid (CSF), which is the liquid that bathes the brain and spinal cord.

For this test, the doctor first applies a numbing cream in an area in the lower part of the back over the spine. The doctor usually also gives the child medicine to make him or her sleep during the procedure. A small, hollow needle is then put in between the bones of the spine to withdraw some of the fluid, which is then sent to a lab for testing.

In children already diagnosed with leukemia, lumbar punctures might also be used to give [chemotherapy](#)<sup>5</sup> drugs into the CSF to try to prevent or treat the spread of leukemia to the spinal cord and brain. (This is known as **intrathecal chemotherapy**.)

### **Lymph node biopsy**

This type of biopsy is important in diagnosing lymphomas, but it is rarely needed for children with leukemias.

During this procedure, a surgeon cuts through the skin to remove an entire lymph node (known as an excisional biopsy). If the node is near the skin surface, this is a simple operation. But it is more complex if the node is inside the chest or abdomen. Most often the child will need general anesthesia (where the child is asleep).

## Lab tests to diagnose and classify leukemia

All blood, bone marrow, and other samples are sent to a lab for further testing.

### Microscopic exams

All of the samples taken (blood, bone marrow, lymph node tissue, or CSF) are looked at with a microscope. The samples might be exposed to chemical stains (dyes) that can cause color changes in some types of leukemia cells.

Doctors will look at the size, shape, and staining patterns of the blood cells in the samples to [classify them into specific types](#)<sup>6</sup>.

A key element is whether the cells look mature (like normal blood cells) or immature (lacking features of normal blood cells). The most immature cells are called **blasts**. Having too many blasts in the sample, especially in the blood, is a typical sign of leukemia.

An important feature of a bone marrow sample is its **cellularity**. Normal bone marrow contains a certain number of blood-forming cells and fat cells. Marrow with too many blood-forming cells is said to be **hypercellular**. If too few blood-forming cells are found, the marrow is called **hypocellular**.

### Flow cytometry and immunohistochemistry

These tests are used to classify leukemia cells based on certain proteins in or on the cells (known as **immunophenotyping**). This kind of testing is very helpful in determining the exact type and [subtype](#)<sup>7</sup> of leukemia. It is most often done on cells from bone marrow, but it can also be done on cells from the blood, lymph nodes, and other body fluids.

For both flow cytometry and immunohistochemistry, samples of cells are treated with antibodies, which are proteins that stick to certain other proteins on cells. For

immunohistochemistry, the cells are then examined under a microscope to see if the antibodies stuck to them (meaning they have these proteins), while for flow cytometry a special machine is used.

Flow cytometry can also be used to estimate the amount of DNA in the leukemia cells. This is important to know, especially in ALL, because cells with more DNA than normal (a **DNA index** of 1.16 or higher) are often more sensitive to chemotherapy, and these leukemias have a better prognosis (outlook).

Flow cytometry can also be used to measure the response to treatment and the existence of minimal residual disease (MRD) in some types of leukemias. (See [Prognostic Factors in Childhood Leukemia](#)<sup>8</sup>.)

### Chromosome tests

These tests look at the chromosomes (long strands of DNA) inside the cells. Normal human cells have 23 pairs of chromosomes, each of which is a certain size and looks a certain way under the microscope. But in some types of leukemia, the cells have changes in their chromosomes.

For instance, sometimes 2 chromosomes swap some of their DNA, so that part of one chromosome becomes attached to part of a different chromosome. This change, called a *translocation*, can usually be seen under a microscope. Other types of chromosome changes are also possible. Recognizing these changes can help identify certain subtypes of acute leukemias and can help determine prognosis (outlook).

Sometimes the leukemia cells have an abnormal number of chromosomes (instead of the usual 46) – they may be missing some chromosomes or have extra copies of some. This can also affect a child's outlook. For example, in ALL, chemotherapy is more likely to work if the cells have more than 50 chromosomes and is less likely to work if the cells have fewer than 46 chromosomes.

Finding these types of chromosome changes with lab tests can be very helpful in predicting a child's outlook and response to treatment.

**Cytogenetics:** For this test, leukemia cells are grown in a lab dish and the chromosomes are looked at under a microscope to detect any changes, including missing or extra chromosomes. (Counting the number of chromosomes by cytogenetics provides similar information to measuring the DNA index by flow cytometry, as described above.)

Cytogenetic testing usually takes about 2 to 3 weeks because the leukemia cells must

grow in lab dishes for a couple of weeks before their chromosomes are ready to be looked at.

Not all chromosome changes can be seen under a microscope. Other lab tests can often help detect these changes.

**Fluorescent in situ hybridization (FISH):** This is another way to look at chromosomes and genes. It uses special fluorescent dyes that only attach to specific parts of particular chromosomes. FISH can find most chromosome changes (such as translocations) that are visible under a microscope in standard cytogenetic tests, as well as some changes too small to be seen with usual cytogenetic testing.

FISH can be used to look for specific changes in chromosomes. It can be used on blood or bone marrow samples. It is very accurate and can usually provide results within a couple of days.

**Polymerase chain reaction (PCR):** This is a very sensitive test that can also find some chromosome and gene changes too small to be seen under a microscope, even if there are very few leukemia cells in a sample. This test can be very useful in looking for small numbers of leukemia cells ([minimal residual disease, or MRD<sup>9</sup>](#)) that might not be detected with other tests during and after treatment.

**Other molecular and genetic tests:** Newer types of lab tests, sometimes called **next generation sequencing (NGS) tests**, can also be done on the samples to look for specific gene changes in the leukemia cells.

### Other blood tests

Children with leukemia will have tests to measure certain chemicals in the blood to check how well their body systems are working.

These tests aren't used to diagnose leukemia, but in children already known to have it, they can help find damage to the liver, kidneys, or other organs caused by the spread of leukemia cells or by certain chemotherapy drugs. Tests are also often done to measure blood levels of important minerals, as well as to make sure the blood is clotting properly.

Children might also be tested for blood infections. It's important to diagnose and treat infections quickly in children with leukemia because their weakened immune systems can allow infections to spread.

### Imaging tests

Imaging tests use x-rays, sound waves, magnetic fields, or radioactive particles to make pictures of the inside of the body. Leukemia doesn't usually form tumors, so imaging tests aren't as useful as they are for other types of cancer. But if leukemia is suspected or has been diagnosed, your child's doctor may order some of these tests to get a better idea of the extent of the disease or to look for other problems, such as infections. For more details, see [Imaging Tests](#)<sup>10</sup>.

### **Chest x-rays**

A chest [x-ray](#)<sup>11</sup> can help detect an enlarged thymus or lymph nodes in the chest. If the test result is abnormal, a computed tomography (CT) scan of the chest may be done to get a more detailed view.

Chest x-rays can also help look for pneumonia if your child might have a lung infection.

### **Computed tomography (CT) scan**

The [CT scan](#)<sup>12</sup> isn't usually needed for children with leukemia, but it might be done if the doctor suspects the leukemia is growing in lymph nodes in the chest or in organs like the spleen or liver. It is also sometimes used to look at the brain and spinal cord, but an MRI scan may also be used for this.

**PET/CT scan:** Some machines combine the CT scan with a [positron emission tomography \(PET\) scan](#)<sup>13</sup>, which can provide more information about any abnormal areas that appear on the CT.

### **Magnetic resonance imaging (MRI) scan**

An [MRI scan](#)<sup>14</sup>, like a CT scan, makes detailed images of soft tissues in the body. It's most helpful in looking at the brain and spinal cord, so it's most likely to be done if the doctor has reason to think the leukemia might have spread there (such as if the child has symptoms like headaches, seizures, or vomiting). This test doesn't expose the child to radiation.

### **Ultrasound**

[Ultrasound](#)<sup>15</sup> can be used to look at lymph nodes near the surface of the body or to look for enlarged organs inside the abdomen such as the kidneys, liver, and spleen. (It can't be used to look at organs or lymph nodes in the chest because the ribs block the sound waves.)

This is a fairly easy test to have, and it uses no radiation.

## Hyperlinks

1. [www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/signs-and-symptoms.html](http://www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/signs-and-symptoms.html)
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13. [www.cancer.org/treatment/understanding-your-diagnosis/tests/nuclear-medicine-scans-for-cancer.html](http://www.cancer.org/treatment/understanding-your-diagnosis/tests/nuclear-medicine-scans-for-cancer.html)
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## Childhood Leukemia Subtypes

The type and subtype of leukemia a child has plays a major role in both treatment options and the child's outlook (prognosis). Determining the [type](#)<sup>1</sup> (acute lymphocytic leukemia (ALL), acute myeloid leukemia (AML), etc.) and subtype of the leukemia is done by testing samples of the blood, bone marrow, and sometimes lymph nodes or cerebrospinal fluid (CSF), as described in [Tests for Childhood Leukemia](#)<sup>2</sup>.

Be sure to ask your health care team or your child's doctor if you have any questions about the subtype of your child's leukemia.

### Acute lymphocytic (lymphoblastic) leukemia (ALL)

Acute lymphocytic leukemia (ALL) is a fast-growing cancer of lymphocyte-forming cells

called **lymphoblasts**. There are several subtypes of ALL, which are based mainly on:

- The type of lymphocyte (most often B cell or T cell) the leukemia cells come from (and how mature the cells are). This is known as the **immunophenotype** of the leukemia.
- If the leukemia cells have certain **gene or chromosome changes**

### **B-cell ALL**

Most often in children with ALL, the leukemia starts in early forms of B cells. There are several subtypes of B-cell ALL. **Mature B-cell ALL** (also called **Burkitt leukemia**), a rare subtype, is essentially the same as Burkitt lymphoma (a type of non-Hodgkin lymphoma) and is treated the same way. (See [Treatment of Non-Hodgkin Lymphoma in Children, by Type and Stage](#)<sup>3</sup>.)

### **T-cell ALL**

This type of leukemia affects older children more than B-cell ALL does. It often causes an enlarged thymus (a small organ in front of the windpipe), which can sometimes lead to breathing problems. It may also spread to the cerebrospinal fluid (CSF, the fluid that surrounds the brain and spinal cord) early in the course of the disease.

For more detailed information on the subtypes of ALL, see [Acute Lymphocytic Leukemia \(ALL\) Subtypes and Prognostic Factors](#)<sup>4</sup>.

Aside from the subtype of ALL, other factors are important in determining a child's outlook (prognosis). These are described in [Prognostic Factors in Childhood Leukemia](#)<sup>5</sup>.

### **Acute myeloid leukemia (AML)**

Acute myeloid leukemia (AML) is typically a fast-growing cancer that starts in one of the following types of early (immature) bone marrow cells:

- **Myeloblasts:** These cells normally form white blood cells called **granulocytes** (neutrophils, eosinophils, and basophils).
- **Monoblasts:** These cells normally become white blood cells called **monocytes** and **macrophages**.
- **Erythroblasts:** These cells mature into red blood cells.
- **Megakaryoblasts:** These cells normally become megakaryocytes, the cells that

make platelets.

AML has many subtypes, which are based mainly on:

- The type of bone marrow cell the leukemia cells come from, and how mature the cells are (the **immunophenotype** of the leukemia)
- If the leukemia cells have certain **gene or chromosome changes**
- If the leukemia is related to the **treatment of an earlier cancer** (with chemotherapy or radiation)
- If the child with leukemia has **Down syndrome**

**Acute promyelocytic leukemia (APL)** is a special subtype of AML. It is [treated differently](#)<sup>6</sup> from other subtypes of AML, and it tends to have a better outlook.

For more detailed information on the subtypes of AML, see [Acute Myeloid Leukemia \(AML\) Subtypes and Prognostic Factors](#)<sup>7</sup>.

Aside from the AML subtype, other factors are important in determining a child's outlook (prognosis). These are described in [Prognostic Factors in Childhood Leukemia](#)<sup>8</sup>.

## Chronic myeloid leukemia (CML)

Chronic myeloid leukemia (CML) is typically a slower-growing cancer of early (immature) myeloid bone marrow cells. CML is not common in children, but it can occur.

CML does not have subtypes. Instead, the course of CML has 3 **phases**, based mainly on the number of immature white blood cells – myeloblasts (or blasts) – that are seen in the blood or bone marrow. CML can sometimes progress to more advanced phases over time.

### Chronic phase of CML

In this earliest phase, children usually have fairly mild symptoms (if any), and the leukemia usually responds well to standard [treatments](#)<sup>9</sup>. Most children are in the chronic phase when they are diagnosed.

### Accelerated phase of CML

Children whose CML is in accelerated phase may have symptoms such as fever, night

sweats, poor appetite, and weight loss. CML in the accelerated phase might not respond as well to treatment as CML in the chronic phase.

### **Blast phase (also called acute phase or blast crisis) of CML**

In this phase, the leukemia cells often spread to tissues and organs outside the bone marrow. Children with CML in this phase often have fever, poor appetite, and weight loss. At this point the CML acts much like an aggressive acute leukemia (AML or, less often, ALL).

For more detailed information on the phases of CML, see [Phases of Chronic Myeloid Leukemia](#)<sup>10</sup>.

### **Hyperlinks**

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## Prognostic Factors in Childhood Leukemia (ALL or AML)

In children with acute lymphocytic leukemia (ALL) or acute myeloid leukemia (AML), certain factors that can affect a child's outlook (prognosis) are called **prognostic factors**. They help doctors decide how intense treatment needs to be. Prognostic factors seem to be more important in ALL than in AML.

### Prognostic factors for children with ALL

Children with ALL are often put into **risk groups** (such as low risk, standard risk, high risk, or very high risk), with more intensive treatment given to higher risk patients. Generally, children at low risk have a better outlook than those at very high risk. But it's important to know that even children in higher risk groups can often still be cured.

While all of the following are prognostic factors, only certain ones are used to determine

which risk group a child is in. (The first 2 factors – age at diagnosis and initial white blood cell count – are thought to be the most important.)

### **Age at diagnosis**

Children between the ages of 1 and 9 with B-cell ALL tend to have better cure rates. Children younger than 1 year and children 10 years or older are considered high-risk patients. The outlook in T-cell ALL isn't affected much by age.

### **Initial white blood cell (WBC) count**

Children with ALL who have very high WBC counts (greater than 50,000 cells per cubic millimeter) when they are diagnosed are at higher risk and need more intensive treatment.

### **ALL subtype**

Children with early B-cell [ALL subtypes](#)<sup>1</sup> generally do better than those with mature B-cell (Burkitt) leukemia. The outlook for T-cell ALL seems to be about the same as that for B-cell ALL as long as treatment is intense enough.

### **Gender**

Girls with ALL may have a slightly higher chance of being cured than boys, but as treatments have improved in recent years, this difference has shrunk.

### **Number of chromosomes in the leukemia cells (ploidy)**

Normal human cells have 46 chromosomes. Children are more likely to be cured if their leukemia cells have more than 50 chromosomes (called **hyperdiploidy**), especially if there is an extra chromosome 4, 10, or 17. Hyperdiploidy can also be expressed as a [DNA index](#)<sup>2</sup> of more than 1.16. Children whose leukemia cells have fewer than 44 chromosomes (known as **hypodiploidy**) have a less favorable outlook.

### **Chromosome changes (such as translocations)**

Translocations occur when chromosomes swap some of their genetic material (DNA). Children whose leukemia cells have a translocation between chromosomes 12 and 21 are more likely to be cured. Those with a translocation between chromosomes 9 and 22 (the Philadelphia chromosome) or 4 and 11 tend to have a less favorable prognosis.

Some of these “poor” prognostic factors have become less important in recent years as treatment has improved.

### **Response to initial treatment**

Children whose leukemia goes into **remission** (major reduction of cancer cells in the bone marrow) within 1 to 2 weeks of chemotherapy have a better outlook than those whose leukemia does not. Having **minimal residual disease** (MRD), which is a very small amount of leukemia cells still detectable by sensitive lab tests, can also affect outlook. (See "Status of acute leukemia after treatment" below for more on this.) Children whose cancer does not respond as well may be given more intensive chemotherapy.

### **Prognostic factors for children with AML**

Prognostic factors are not quite as important in predicting outcome or in guiding treatment for AML as they are for ALL.

#### **Initial white blood cell (WBC) count**

Children with AML whose WBC count is less than 100,000 cells per cubic millimeter at diagnosis tend to do better than those with higher counts.

#### **Down syndrome**

Children with Down syndrome who develop AML tend to have a good outlook, especially if the child is 4 years old or younger at the time of diagnosis.

#### **AML subtype**

Some [subtypes of AML](#)<sup>3</sup> tend to have a better outlook than others. For example, the acute promyelocytic leukemia (APL) subtype tends to have a better outlook than most other subtypes.

#### **Chromosome or gene changes**

Children with leukemia cells that have translocations between chromosomes 15 and 17 (seen in most cases of APL) or between 8 and 21, or with an inversion (rearrangement) of chromosome 16 have a better chance of being cured. Children whose leukemia cells are missing a copy of chromosome 5 or 7 (known as **monosomy**) or just part of

chromosome 5 (known as a **deletion**) tend to have a poorer prognosis.

Children whose leukemia cells have a mutation in the *FLT3* gene tend to have a poorer outlook, although [new drugs that target cells with this abnormal gene](#)<sup>4</sup> might lead to better outcomes. On the other hand, children whose leukemia cells have changes in the *NPM1* gene (and not in the *FLT3* gene) seem to have a better prognosis than children without this change. Changes in the *CEBPA* gene are also linked to a better outcome.

### **Myelodysplastic syndrome or secondary AML**

Children who first have a [myelodysplastic syndrome](#)<sup>5</sup> (“smoldering leukemia”) or whose leukemia is the result of treatment for another cancer tend to have a less favorable outlook.

### **Response to initial treatment**

Children whose leukemia responds quickly to treatment (only one chemotherapy cycle needed to achieve remission) are more likely to be cured than those whose leukemia takes longer to respond or does not respond at all.

### **Status of acute leukemia after treatment**

How well (and how quickly) ALL or AML responds to the initial (induction) treatment can affect long-term prognosis.

### **Remission**

A **remission** (or **complete remission**) is usually defined as having no evidence of leukemia after the initial treatment. This means:

- The bone marrow contains fewer than 5% blast cells
- The blood cell counts are within normal limits
- There are no signs or symptoms of the disease

A **complete molecular remission** means there is no evidence of leukemia cells in the bone marrow, even when using very sensitive lab tests, such as [polymerase chain reaction \(PCR\)](#)<sup>6</sup>.

Even when leukemia is in remission, this does not always mean that it has been cured.

## Minimal residual disease

**Minimal residual disease (MRD)** is a term used after treatment when leukemia cells can't be found in the bone marrow using standard lab tests (such as looking at cells under a microscope), but they can still be detected with more sensitive tests (such as flow cytometry or PCR).

In general, children with MRD during or after induction chemotherapy are more likely to have the leukemia relapse (come back) and therefore may need more intense treatment. Children with more MRD have a greater risk of relapse than those with less MRD.

## Active disease

**Active disease** means that either there is evidence that the leukemia is still present during treatment or that the disease has relapsed (come back) after treatment. For a patient to have relapsed, more than 5% of the bone marrow must be made up of blast cells.

## Hyperlinks

1. [www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/how-classified.html](http://www.cancer.org/cancer/leukemia-in-children/detection-diagnosis-staging/how-classified.html)
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## Survival Rates for Childhood Leukemias

Survival rates are often used by doctors as a standard way of discussing a child's prognosis (outlook). These numbers tell you what portion of children in a similar situation (such as with the same type and subtype of leukemia) are still alive a certain amount of time after they were diagnosed. They can't tell you exactly what will happen in an individual child's case, but they may help give you a better understanding about how likely it is that treatment will be successful. Some people find survival rates helpful, but some people might not.

The **5-year survival rate** refers to the percentage of children who live **at least** 5 years after their leukemia is diagnosed. With acute leukemias (ALL or AML), children who are free of the disease after 5 years are very likely to have been cured, because it's very rare for these cancers to return after this long.

Knowing the type and [subtype](#)<sup>1</sup> of leukemia is important in estimating a child's outlook. But a number of other factors, including the child's age and leukemia characteristics, can also affect outlook. Many of these factors are discussed in [Prognostic Factors In](#)

[Childhood Leukemia \(ALL or AML\)](#)<sup>2</sup>. Even when taking these other factors into account, survival rates are at best rough estimates. Your child's doctor can probably tell you how these numbers apply to your child, as he or she knows your situation best.

Current 5-year survival rates are based on children first diagnosed and treated more than 5 years ago. Improvements in treatment since then might result in a better outlook for children now being diagnosed.

### **Acute lymphocytic leukemia (ALL)**

The 5-year survival rate for children with ALL has greatly increased over time and is now about 90% overall. In general, children in lower risk groups have a better outlook than those in higher risk groups. But it's important to know that even children in higher risk groups can often still be cured.

### **Acute myelogenous leukemia (AML)**

The overall 5-year survival rate for children with AML has also increased over time, and is now in the range of 65% to 70%. However, survival rates vary depending on the subtype of AML and other factors. For example, most studies suggest that the cure rate for acute promyelocytic leukemia (APL), a subtype of AML, is now higher than 80%, but rates are lower for some other subtypes of AML.

### **Other childhood leukemias**

Accurate survival rates for less common forms of childhood leukemia are harder to find.

#### ***Juvenile myelomonocytic leukemia (JMML)***

For JMML, 5-year survival rates of about 50% have been reported.

#### ***Chronic myeloid leukemia (CML)***

For CML, which is rare in children, 5-year survival rates are less helpful, because some children may live for a long time with the leukemia without actually being cured. In the past, 5-year survival rates for CML were reported to be in the range of 60% to 80%. But with the newer, more effective [medicines used to treat CML](#)<sup>3</sup> in recent years, survival rates are likely to be higher now.

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# Questions to Ask About Childhood Leukemia

It's important to have open, honest discussions with your child's cancer care team. They want to answer all of your questions, no matter how small they might seem. For instance, consider these examples:

## If leukemia has just been diagnosed

- What [type of leukemia](#)<sup>1</sup> does my child have?
- How will the [subtype of the leukemia](#)<sup>2</sup> or any [other factors](#)<sup>3</sup> affect my child's prognosis?
- Do we need other [tests](#)<sup>4</sup> before we can decide on treatment?
- Will we need to see other doctors?
- How much experience do you have treating this type of leukemia?
- Who else will be on the treatment team, and what do they do?

## When deciding on a treatment plan

- What are our [treatment choices](#)<sup>5</sup>?
- What do you recommend and why?
- Should we get a [second opinion](#)<sup>6</sup>? How would we do that? Can you recommend a doctor or cancer center?
- Should we consider a [stem cell transplant](#)<sup>7</sup>? When?
- Are there any [clinical trials](#)<sup>8</sup> we should consider?
- How soon do we need to start treatment?
- What should we do to be ready for treatment?
- How long will treatment last? What will it be like?
- How much of the treatment will need to be done in the hospital?
- How will treatment affect our daily lives (school, work, etc.)?
- What are the risks and side effects of the treatments you recommend?
- Which side effects start shortly after treatment, and which ones might develop later on?
- Will treatment affect my child's ability to learn, grow, and develop?
- Will treatment affect my child's future ability to have children?
- What are the chances of curing the leukemia?

## During and after treatment

Once treatment begins, you'll need to know what to expect and what to look for. Not all of these questions may apply, but getting answers to the ones that do may be helpful.

- What type of [follow-up](#)<sup>9</sup> will we need after treatment?
- How will we know if the treatment is working?
- Is there anything we can do to help manage side effects?
- What symptoms or side effects should we tell you about right away?
- How can we reach you or someone on your team on nights, weekends, or holidays?
- Who can we talk to if we have questions about costs, insurance coverage, or social support?
- What will our options be if the treatment doesn't work or if the leukemia comes back?
- Do you know of any support groups where we can talk to other families who have been through this?

Along with these sample questions, be sure to write down your own. For instance, you might want to ask about possible long-term risks of cancer or other health problems.

Also keep in mind that doctors are not the only ones who can give you information. Other health care professionals, such as nurses and social workers, may have the answers to some of your questions. You can find out more about speaking with your health care team in [The Doctor-Patient Relationship](#)<sup>10</sup>.

## Hyperlinks

1. [www.cancer.org/cancer/leukemia-in-children/about/what-is-childhood-leukemia.html](http://www.cancer.org/cancer/leukemia-in-children/about/what-is-childhood-leukemia.html)
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