



Infections in People With Cancer

What are infections and who is at risk?

Infection is what happens when germs (also called *microbes* or *microorganisms*) enter the body, multiply, and cause harm or illness. The main types of germs are bacteria, viruses, protozoa (parasites), and fungal organisms (also called fungi).

Infections that develop in people who have cancer or are getting cancer treatment can be more serious than those developing in healthy people. They can also be harder to treat. If you have cancer, it is important to find infections early and treat them before they get worse and spread.

By learning more about them, you and your family may be able to help prevent problems that infections can cause:

- You can take steps to avoid being exposed to dangerous germs.
- There are drugs you can take and things you can do to help prevent some illnesses even after you are exposed to the germs.
- If you do get an infection, the information here will help you know what to look for and what you can do to get treatment quickly.

Cancer and the risk of infection

Cancer itself can increase your risk of getting a serious infection. So can certain types of cancer treatment. Once the cancer is gone and treatment is finished, the risk of infection usually goes back to a normal level. For most people with cancer, the high-level risk for serious infection only lasts for a limited time. Most people with cancer do not have a high risk of getting the kinds of infections described here.

Your risk of infection depends on the type of cancer you have and the treatment you get. For example, surgery does not weaken a person's resistance to infection nearly as much as a bone marrow transplant. (For more information, see our document, *Bone Marrow*

and Peripheral Blood Stem Cell Transplants.) And some chemotherapy drugs are less likely than others to affect a person's resistance to infection.

It is important to weigh the risk of infection and other side effects against the benefits of cancer treatment. Talk with your doctors before or during chemotherapy or radiation therapy to see how this information applies to you. Here are some questions you can ask your doctor or cancer care team before and during cancer treatment:

- Will my cancer treatment make me more likely to get infections?
- If I get an infection, how severe is it likely to be, and how long might it last?
- Will you do anything special to help keep me from getting infections?
- What can I do to lower my risk of infection?
- How will I know if I have an infection?
- What should I do if I think I have an infection?
- If I get a fever (increase in body temperature), does that mean I have an infection?
- How will you decide how to treat my infection?
- What will you do if the treatment does not get rid of my infection?
- What are the likely side effects of the proposed treatments for infection?

How does a person's body normally resist infections?

Your body has many ways to protect itself from infections. It helps to understand the normal ways your body does this, and how cancer and cancer treatment change this process. This may help you better understand why infections can develop so easily and be so serious in people with cancer.

Skin and mucous membranes

The skin is your body's largest organ and the most important barrier against infections. It is your first line of defense in protecting internal tissues from harmful germs. It also keeps body tissues from drying out (dehydrating). When there is a break in the skin, germs (sometimes from the air, but most often from the skin or things we touch) can enter the body and cause infection.

The mucous membranes, which form the moist, pink lining layer of the mouth, throat, nose, eyelids, urethra, vagina, and digestive (gastrointestinal) system, also act as a partial barrier against infection. These membranes normally help protect us from germs in the air we breathe, our environment, and in our food and drink.

Cancer treatments (such as chemotherapy, radiation therapy, or surgery) and invasive procedures (like putting in catheters or IVs, or getting shots) can damage the skin or mucous membranes so that it is easier for germs to get inside the body.

The immune system and blood cells

If germs get through the skin or mucous membranes, the job of protecting the body shifts to the immune system and some of its special cells. The immune system is a complex network of cells, signals, and organs that work together to help kill germs that cause infections. Many of these are special blood cells that travel in the blood until they find germs to attack. Others spend part of their time in the blood and the rest of their time in immune system organs.

How blood cells are made

Blood is made when cells in the bone marrow, called *stem cells*, grow into different kinds of mature cells and are released into the blood to do their work. There are 3 major kinds of blood cells.

- Red blood cells (RBCs or erythrocytes) carry oxygen to cells throughout the body.
- Platelets (thrombocytes) help make clots to plug up holes that form in blood vessels from injuries such as cuts, scrapes, or bruises.
- White blood cells (WBCs or leukocytes) help fight germs that get into the body.

White blood cells help fight infection

Unlike red cells and platelets, white blood cells are part of the immune system. There are different types of white blood cells, and they each have a key role in the body's defense against germs.

The type of white blood cell we normally have the most of is called the *neutrophil*. These cells form a very important defense against most types of infections. In most people with cancer, having a low neutrophil count is the biggest risk factor for getting a serious infection.

Neutropenia is the medical term used to describe a shortage of neutrophils. Ask your doctor if your cancer treatment will cause neutropenia.

There are other important types of white blood cells:

- Lymphocytes (which include T-lymphocytes and B-lymphocytes)
- Monocytes
- Macrophages

Each type of white blood cell has a special job in fighting infections.

Some treatments, most often those given during bone marrow transplants, can cause a shortage of lymphocytes. B and T lymphocytes help fight viruses, but have different jobs:

- B-lymphocytes make antibodies that recognize and kill some germs. They also can mark germs to be destroyed.
- T-lymphocytes make signaling substances called *cytokines* that tell other cells what to do. They also destroy cells infected by viruses.

Monocytes and macrophages have special jobs, too:

- They help lymphocytes recognize germs.
- They can surround and digest germs that have been coated by antibodies (the proteins made by B-lymphocytes).
- They help fight bacteria, fungal organisms, and parasites.

What risk factors make people with cancer more likely to get infections?

Some types of cancer can damage the immune and blood systems or change the way they work. For instance, lymphomas (Hodgkin and non-Hodgkin) and certain types of leukemias start in immune system cells. They change the immune system cells so that cells that once protected the body begin to interfere with the normal way the immune system works. Many other types of cancer can also affect the immune system.

But in most cases it is the cancer treatment, not the cancer itself, that changes the immune system. The treatments can cause short- or long-term damage. For example, long-term damage happens when immune system organs such as the spleen are removed. A *splenectomy* (surgery to remove the spleen) is sometimes done to remove cancer or learn how much it has spread. Chemotherapy, radiation therapy, or a combination of both can also lead to short-term immune system damage. Sometimes the damage can last for months after treatment ends.

Some people with cancer have a higher risk of infection because of the changes in their body's defense systems. Cancer and cancer treatments can affect these systems in different ways.

Immune suppression, leukopenia, and neutropenia

Chemotherapy, radiation therapy, surgery, stem cell transplant, bone marrow transplant, steroids, or the cancer itself can suppress or weaken the immune system. This is called *immunosuppression*. These treatments can lower the number of white blood cells (WBCs) and other immune system cells, and can also cause them to not work the way they should. You may get an infection when there aren't enough WBCs, especially neutrophils, to destroy germs.

When looking at your risk of getting an infection, doctors look to see if you have a decrease in the number of neutrophils. A low number of neutrophils is called *neutropenia*. The doctor may say you are *neutropenic*.

It is possible for your total WBC count to be normal while you are still neutropenic. But in most cases the WBC count is low when the neutrophil count is low.

Absolute neutrophil count

You may hear your doctor or nurse talk about your *absolute neutrophil count* or *ANC*. This is the number of neutrophils you have in a certain amount of blood. Your health care team will use this number to get an idea of how well your immune system is working while you are getting treatment. You might want to keep track of your ANC so you will know when you are at a higher risk of getting an infection.

Figuring out your ANC: The numbers for your ANC are taken from the results of a blood test called the *differential white blood cell (WBC) count*. You can find out the results of these blood tests or get copies of the test results from your doctor. You may have to ask the doctor or nurse what the different numbers are on the lab report before you start figuring out your ANC.

Normally, neutrophils make up 50% to 70% of WBCs. To find out your ANC, multiply the percentage of neutrophils by the total number of WBCs. (Neutrophils are sometimes called "segs" or "polys," and young neutrophils may be called "bands" on your lab report. If there are bands listed as a percentage of WBCs, those are added to the neutrophils before multiplying.)

You can figure out your ANC using this formula:

$$[(\% \text{ of neutrophils} + \% \text{ of bands}) \div 100] \times \text{WBC count} = \text{ANC}$$

So, for example, if a patient's WBC count is 1,000 and the percentage of neutrophils is 70%, and there are no bands, then the ANC is 700, which is calculated like this:

$$[(70 + 0) \div 100] \times 1,000$$

$$(70 \div 100) \times 1,000$$

$$0.7 \times 1,000 = 700$$

Another example is if the patient's WBC is 1,300, with 60% neutrophils and 5% bands. The bands are added with the neutrophils (60 + 5), and the ANC is 845:

$$[(60 + 5) \div 100] \times 1,300$$

$$(65 \div 100) \times 1,300$$

$$0.65 \times 1300 = 845$$

What the absolute neutrophil count means: An ANC less than 1,000 means that you have a low number of neutrophils and your immune system is weak.

The lower the ANC drops and the longer it stays low, the higher your risk for getting a serious infection. If the ANC drops below 500 for a few days, you are at a high risk of getting an infection. If your ANC is 100 or less for more than a week, your risk of serious infection is extremely high.

In a person with a healthy immune system, the usual signs of infection are fever, pus, pain, swelling, and redness. As the ANC gets lower, most of these signs may not show up when an infection starts. This is because these signs are caused by neutrophils fighting off germs. So if you're neutropenic, you may not have enough neutrophils to show signs the body is fighting back, even though the germs are there. This makes it hard to know if you have an infection. The good thing is that another WBC, called the monocyte, can still cause fever in the person who has neutropenia. In people with severe neutropenia, a fever may be the only sign of an infection.

If your ANC is 1,000 or lower and you have a fever of 100.5° F (37° C) or higher when taken by mouth, your doctor will likely assume that the fever is caused by an infection. Treatment with antibiotics is usually started right away. When a person has neutropenia, infections must be found and treated as quickly as possible.

Problems due to the cancer

Cancer cells can get into the bone marrow where blood cells are made. The cancer cells then compete with the normal bone marrow cells for space and nutrients. If too many normal marrow cells are destroyed or pushed out of the bone marrow, the few cells that are left will not be able to make enough white blood cells (WBCs) to fight infection.

Cancer can also damage other parts of the immune system. A tumor can grow through the skin or mucous membranes, breaking natural barriers and allowing germs to get in. Tumors may also reduce blood flow to the normal tissues by pressing on them or their blood supply. Tumors in the lungs may block normal mucus drainage, which can lead to infections. And tissues that have been damaged by cancer are more prone to infections.

Cancer cells can also release chemicals that change normal immune cells. This is a well-known effect of many cancers that start in immune system cells, such as lymphomas, leukemias, and multiple myeloma. It can happen with other cancers, too.

Poor nutrition

All cells need nutrients to grow and work. Lack of vitamins, minerals, calories, and protein can make your immune system weaker. Poor nutrition makes your immune system less able to find and destroy germs. This means people who are *malnourished* are more likely to develop infections. People who are malnourished either do not take in enough calories and nutrients, or the body can't use the food they do take in. Either way, it can weaken your immune system.

People with cancer often have poor nutrition for many reasons:

- The cancer itself may make it hard to eat or digest food. This is common in people with cancers of the digestive system, mouth, or throat.
- Cancer treatments, like radiation therapy and chemotherapy, may cause nausea and a loss of appetite.
- People with cancer often need extra calories and protein to support their immune system cells and other tissues.
- Recovery from surgery increases the body's need for nutrients.
- Cancer cells use up nutrients, leaving less to meet the needs of normal, healthy tissues.

People with cancer often need help from dietitians or doctors to get enough calories and nutrients. Dietary supplements, tube feedings, or even intravenous (IV, through a vein) feedings may help in some cases.

Nutrition counseling and stress management may help improve the immune function of people with cancer, which may help prevent infections. Nutrition counseling should include the importance of a high intake of calories, protein, and vitamins. This is tailored to each person's own food intake and nutrition problems. Other therapies such as biofeedback, humor, music therapy, guided imagery, counseling, and meditation may help manage stress and make it easier to eat.

Cancer treatment

Most of the cancer treatments used today can increase your risk for infection.

Surgery

Any type of major surgery can suppress the immune system, but the reason for this is not very clear. Researchers have seen decreases in immune function within hours of surgery. Anesthesia (the drugs used to make the patient sleep) may play a role. It may take from 10 days to many months for an immune system to recover completely.

Surgery also breaks the skin and mucous membranes and can expose internal tissues to germs. The wound caused by surgery (the *incision*) is a common place for infection.

Surgery is often used to diagnose, stage, or treat people with cancer. Things that raise the risk of infection after surgery include:

- How long the person was in the hospital
- The extent of the surgery (how much cutting was done)
- How long the operation lasted
- The amount of bleeding during surgery
- Nutritional status of the patient

- Prior cancer treatment, such as chemotherapy or radiation
- Other medical problems, such as diabetes, or heart or lung problems

People with cancer may get antibiotics before having surgery to help protect them from infection. Because surgery is often used to treat people with cancer, it is important to know there is a chance of infection after surgery.

Chemotherapy

Chemotherapy (often called simply "chemo") is the most common cause of a weakened immune system in people getting cancer treatment. The effects on the immune system depend on many things, including:

- Which chemo drugs are used
- Chemo doses (how much is given at once)
- Schedule (how often chemo is given)
- Prior treatments for cancer
- Age
- Nutritional status
- Type of cancer
- Stage of the cancer

Some drugs have a greater effect on the bone marrow and immune system than others. But chemo drugs may have different effects on how well the body makes white blood cells, red blood cells, and platelets. In most cases, white blood cells are the ones most affected by chemo drugs. The effect chemo has on your blood cells doesn't last. Over time your blood cell counts usually go back to normal after treatment ends.

Radiation therapy

The effects of radiation therapy on the cells of the bone marrow are much like the effects of chemo. Both of these treatments may cause low white blood cell counts (including neutropenia), which increases the risk for infections.

Many things affect the degree of neutropenia from radiation therapy. These include:

- The total radiation dose
- The radiation schedule
- The part of the body being treated with radiation
- How much of the body is treated with radiation

Total body irradiation or TBI (where a person's entire body is treated with radiation) is the only type of radiation likely to cause very low blood counts. Radiation is most often given to just one area of the body, so the whole immune system is not damaged by it. Still, depending on the dose and the part of the body being treated with radiation, the skin or mucous membranes may be damaged, so you're less able to keep germs out.

Today, radiation treatments are given over many sessions rather than in one large dose. This helps decrease the amount of skin and tissue damage, immune suppression, and the risk of infections.

Biotherapy or immunotherapy

Biotherapy is also known as *biologic therapy* or *immunotherapy*. It is given to make your immune system better able to recognize and attack cancer cells. This can be done by helping your own immune system work harder or smarter, or by giving you things like man-made immune system proteins. Immunotherapy is sometimes used by itself to treat cancer, but it is often used along with or after another type of treatment to add to its effects.

These treatments promote immune reactions against cancer cells, but sometimes they can change the way the immune system works. Because of this, people who get biologic therapies may be at risk for immune suppression and neutropenia. In fact, some immunotherapy drugs cause the levels of all white blood cells (not just neutrophils) to become low. When the lymphocyte levels become low, the chance of getting certain serious viral and fungal infections become very high. Their absolute neutrophil counts may also drop. Most of the time the neutrophil counts return to normal soon after the treatment is stopped, but the lymphocyte counts can stay low for months. (For more information see our document *Immunotherapy*.)

Hematopoietic stem cell transplant (bone marrow transplant)

Hematopoietic stem cell transplant (HSCT) is the term now used to include *bone marrow transplant* (BMT), *peripheral blood stem cell transplant* (PBSCT), and *umbilical cord blood stem cell transplant* (UCBSCT). These transplants require very high doses of chemo and/or total body irradiation (TBI) to try to kill all the cancer cells in the body. In the process of killing the cancer cells, the blood-forming stem cells of the patient's normal bone marrow are also killed. Because of this, stem cells (either from the blood or bone marrow) are removed from the patient and saved before the high-dose chemo is given. Or, they may be taken from a donor or banked umbilical cord blood. Once the cancer cells are killed, the saved or donated stem cells are given to the patient so that blood cells can be made and the immune system rebuilt.

High-dose chemo is sometimes used with TBI for transplants. This causes more severe neutropenia that lasts for a longer time. These treatments, especially when used together, also damage the skin and mucous membranes and make them less able to keep germs out of the body.

For these reasons, very strict precautions are taken to try to protect transplant patients from getting infections. This usually includes:

- Keeping the transplant patient in a special area of the hospital until WBC counts begin to reach normal (this often takes weeks)
- Limiting their exposure to other people or other sources of germs
- Watching them closely for signs of infection, such as fever

Patients who get stem cells from other people may also need medicine to prevent a serious problem called *graft-versus-host disease*. These medicines suppress the immune system. For more information on these transplants, see our document *Bone Marrow and Peripheral Blood Stem Cell Transplants*.

Neutropenia and infection risk

Risk factors for infection can add up

When your cancer treatment causes low white blood cell counts, you have a higher risk of getting an infection. And when your absolute neutrophil count (ANC) is low, there are other factors that can make your risk for infection even higher. For example, your chance of getting a serious infection is much higher if your ANC is low and you:

- Are in the hospital when your fever starts
- Have other serious illnesses
- Have cancer that is not controlled or is getting worse
- Have a very low neutrophil count (ANC is 100 or less) for a week or more
- Are age 60 or older
- Have had a recent stem cell transplant
- Do not have normal liver and/or kidney function
- Have lung disease, like emphysema or chronic obstructive pulmonary disease
- Can't eat because of severe mouth sores
- Are dehydrated
- Are taking alemtuzumab (Campath®)

The same person may have more than one of these risk factors, which can raise the risk of infection even higher.

Factors that may work in your favor

When your ANC is low, your risk for a serious infection is not as high if you:

- Have none of the high-risk factors listed above
- Are expected to have neutropenia for less than a week
- Are still able to do most of your daily activities for yourself

How does the doctor know what kind of infection a person with cancer has?

People with cancer may get many different types of infections. These infections differ in their risk factors, the symptoms they cause, how they are treated, and the chance for curing the infection. When looking at the different types, the doctor will want to know 2 important things:

- The part of the body affected
- The type of germ causing the infection

Parts of the body most likely to get infections

Your signs and symptoms (for example, where you have pain, redness, or swelling) help your doctor know what tests are needed to find the cause of the infection. The results of certain tests (such as x-rays, CT scans, or lab tests done on body fluids) help pinpoint where the infection is.

Common sites of infection in people with cancer include

- The skin and mucous membranes
- The digestive system (esophagus or swallowing tube, stomach, and intestines)
- The lungs and breathing passages (sinuses, throat, and lungs)
- The urinary system (bladder and kidneys)
- The nervous system (brain and spinal cord)
- The skin and tissue around a vascular access device (VAD). The VAD is a tube or catheter put in a vein that is used to draw blood and give IV medicines or fluids (like a PICC line or port-a-cath).

Knowing some of these terms can help you understand your medical condition so that you can take a more active part in your own treatment decisions. It may help to know that the medical names for various types of infections sometimes simply have "-itis," added after the English, Latin, or Greek name of a tissue or organ. For example:

Part of the body affected by infection	Medical term
Deep layers of skin	Cellulitis
Any area of mucous membranes	Mucositis
Mucous membranes of the mouth	Stomatitis
Mucous membranes of the esophagus (the swallowing tube that connects the throat and stomach)	Esophagitis
Stomach and intestines (gastrointestinal system)	Gastroenteritis
Mucous membranes of the small intestine	Enteritis
Mucous membranes of the large intestine (colon)	Colitis
Mucous membranes of the small and large intestines	Enterocolitis
Sinuses	Sinusitis
Mucous membranes of the throat (pharynx)	Pharyngitis
Tubes leading into the lungs (bronchi)	Bronchitis
Lungs	Pneumonitis or pneumonia
Urinary system in general	Urinary tract infection (UTI)
Urinary bladder	Cystitis
Kidneys	Pyelonephritis
Liver	Hepatitis
Bone	Osteomyelitis
Covering layer of the brain and spinal cord (meninges)	Meningitis
Brain	Encephalitis
Retina (part of the eye)	Retinitis
Eye covering or lining (conjunctiva)	Conjunctivitis
Heart (the heart muscle is called the myocardium)	Myocarditis

Finding the germs that cause infections in people with cancer

Infections are grouped by the type of germs that cause them. Bacteria, viruses, protozoa (parasites), or fungi may cause infections in people with cancer.

Most of the infections in people with cancer are caused by germs that normally live on the skin, in the intestines, or in the environment. These germs usually do not cause infections in people with normal defenses and immune systems. But if the normal barriers and immune system are weak, these germs can begin to grow and cause damage. These infections are often called *opportunistic infections*, because the germs use the opportunity of a patient's weakened defenses to cause illness.

Naming germs

Like all other living things, germs are given scientific names that are made up of first names (genus) and last names (species). These names tell biologists and health care workers which germs are related and may be like each other. For example, the biological names *Felis domesticus* (house cats) and *Felis leo* (lions) tell biologists the animals are related. (Note that scientific names are usually written in italics, except for viruses.)

In the same way, *Staphylococcus epidermidis* and *Staphylococcus aureus* are related bacteria. But, like house cats and lions, they differ in important details. *Staphylococcus epidermidis* lives on our skin and rarely causes infections in healthy people. But it can cause infections in people with cancer who have an IV (intravenous) or vascular access device (VAD) and a low white blood cell count. *Staphylococcus aureus* can cause very serious infections even in those with healthy immune systems. It is often resistant to antibiotics. This means these infections can be very hard to treat.

Although most germs have first and last names, those that are very well known are often called by their first names only. Germs like this include *Pneumococcus*, *Candida*, and *Aspergillus*. And like some people, germs with long names are sometimes more commonly known by their initials or nicknames. These include E. coli (*Escherichia coli*), Staph epi (*Staphylococcus epidermidis*), and CMV (cytomegalovirus).

Lab tests to identify germs

Knowing the exact type of germ that is causing an infection helps doctors choose the best treatment. Different drugs are used to treat each of the main types of germs -- bacteria, viruses, fungi, and parasites. And even among the main types of germs, different types are treated by different drugs. This means an antibiotic that may kill one type of bacteria can have no effect on another type of bacteria. Your health care team will do all they can to find out exactly what germ is causing your infection. Here are some of the tests they may use.

Gram stain: Sometimes, samples from the suspected site of infection can put on a microscope slide and treated with a series of stains (dyes). This test is called a Gram stain. It changes the colors of the germs and makes them easier to see. Looking at samples from infected tissues under a microscope can give clues about the type of germ involved. Bacteria, fungi, and parasites are big enough to see under a regular microscope, though they are much too small to see without one. It takes only a few minutes to stain the sample and look at it. The colors and shapes of the stained germs often give doctors an idea of which germ is causing the infection. This can help narrow the choice of antibiotics until more precise test results are available.

Tests for viruses: Viruses are too small to be seen with most microscopes. Instead, viruses are often identified by the types of changes they cause in the cells they infect. Sometimes these changes can be seen in cells from samples taken right from the patient. In other cases, samples must be added to test cells grown in lab dishes. If a virus is present, the test cells will go through changes that lab experts can recognize.

Genetic tests: New medical lab tests can quickly identify some germs by testing their DNA, RNA, or other substances. These tests often help doctors choose the best treatment more quickly than older tests. This means they can help get the right treatment started before the infection causes serious harm.

Culture: Samples from the suspected site of infection are put in a nutrient broth or gel and kept warm until the germs grow. Germs most often need many days to grow in the lab before they can be seen. After enough germs have grown, some are removed and tested so they can be identified. This test is older but is fairly reliable. And if the doctor wants to find out exactly what will kill or stop the germ, the culture sample can be used for a special test to find out (sensitivity test).

Sensitivity tests: Once a germ has been cultured, an extra test called a sensitivity test may be done. This is often needed because some germs resist certain antibiotics that kill others of that same type. So you can't always tell from the identity of the germ what will kill it or stop it from growing. This test also takes time, but it shows the best antibiotic to kill the germ involved in a certain infection. Because infections in people with cancer may quickly get worse, treatment is usually started before test results are back. Medicine to treat an infection may then be changed after the lab tests have identified the exact germ and what will work best to cure the infection.

But how do doctors treat the infection while they wait for lab test results?

Doctors know which germs tend to infect which organs of people with cancer. So they can often make an educated guess at which germs are most likely causing a patient's infection. Sometimes they are able to use tests that can be done quickly, like the Gram stain, to narrow down the type of germ. And many times patients who have had infections before have the same germ come back later and cause another infection. Educated guesses are very important because it can take many days to get the results of the tests that show the exact type of germ causing an infection and what drug will best stop or kill it.

Test samples or specimens

All of the tests listed above are done on samples or specimens from the patient. Types of samples include:

- Blood
- Urine
- Spinal fluid
- Wound drainage or pus
- Phlegm (sputum)

If you have symptoms that point to a certain organ, samples are taken to check for germs in that area. For example, sputum samples may be taken if you have a cough or shortness of breath. Urine samples may be taken if you have blood in your urine or feel pain while urinating. Sometimes, if a person has a very low white blood cell count and is at high risk for developing infections, samples will be taken before the patient has any symptoms. If an infection is found, treatment can then be started before symptoms start.

What kinds of germs cause infections in people with cancer?

Bacteria

Bacteria are the smallest forms of life. Biologists believe that bacteria are a separate life form -- they are different from plants and animals. Bacteria cause most of the infections in people with cancer. Some bacteria that commonly cause infections in people with cancer include:

- *Pseudomonas aeruginosa*
- *Klebsiella pneumonia*
- *Escherichia coli* (*E. coli*)
- *Salmonella*
- *Clostridium difficile* (*C. diff*)
- *Staphylococcus aureus* (*Staph aureus*)
- *Staphylococcus epidemidis* (*Staph epi*)
- *Streptococcus viridans*
- *Pneumococcus*

- *Enterococcus*

Viruses

Viruses are the smallest known germs. Unlike bacteria, they are not really alive because they cannot grow on their own. Viruses can only make new viruses when they are inside living cells, such as human, animal, or plant cells. Most viral infections in people with very low white blood cell counts are caused by

- Varicella zoster virus (VZV), the virus that causes chickenpox and shingles
- Herpes simplex virus (HSV), the virus that causes cold sores and genital herpes
- Cytomegalovirus (CMV)

Other viruses, such as respiratory and hepatitis viruses, may cause problems, too.

Varicella zoster virus

Varicella zoster virus (VZV) can cause serious infections in people with cancer, especially children. Unlike many other infections, a VZV infection never completely goes away even in a healthy person. This means when a person recovers from chickenpox, some of the virus stays in their nerve cells. If the person's immune system is weakened, even many years later, the virus can become active again and cause a problem known as *shingles*. People with shingles have groups of tiny, painful blisters on their skin. The blisters form along the paths of nerves. The pain from shingles can last long after the blisters go away.

These skin blisters hurt, but the most serious part of VZV infection in people with a weak immune system is that the virus may spread to other organs. This can lead to pneumonia (lung infection) or encephalitis (infection of the brain). The risk of serious damage from VZV is high in people with low white blood cell counts and immune systems that have been weakened by cancer. Unlike chickenpox infections in healthy people, VZV infections can be deadly in people with cancer.

Herpes simplex virus

Herpes simplex virus (HSV) is from the same family of viruses as varicella zoster. Like varicella zoster, HSV causes mild infections in people with healthy immune systems, but it also stays in their nerve cells. It can become active again years later, especially if the immune system changes. And like varicella zoster, HSV can also cause pneumonia and encephalitis.

Cytomegalovirus

Cytomegalovirus (CMV) infection is common in healthy people and is usually not serious. But in people with weak immune systems, CMV can cause things like serious pneumonia, enteritis (intestinal infection), hepatitis (liver infection), and retinitis, a

serious eye infection that can lead to permanent blindness if not treated. CMV infection can be very hard to treat in patients with low white blood cell (WBC) counts, because the drugs that work against the virus also lower the number of WBCs. This makes it hard for the body to fight the infection. Often, the best thing to do in patients with weak immune systems is to try to prevent the infection. This is done by giving certain anti-viral drugs before symptoms begin.

Respiratory viruses

Respiratory viruses are those like influenza (the flu), respiratory syncytial virus (RSV), and other seasonal viruses. They can cause illness in people with normal immune systems, but these illnesses may become severe in those with weak immunity. Respiratory viruses can affect the nose, throat, sinuses, breathing passages, and lungs. Pneumonia, which affects the lungs, is the most serious problem that can be caused by respiratory viruses. Pneumonia is more likely when one of these viruses infects a person whose immune system isn't working well.

The best way to prevent influenza is to get the flu shot every fall and have other household members vaccinated, too. Wash your hands often when these viral infections are going around. This will also help decrease the chances of infection. People with low white blood cell counts should try to stay away from crowds and people with these kinds of infections. We will talk about this more in the section "What can people with cancer do to prevent infections?"

Protozoa

Protozoa are one-celled creatures that are thought to be the smallest and simplest form of animals. Some protozoa can infect people who have healthy immune systems. But these infections are more common in less-developed countries than in the United States. In the US, most protozoal infections happen in people with weak immune systems. People who have organ transplants, cancer, AIDS, or other diseases can get life-threatening infections with protozoa. Common protozoa that can cause serious illness in people with cancer include

- *Toxoplasma gondii*
- *Cryptosporidium*

Toxoplasma gondii

Toxoplasma gondii is found in soil, cat waste, water contaminated with cat waste, and undercooked meats. It can cause fever and lymph node swelling or no symptoms at all in adults with normal immune systems. It usually stays inactive in healthy people, but when the immune system is weak the infection may become active and damage the brain or heart. People with cancer can have old infections become active, or they can get infected for the first time while their immune system is weak.

Cryptosporidium

Cryptosporidium is a common cause of diarrhea and stomach pain in people with weak immune systems. It is spread by infected people and animals, often through drinking water contaminated with stool. It can cause very severe diarrhea, leading to malnutrition, weight loss, imbalances in blood chemistry, and dehydration.

Fungi

In humans, fungi can live in balance with other germs that normally live on or in the body without causing symptoms or damage. But a fungal infection can happen when there are changes in this balanced environment. Things that can change the normal balance include:

- Damage to the skin or mucous membranes
- Low white blood cell counts
- A weak immune system
- Lower numbers of bacteria than normally found on the body's surfaces or mucous membranes (such as the intestines or vagina -- this often happens with antibiotic treatment)

Fungal infections can be serious and even deadly. Fungi that commonly infect people with cancer include:

- *Pneumocystis jirovecii* (formerly known as *P. carinii*)
- *Candida* (yeast)
- *Aspergillus*
- *Cryptococcus*
- *Histoplasma*
- *Coccidioides*

Pneumocystis jirovecii

Pneumocystis jirovecii is usually classified as a protozoan, even though its DNA, RNA, and other parts look more like a fungus. It causes pneumonia and rarely spreads to other organs, but the pneumonia can make it very hard to breathe. Infection with *Pneumocystis* is common enough in some patients with weak immune systems that doctors will give medicine to help prevent infection.

Candida

This is the most common cause of fungal infection. *Candida* can live in a healthy person without causing any problems. Sometimes it may cause a mild skin rash or vaginal discharge (called a yeast infection). But a person with a weak immune system is at risk for a much more serious infection called *thrush*. It can affect the mouth and esophagus (swallowing tube) and may spread to other organs.

Aspergillus

Aspergillus is a fungus that is often found in the air and in our environment. It is rarely a problem in healthy people, but it can cause serious infections of the sinuses, lungs, kidneys, brain, and heart valves in people with cancer. This is especially true for those with very low white blood cell counts or those getting cancer treatments that suppress the immune system. This type of infection is often hard to diagnose. Quick, aggressive treatment is needed as soon as it is suspected.

Cryptococcus

Cryptococcus is found in the soil and in bird droppings, especially pigeon waste. It is thought to be spread by breathing in the germ when it has dried out and gets stirred up into the air. In people with healthy immune systems it may cause a lung infection that goes away without symptoms. But the fungus can remain inactive in the lungs for years. And if the person's immune system becomes weak, *Cryptococcus* can begin to grow and spread to other parts of the body. One of the most serious outcomes of this infection is meningitis, an infection of the membranes that cover the brain and spinal cord.

Histoplasma

Histoplasma is another fungus that often infects the lungs of healthy people without causing any symptoms or tissue damage. Infection with *Histoplasma* is quite common in the Mississippi River Valley in the United States, as well as some regions of South America and Africa. People become infected through contact with soil or breathing the dust from soil that contains bird or bat waste. Like *Cryptococcus*, the fungus may remain inactive for years in the lungs of healthy people. But it can become active if their immune system is weakened. In people with cancer, *Histoplasma* may cause a serious illness and may spread to the lymph system, liver, spleen, and other organs. Anyone who has lived in any part of Arkansas, Kentucky, Missouri, Tennessee, and West Virginia is likely to be infected. People from certain parts of Alabama, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Mississippi, Nebraska, Ohio, Oklahoma, Texas, and Virginia are also likely to be infected with *Histoplasma*.

Coccidioides

Coccidioides causes a fungal disease called *coccidioidomycosis* or Valley Fever. The fungus lives in the soil in the southwestern United States, parts of Mexico, and Central

and South America. People breathe in this fungus when dust containing it is stirred up. Most people with healthy immune systems do not know they have the disease and it goes away on its own. But *Coccidioides* can cause serious illness in people with weak immune systems. It can spread outside the lungs to the skin, nerves, brain, bones, and joints.

What can people with cancer do to prevent infections?

Infection is one of the most common life-threatening complications of cancer. While you are being treated for cancer, there are things you can do to reduce your risk of infection.

Immunizations and live virus vaccines

People with weak immune systems should not get vaccines that contain live virus. There have been fatal infections caused by polio, measles, and smallpox because live virus vaccines were given to patients with weak immune function.

In many cases, live virus vaccines can be given at least 3 months after all immune-suppressing treatment has stopped. But this time varies and you should talk to your doctor before you or anyone you spend a lot of time with gets a live virus vaccine.

Even when your immune system is weak, some preventive immunizations can be very helpful. Your doctor should tell you about any vaccines that may help you, such as certain ones that may be recommended after bone marrow or stem cell transplant. But it's important to know which vaccines are safe for people with weak immune systems. We will talk about the most common vaccines here.

Be sure to talk to your cancer doctor before you get any vaccine. You should also tell your doctor before anyone you spend a lot of time with gets any vaccines.

Flu shots

The flu shot is given to reduce your risk of getting influenza (the flu). Since the flu raises your risk of pneumonia (lung infection), avoiding the flu lowers that risk. The flu shot may be given at least 2 weeks before chemo or between chemo cycles. It can be given 6 months after a bone marrow or stem cell transplant, and every year after that.

Flu-mist[®], the nasal mist version of the flu vaccine, contains a weakened version of the live virus. The nasal mist flu vaccine should not be used for people with cancer. Family members of a person with cancer can safely get the nasal spray unless the patient is being cared for in a germ-protected area. For example, household members should not get the nasal mist vaccine after a family member recently got a stem cell or bone marrow transplant.

For more information on this, see our document *Seasonal and H1N1 Flu Vaccine Information*.

Polio and smallpox

Polio vaccine: Children who have weak immune systems, as well as their siblings and others who live with them, only should get *inactivated* polio virus vaccines. Most doctors in the United States use only the inactivated polio vaccine. The older oral polio virus vaccine (which is taken by mouth) contains a live virus. People who get the live virus vaccine can pass the poliovirus on to people with weak immune systems.

Smallpox vaccine: In general, people with weakened immune systems should not get the smallpox vaccine. Household members of those with weak immune systems should not get it either. There are many other restrictions and exceptions on how this vaccine is used. For more information on smallpox vaccination, see our document *Smallpox Vaccine and Cancer*.

Measles-mumps-rubella

People who have very weak immune systems should not get the measles-mumps-rubella (MMR) vaccine because it contains live virus. But unlike the smallpox vaccine, it is safe for other household members to get it.

After exposure to measles: If the patient being treated for cancer is exposed to someone with measles, let the doctor know right away. Sometimes, measles immune globulin (a blood product that contains antibodies to the measles virus) can be given to help fight measles before it starts.

Pneumococcus (pneumococcal pneumonia)

Your doctor may recommend one or more doses of the pneumococcal vaccine, depending on your age and health history. If you are to have your spleen removed, the vaccine will be given before surgery. Most adults with long-term health problems get the Pneumovax[®] or PPSV 23 vaccine. The vaccine can help people with weak immune systems fight off serious infections, such as pneumonia, caused by certain bacteria. Children and those with recent bone marrow transplants may get a different vaccine (called PCV) to help them fight this germ, although some may need the PPSV 23 too.

Pneumococcus can cause serious infections that can invade the lungs, the blood, or the brain (meningitis). These infections can be life-threatening. People with chronic illness, including a weak immune system, can reduce their risk of this infection if they take the pneumococcal vaccine.

Varicella (chickenpox)

This is another live virus vaccine that is given only to people with blood tests that do not show immunity to the varicella zoster virus (VZV). Varivax[®] is intended to prevent chickenpox in people who have never had it. But this vaccine should not be given to people while their immune systems are weak. It is OK for household members of the person with weakened immunity to get the varicella vaccine.

After exposure to chickenpox: A person with weak immunity who has been exposed to chickenpox should call the doctor right away. The patient may need *VZV immune globulin* (a blood product that contains antibodies to the VZV virus) to help fight the virus. It must be given within 72 hours of exposure. Cancer treatment may be stopped and restarted after the end of the VZV incubation period (the time it takes to see if you became infected, usually about 21 days). If a person with cancer has signs of VZV infection, the doctor may hold off on cancer treatment that causes immune suppression until scabs have formed.

Varicella zoster (shingles)

Zostavax[®] is a newer live virus vaccine that is given to prevent shingles (or make symptoms of shingles less severe) in adults age 60 and older who have had chickenpox. It is not used in people with weak immune systems.

People who have had stem cell transplants must wait at least 2 years after the transplant to take this vaccine. And if you are on any drug that suppresses the immune system, you should not get Zostavax. Talk to your doctor before you or anyone in your household gets this vaccine.

See the section, "Varicella zoster virus" under "What kinds of germs cause infections in people with cancer?" for more information about shingles.

Precautions you can take

Always know when your absolute neutrophil count (ANC) is low. Ask your doctor or nurse. Here are some things you can do that may help prevent illness during that time:

- Be aware of the signs and symptoms of infection. Report any you have to your doctor or nurse right away.
- After bathing, look for redness, swelling, and soreness where any tubes or catheters enter your body.
- Get your flu shot every fall. Encourage other members of your household to get it, too. (Do NOT get the nasal mist flu vaccine if you have weak immune function.)

Here are some things you can do to avoid being exposed to infection while your ANC is low:

- Wash your hands often with soap and warm water. Be sure to wash your hands before eating and before touching your face or mucous membranes (eyes, nose, mouth, etc).
- Wash your hands after using the bathroom, blowing your nose, coughing or sneezing.
- Wash your hands after touching animals, collecting trash, or taking out garbage.
- Use moist cleaning wipes to clean surfaces and things that you touch, such as door handles, ATM or credit card keypads, and any items that are used by other people.

- Avoid large crowds of people such as school, travel, shopping, social events, and public gatherings. Wash your hands after visiting a public place or touching items used by others.
- Stay away from anyone with a fever, flu, or other infection.
- Keep yourself clean by bathing each day. Be sure to wash your feet, groin, armpits, and other moist, sweaty areas.
- Wear gloves for gardening and wash up afterward.
- Keep your mouth clean by brushing your teeth twice each day. Ask your doctor or nurse if it is OK to gently floss your teeth. Tell your doctor or nurse if your gums bleed. Your doctor or nurse may give you a special mouthwash to help clean your mouth. Do not use alcohol-based mouthwash.
- Keep your groin area and anal area clean, using soft moist cloths such as disposable baby wipes.
- Do not get manicures or pedicures. Do not use false nails or nail tips.
- Do not wade, play, or swim in ponds, lakes, rivers, or water parks.
- Do not get into hot tubs.
- Wear shoes all the time -- in the hospital, outdoors, and at home. This helps you avoid injury and keep germs off your feet.
- Use an electric shaver instead of a razor. Do not share shavers.
- If you cut or scrape your skin, clean the area right away with soap and warm water. Cover the area with a clean bandage to protect it. If the bandage gets wet or dirty, clean the area and put on a new bandage. Tell your doctor if you notice redness, swelling, pain, or tenderness.
- Prevent constipation and straining to have a bowel movement by drinking 2 quarts of fluid each day. Exercising each day can help, too. Let your doctor or nurse know if you are having bowel problems. If needed, your doctor may give you medicine that softens your stool. Do not put anything in your rectum, including enemas, thermometers, and suppositories.
- Women should not use tampons, vaginal suppositories, or douche.
- Use water-based lubricants during sex to avoid injury or abrasion of the skin and mucous membranes. Use latex or plastic condoms to reduce the risk of sexually transmitted infections.
- Do not keep fresh flowers or live plants in your room.
- Do not clean up droppings from your pets. Do not clean bird cages or fish or turtle tanks. Let someone else do this for you.

- Place cat litter boxes away from kitchens and food areas. Litter boxes should be cleaned every day by someone else.
- Do not touch soil that may contain feces (stool) of animals or people.
- Do not change diapers, but if you do, wash your hands very well afterward.
- If you use disposable gloves to avoid touching things like soil or waste, wash your hands after you take off the gloves. (Gloves can have tiny holes that you can't see.)
- Stay away from all standing water, for example, in vases, denture cups, and soap dishes.
- Use hot water to clean your dishes.
- Do not share bath towels or drinking glasses with others, including family members.
- Stay away from chicken coops, caves, and any place where dust from the ground is being blown into the air, such as construction sites.
- Talk with your doctor or nurse if you are planning any travel during this time.

Food safety

Food safety is very important when your ANC is low. Infections can be picked up from food and drinks. A low microbial diet (low-germ or *neutropenic diet*) may be suggested if your ANC is low. This type of diet and these actions may help you reduce infection risk from foods:

- Do not eat or drink any raw milk or raw milk products, or any milk or milk product that has not been pasteurized, including cheese and yogurt made from unpasteurized milk.
- Do not eat Mexican-style soft cheese such as queso fresco or queso blanco.
- Do not eat cheese containing chili peppers or other uncooked vegetables.
- Do not eat raw or undercooked meat, fish, chicken, eggs, or tofu.
- Do not eat cold smoked fish, including lox, jerky, kippered, or nova-style fish.
- Do not eat miso or tempeh products.
- Do not eat hot dogs, deli meats, or processed meats (unless they have been cooked or thoroughly re-heated just before eating).
- Do not eat any food that contains mold (for example, brie, feta, or blue cheese, including that in salad dressings).
- Do not eat any uncooked vegetables and fruits.

- Do not eat uncooked grain products.
- Do not eat unwashed salad greens.
- Do not eat vegetable sprouts (alfalfa, bean, and others).
- Do not drink fruit or vegetable juices that have not been pasteurized.
- Do not eat raw honey (honey that has not been pasteurized).
- Do not eat raw nuts or nuts roasted in their shells.
- Do not drink beer that has not been pasteurized (this is most often home brewed and some microbrewery beers).
- Do not drink cold-brewed tea made with warm or cold water.
- Do not drink maté tea.
- Do not drink unboiled well water.
- Do not eat brewer's yeast.
- Do not eat any outdated food.
- Do not eat any cooked food that has been left at room temperature for 2 hours or more.
- Do not eat any food that has been handled or prepared with unwashed hands.
- Talk with your doctor about any dietary concerns you may have, or ask to talk with a registered dietitian.

For more basic food safety information, see our document *Nutrition for the Person With Cancer During Treatment: A Guide for Patients and Families*.

Using medicines to prevent infections

Sometimes, antibiotics are given when a person's ANC is very low -- even though there is no sign of an infection. These can be anti-bacterial, anti-viral, and/or anti-fungal drugs. You may hear this called *prophylactic antibiotic* use. The drugs are given to help keep you from getting an infection. This is only done when there is a very high risk of getting infections, for example, if you are expected to have severe neutropenia for a week or longer. Antibiotics may also be given if you are on other medicines that can make your immune system weak, such as a long course of steroids or some immunotherapy drugs. The prophylactic antibiotics are then stopped when your ANC begins to improve or the immune weakening drugs are stopped. Using antibiotics in this way does not prevent all infections, so it is still important to use the same precautions as when you are not taking prophylactic antibiotics.

Use of growth factors

Growth factors are proteins your body makes to help your blood cells grow. They are also known as *colony-stimulating factors (CSFs)*. Man-made CSFs are most often used after chemo to keep your white blood cell (WBC) count up and help prevent infection. You may be given a CSF to help your WBCs grow and keep your absolute neutrophil count (ANC) from getting too low. Or, you may get it when your ANC is low to help build it back up. Your doctor also may give you a CSF if your ANC is low and you have a serious infection that is getting worse even though you are getting treatment.

CSF drugs used today include filgrastim (Neupogen[®]) and pegfilgrastim (Neulasta[®]), which affect the neutrophils. Sargramostim (Leukine[®]) is a CSF that affects neutrophils, monocytes, and macrophages. All of these medicines shorten the length of time a person is neutropenic and make the shortage of WBCs and the neutropenia (a shortage of neutrophils) less severe. Growth factors do have side effects that can be serious in some people, but they can reduce the risk of infection in the patients who need them. You can call us to get more information on each of these drugs.

What signs of infection should people with cancer watch for?

It is important to watch for early signs of infection and tell your health care team about them right away. Then treatment can be started as early as possible. This is most important for people who have a low white blood cell count. Signs and symptoms of an infection might include:

- Body temperature of more than 100.5° F or higher taken by mouth
- Shaking chills or sweats (often goes along with fever)
- Sore throat
- Cough or shortness of breath
- Nasal congestion
- Burning or pain when passing urine, bloody or cloudy urine
- Redness, swelling, drainage, or warmth at the site of an injury, surgical wound, or vascular access device (VAD), or anywhere on the skin including the genital and rectal areas
- Stiff neck
- Sinus pain or headache

Fever is especially important because it is often the first sign of an infection in people with cancer. Patients may be told to call their doctor or nurse if they have a fever greater than 100.5° F or higher, or if they have other signs and symptoms of infection. *Don't take*

medicines to reduce your fever (such as Tylenol[®], Advil[®], Motrin[®], or aspirin) without checking with your doctor first. Ask your doctor what you should do and when you should call. Be sure you know how to reach your health care team after hours, and nights, and weekends.

It is important for people with cancer and their families and friends to know these things:

- The patient's risk for infection
- How long the white blood cell count (WBC) or absolute neutrophil count (ANC) is likely be low after treatment
- The importance of taking the patient's temperature, how to take it the right way, when to check it, and how often to check it
- When to report a fever or other signs and symptoms of infection to the doctor or nurse
- The importance of basic hand washing and hygiene for the patient and the people they come in contact with
- The importance of cleaning around the anus after each bowel movement
- How to take good care of the mouth and check for sores and fungal infections
- Good care of vascular access devices (VADs)
- Where to look for signs of infection (skin, mouth, and VAD sites)
- The importance of good nutrition, a balanced diet, and drinking plenty of fluids
- The importance of sleep and exercise, and how to pace yourself to save energy
- The need to take medicines as prescribed and being sure the doctor knows about all medicines you are taking (prescription, over-the-counter, vitamins, herbs, and supplements); keep a list and update it at each doctor visit
- Ways to prevent dryness of the skin and mucous membranes
- The need to talk with your health care team or doctor before getting any immunizations (vaccinations) and before close contact with children or adults who have recently been immunized (vaccinated)

How is infection treated in people with cancer?

Fever and other signs of infection in a person with a weak immune system are treated as medical emergencies. Antibiotics need to be started right away. After a complete physical exam, lab tests will be done to try to find out exactly which germ is causing the infection and where the infection is. Antibiotics (which can be anti-bacterial, anti-viral, anti-fungal, or anti-protozoal drugs) are started quickly. After the exact germ is identified, the

antibiotic may be continued if the germ is sensitive to it, or a new medicine may be started if the tests show it would work better.

Where treatment is given

In the past, patients were almost always put in the hospital to treat these infections, and many still are. But some patients can take their antibiotics in pill or liquid form. And some patients who need intravenous (IV) antibiotics may be able to get them in clinics, doctor's offices, or at home. Still, home care is only used with infections that are not likely to become more serious. The patient must have a responsible adult at home with them at all times, and be able to handle treatment at home. The patient must have a phone, and be close enough to the hospital or clinic to get there quickly. The doctor or cancer care team must be able to see the patient each day for the first few days and do needed tests. If all goes well, they still will need to stay in close contact during treatment. Otherwise, the patient may need to be put in the hospital.

What treatment may be like

At first, the patient is watched closely and lab results are checked often. The white blood cell (WBC) count and absolute neutrophil count (ANC) are checked daily. Antibiotics may be changed when the final culture results come in. (The culture tells which germ is causing the infection; see "Lab tests to identify germs" under the section, "How does the doctor know what kind of infection a person with cancer has?") If the infection does not get better, an infectious disease specialist may be called in. These are doctors who specialize in treating infections. This doctor may recommend extra testing and different treatments. In some cases, CSFs (colony-stimulating factors) may be given to boost the WBCs so the body can better fight the infection.

Each type of infection (bacterial, viral, protozoal, and fungal) is treated with different drugs. If you have any questions about drugs you might be given or why you're taking them, talk with your doctor or nurse.

Bacterial infections

When treating bacterial infections in people with weak immune systems, antibiotics are started after samples for lab tests have been taken, but before these test results have identified the germ. Doctors think about the site of infection and the germ most likely causing it when choosing antibiotics to use at this point. Most often, antibiotics that will treat many different bacteria are chosen. These are called *broad-spectrum antibiotics*. Sometimes 2 or 3 antibiotics are used at the same time.

Drug-resistant germs: Even in serious situations, overuse of antibiotics must be avoided because this can cause some bacteria to become resistant to these drugs. For example, some strains of *Staphylococcus* have become resistant to most antibiotics given by mouth, and even intravenous (IV) vancomycin, which was once used to treat them. Such germs are called *drug resistant* because they no longer respond to the antibiotics that killed them in the past. Germs change and adapt all the time. The good thing is that there

are a handful of newer drugs, such as quinupristin/dalfopristin (Synercid[®]), linezolid (Zyvox[®]), daptomycin (Cubicin[®]), and Tigecycline (Tygacil[®]) that can still work against some of these hard-to-kill germs. To avoid spreading drug-resistant bacteria to other patients, health care workers often wear disposable gowns and gloves when caring for people known to have these infections.

Viral infections

While anti-bacterial antibiotics have been available for more than 65 years, anti-viral drugs are much newer. Herpes simplex virus (HSV) and varicella zoster are most often treated with anti-viral agents. HSV may be treated with acyclovir, valacyclovir (Valtrex[®]), famciclovir (Famvir[®]), ganciclovir, or foscarnet (Foscavir[®]). Acyclovir, ganciclovir, valganciclovir (Valcyte[®]), foscarnet (Foscavir), or cidofovir (Vistide[®]) are used to treat cytomegalovirus (CMV).

If you have chronic hepatitis B, cancer treatment drugs (such as rituximab) can cause it to become active. There are drugs to fight hepatitis B that can be used, such as lamivudine (Epivir-HBV, [®]), adefovir (Hepsera[®]), entecavir (Baraclude[®]), telbivudine (Tyzeka[®]), tenofovir (Viread[®]), interferon alfa (Intron A[®]).

Influenza may be treated with zanamivir (Relenza[®]) or oseltamivir (Tamiflu[®]).

Other viruses may be treated with other anti-viral drugs.

Protozoal infections

Protozoa seldom cause problems for healthy people, but they are hard to treat in people with weak immune systems.

Toxoplasma is often treated with pyrimethamine (Daraprim[®]) plus sulfadiazine or clindamycin (for people who are allergic to sulfadiazine). Other drugs are available, too.

There is no one treatment for *Cryptosporidium* infection, which causes severe diarrhea. Treatment is aimed at building up the immune system, treating the diarrhea, and keeping the person from losing too much fluid and nutrients.

Fungal infections

Anti-fungal drugs like nystatin and clotrimazole may sometimes be used for people with *Candida* infections in the mouth and throat. For *Candida* in the esophagus, fluconazole (Diflucan[®]) or another anti-fungal drug is used. For more serious *Candida* infections (such as infections in the blood), drugs like amphotericin B or one of its newer formulas (Abelcet[®], Amphotec[®], or AmBisome[®]) may be given intravenously (IV). Amphotericin is most often used to treat *Aspergillus* infection. *Cryptococcus* and *Histoplasma* infections are usually treated with anti-fungal drugs like amphotericin, fluconazole, or itraconazole.

The usual treatment for people with *Pneumocystis jirovecii* infection is trimethoprim-sulfamethoxazole (TMP/SMX, Septra[®], or Bactrim[®]). If this drug causes side effects, dapsone, atovaquone (Mepron[®]), pentamidine (Nebupent[®]), or other drugs may be used.

Where can I get more information?

From your American Cancer Society

We have selected some related information that may also be helpful to you. These materials may be ordered from our toll-free number, 1-800-227-2345.

Understanding Chemotherapy: A Guide for Patients and Families (also available in Spanish)

Understanding Radiation Therapy: A Guide for Patients and Families (also available in Spanish)

Understanding Your Lab Test Results

Nutrition for the Person With Cancer During Treatment: A Guide For Patients and Families

Seasonal and H1N1 Flu Vaccine Information

Smallpox Vaccine and Cancer

Bone Marrow and Peripheral Blood Stem Cell Transplants (also available in Spanish)

Chemotherapy Principles

Caring for the Patient With Cancer At Home: A Guide for Patients and Families (also available in Spanish)

Helping Children When a Family Member Has Cancer: Dealing With Treatment

National organizations and Web sites*

Along with the American Cancer Society, other sources of information and support include:

Centers for Disease Control and Prevention (CDC)

Toll-free number: 1-800-232-4636 (1-800-CDC-INFO)

Web site: www.cdc.gov

Offers reliable information on infections, prevention, and vaccines as well as chronic diseases and other health information (also offered in Spanish)

National Cancer Institute

Toll-free number: 1-800-422-6237 (1-800-4-CANCER)

Web site: www.cancer.gov

Offers information on cancer and its treatment, a drug dictionary of common medicines used in cancer treatment, and coping with cancer (also offered in Spanish)

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

No matter who you are, we can help. Contact us anytime, day or night, for cancer-related information and support. Call us at **1-800-227-2345** or visit www.cancer.org.

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