Childhood Acute Lymphoblastic Leukaemia (c-ALL)

A Guide for Patients

Leukaemia Care
YOUR Blood Cancer Charity

Introduction

Your child being diagnosed with Acute Lymphoblastic Leukaemia (ALL) can be a shock, particularly when you may have never heard of it. If you have any questions about ALL, including what causes it, who it affects, how it affects your body, what symptoms to expect and likely treatments - this booklet covers the basics for you.

The booklet was written and updated by our Patient Information Writer, Isabelle Leach, and peer reviewed by consultant haematologists.

We are also grateful to our patient reviewers, Ross Happell, Meryl Simons and Karen Collier for their contribution.

Throughout this booklet, you will see QR codes that will take you to the relevant webpage for further support. Open the camera app on your phone and hover it over the QR code to open the link (suitable for Android, iPhone 7 and above).

Alternatively, if you are not able to use QR codes and would like to be sent the relevant webpages as URLs, or you would like the list of references used for this booklet, please email **communications@leukaemiacare.org.uk.**

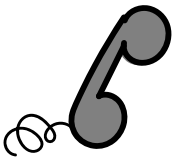
Version 3a
Reviewed: 06/2023
Updated: 04/2024
Review date: 06/2026

In this booklet

About Leukaemia Care

Leukaemia Care is the UK's leading leukaemia charity. For over 50 years, we have been dedicated to ensuring that everyone affected receives the best possible diagnosis, information, advice, treatment and support.

Our services

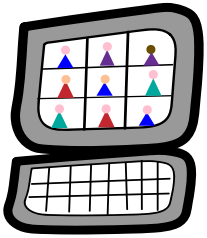


Helpline

Our helpline is available 9am to 5pm Monday to Friday. If you need someone to talk to, call **08088 010 444**.

Alternatively, you can send a message via WhatsApp on **07500 068065** on weekdays 9am to 5pm.

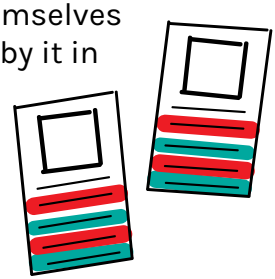
Support groups



Our nationwide support groups are a chance to meet and talk to other people who have been affected by a ALL diagnosis. For more information, scan this QR code:

Buddy support

We offer one-to-one phone support with volunteers who have had ALL themselves or been affected by it in some way. You can speak to someone who knows what you are going through. For more information on how to get a buddy call **08088 010 444** or email support@leukaemiacare.org.uk



Counselling service

Our counselling service helps ALL patients and their loved ones access up to six sessions of counselling. To apply, scan this QR code:

Advocacy and welfare

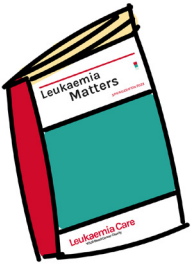
Our advocacy and welfare officers are here to help you find the support you need for many issues surrounding a ALL diagnosis. These include insurance, benefits and clinical trials. If you would like support from our advocacy or welfare officer, email **advocacy@leukaemiacare.org.uk** or call **08088 010 444**.

Write a free will

Using our complimentary service, you can write a simple will so you know what happens to your estate when you die. To start writing your free will today, scan this QR code:

Patient magazine

Our magazine includes inspirational patient and carer stories as well as informative articles by medical professionals. To subscribe to our magazine, scan this QR code:



Patient story: Rufus Palmer

Rufus Palmer was just three years old when he developed an unusual rash. However, when the GP said it was nothing to worry about, Rufus' mum Rosie trusted her instincts and took her son to A&E, where he was later diagnosed with acute lymphoblastic leukaemia. Here, Rosie tells us Rufus' story.

In February 2017, I noticed an unusual rash on Rufus' torso whilst giving him a bath. He was well in himself and behaving normally so I wasn't too worried initially, but I decided I'd phone the GP to be certain. The GP said he wasn't concerned but said I could take him in if I wanted to, so I did. During the appointment, I was told the rash didn't look sinister and was probably viral so we were sent home with a good bill of health.

All afternoon I couldn't stop checking the rash. I compared it to what I found online and then I was panicking. When my husband Tom got home from work we decided to take him to A&E for a blood test, something was telling me this wasn't a virus.

After seeing six different doctors who were all puzzled by the rash, the final paediatrician wanted to examine him further and run the full blood so, Tom and I were taken into a private room and told that the cells showing up in his blood were those commonly seen in leukaemia, his platelet count was critically low which caused the rash and his blood film showed 97% blasts. I will never forget every detail of the moments spent in that room being told that news. My initial reaction was that we were going to lose him. It was absolutely unbelievable.

After a night in intensive care, the diagnosis of acute lymphoblastic leukaemia (ALL) was confirmed. Rufus was fitted with a central line and chemotherapy started straight away. Then began three and a half years of treatment.

His treatment went well with not many admissions over the years and he rang the bell at home during lockdown 2020 to mark the end of chemo. However, the nightmare returned even worse in November 2021 when he relapsed. This time it was more aggressive and he had become resistant to chemo. We had to then discuss CAR-T or a stem cell transplant but we had to reach remission first.

After chemo failed, the national multidisciplinary team (MDT) panel decided to try Blinatumomab (immunotherapy) which helped Rufus achieve remission in as little as a month, which meant he would be accepted for a transplant.

Time was of the essence so he went for his transplant in February 2022. He is now over one year post transplant and despite a couple of complications, is doing amazingly. He is strong, happy and looking forward to being able to return to school and live the life he deserves.

We really hope that sharing Rufus' story will raise awareness of childhood leukaemia. The symptoms were there but they don't present themselves as unusual in children. Some we missed because they were regular coughs and colds. Thankfully, his body gave a sign in the form of the petechial rash which sent alarm bells ringing. We would never have known the symptoms would be so subtle in the first stages.

As Rosie mentioned, being told your child has a diagnosis of ALL can be difficult. Our buddy scheme offers one-to-one support and the opportunity to speak to someone in a similar situation to you. Email **support@leukaemiacare.org.uk** or call **08088 010 444** to find out more.

Glossary of medical terms

Acute leukaemia

Leukaemia which progresses rapidly and is generally aggressive. There are two types: acute lymphoblastic leukaemia and acute myeloid leukaemia.

Acute lymphoblastic leukaemia (ALL)

Leukaemia in which lymphocytes start multiplying uncontrollably in the bone marrow, resulting in high numbers of abnormal, immature lymphocytes. Lymphocytes are a type of white blood cell involved in the immune response.

Allogeneic stem cell transplant

A procedure where bone marrow stem cells are taken from a genetically matched donor and given to the patient through an intravenous line. The donor may be related or unrelated.

Autologous stem cell transplant (ASCT)

Transplant of stem cells derived from part of the same individual.

Blast cell

An abnormal (dysplastic), immature blood cell found in the bone marrow or peripheral blood. As they are not mature, these cells are unable to fulfil their intended function. AML develops from these blast cells.

Blood transfusion

A procedure in which whole blood or one of its components is given to a person through an intravenous line into the bloodstream. A red blood cell transfusion or a platelet transfusion can help some patients with low blood counts.

Bone marrow

The soft blood-forming tissue that fills the cavities of bones and contains fat, immature and mature blood cells, including white blood cells, red blood cells, and platelets.

Chemotherapy

Therapy for cancer using chemicals that stop the growth of cells.

Clinical trial

A medical research study involving patients with the aim of improving treatments and their side effects. You will always be informed if your treatment is part of a trial.

Consolidation (phase)

Treatment following remission intended to kill any cancer cells that may be left in the body (also called intensification phase).

Fatigue

Extreme tiredness, which is not alleviated by sleep or rest. Fatigue can be acute and come on suddenly or it can be chronic and persistent.

Fluorescence in situ hybridisation (FISH)

Process using fluorescent dyes to attach to certain parts of chromosomes for their identification.

Full blood count or FBC

A blood test that counts the number of different blood cells.

Graft-versus-host disease

Serious complication that occurs with allogenic stem cell transplants. It happens when the graft (donated marrow or stem cells) reacts against the host (patient receiving the stem cells).

Immunophenotyping

Process that uses antibodies to identify cells based on the types of antigens or markers on the surface of the cells. This process is used to diagnose specific types of leukaemia and lymphoma by comparing the cancer cells to normal cells of the immune system.

Induction (phase)

First treatment after diagnosis intended to kill the majority of the leukaemia cells and stimulate remission.

Intrathecal therapy

Injection of chemotherapy into the cerebrospinal fluid that surrounds and protects the brain and spinal cord.

Maintenance

Treatment given to prevent cancer from coming back after it has disappeared following the first-line treatment.

Monoclonal antibody

Man-made antibodies created from identical cloned immune cells so that they all bind to the same protein commonly found on the leukaemia cells such as CD20.

Neutropenia

A condition in which the number of neutrophils (a type of white blood cell) in the bloodstream is decreased.

Neutrophil

A type of white blood cell that helps fight infection.

Palliative care

Also known as supportive care, this is a type of care that focusses on improving the quality of life for a patient with a life threatening illness and their loved ones.

Platelet

A disc-shaped element in the blood that assists in blood clotting. During normal blood clotting, the platelets clump together (aggregate). Although platelets are often classed as blood cells, they are actually fragments of large bone marrow cells (megakaryocytes).

Platelet count

A normal platelet count in a healthy individual is between 150,000 and 450,000 per microlitre of blood. In general, low platelet counts increase bleeding risks. Normal platelet count 150-450 $x10^9$/L.

Red blood cells

Small blood cells that contain haemoglobin and carry oxygen and other substances to all tissues of the body.

Stem cells

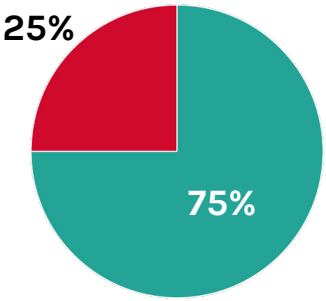
Cells that have the potential to develop into many different or specialised cell types.

White blood cell

One of the cells the body makes to help fight infections. There are several types of white blood cells. The two most common types are the lymphocytes and neutrophils. Normal white cell count is 4-11$x10^9$/L.

Summary: What is childhood ALL?

- Acute lymphoblastic leukaemia (ALL) can be diagnosed in a person of any age, but most cases of **ALL occur in children aged 0 to 4 years**. In this booklet, we include teenagers under 20 years of age in the term children. ALL is the most common type of leukaemia, accounting for **75%** of all leukaemia diagnosed in this age group.



- ALL affects around five in every 100,000 children per year in the United Kingdom (UK). Around 440 children are diagnosed with ALL in the UK each year.
- After a child grows into adulthood, the general occurrence of ALL rises again after age 50. About 4 out of every 10 people diagnosed with ALL are adults.
- Acute lymphoblastic leukaemia (ALL) is an **acute leukaemia**. It is caused by **lymphocytes multiplying in an uncontrolled manner in the bone marrow.** These cells are immature and abnormal and are called blast cells. Because the cells are immature, they do not fight infection normally. They also stop your child's bone marrow making the other blood cells needed.
- In ALL in children, there are three subtypes of lymphocytes:
  - Early immature B-cells seen in 80% to 85% of children
  - Immature T-cells seen in 15% of children
  - Mature B-cells seen in around 2% of children
- ALL is most common in young children aged 0 to 4. Males have a slightly higher incidence in ALL compared with females. This booklet is about ALL in children over the age of one year.

What is childhood ALL?

ALL is an acute leukaemia of the lymphocyte white blood cells. Acute means the ALL develops very quickly.

In children with ALL, only immature and mature B-cells and immature T-cells are seen. These lymphocytes are abnormal and are often called 'leukaemia cells' or 'blasts'.

The leukaemia cells multiply in an uncontrolled manner in the bone marrow. Because the cells are immature, they do not fight infection normally. They also stop your child's bone marrow making the other blood cells needed.

There are three types of lymphocytes:

1. **B-lymphocytes (B-cells):** Made in the bone marrow
2. **T-lymphocytes (T-cells):** Made in the thymus gland behind the sternum
3. **Natural killer lymphocytes (NK-cells):** Made in the bone marrow, lymph nodes, spleen, tonsils, and thymus

In children with ALL:

- 80% to 85% of ALL consists of immature B-cells
- 15% are immature T-cells
- Approximately 2% are mature B-cells

Who gets childhood ALL?

A diagnosis of ALL can occur at any age but it is more common in children. Children between two to five years receive a diagnosis of ALL more often than not. About one in 2,000 children will develop ALL by the age of 15 years.

In the UK, childhood ALL affects about five in every 100,000 children per year. Boys have a slightly higher incidence of ALL compared with girls.

This booklet is about ALL in children over the age of one year.

We have separate booklets for B-cell ALL and T-cell ALL in adults. Scan the QR code to order our booklets:

What causes childhood ALL?

In several cases of childhood ALL, there is no evident cause for the development of the ALL. However, chromosome and gene abnormalities which are not inherited are present at diagnosis in the leukaemia cells of 80% of children. These are acquired mutations. They cannot be passed onto your children. Only chromosome abnormalities and gene mutations that affect the sperm or egg cells can be inherited.

The acquired chromosome and gene abnormalities in children with ALL include:

- Philadelphia chromosome (BCR-ABL1 gene) present in 3-5% of children with B-cell ALL
- In children with T-cell ALL, the following gene mutations are present:
  - *NOTCH1* (70.3% of children)
  - *FAT1* (32.8% of children)
  - *FBXW7* (28.1% of children)
  - *KMT2D* (28.1% of children)

Inherited genetic syndromes which make children more likely to develop ALL include:

- Down syndrome
- Ataxia-telangiectasia
- Wiskott-Aldrich syndrome

For more information on genetics in ALL we have a dedicated booklet. Scan the QR code to order or download the booklet:

Environmental causes related to ALL that have been confirmed include high levels of radiation.

Other causes that have been suggested, but for which no scientific evidence from studies is available are:

- Power lines
- Nuclear power plants
- Mobile phone masts

What are the symptoms of childhood ALL?

In childhood ALL, as in adult ALL patients, the increased number of lymphoblasts in the bone marrow prevents the production of normal blood cells. This results in low numbers of normal blood cells such as:

- Red blood cells
- White blood cells
- Platelets

If all the types of blood cells are lower than normal, then patients are said to have pancytopenia.

These changes in blood cell levels lead to most of the common symptoms of ALL:

- Anaemia – looking pale, breathlessness, easily tired
- Low white cell count – frequent, persistent infections

- Low numbers of platelets – bruising and/or bleeding

The most common symptoms of ALL in children are:

- Fever (high temperature)
- Fatigue (excessive tiredness)
- Easy bruising and bleeding (bleeding from the gums on brushing teeth)
- Swollen liver and/or the spleen
- Swollen lymph nodes
- Bone or joint pains

Most young children may not have all of these symptoms. A child may just feel generally unwell. They may have paleness, lethargy (tiredness) or malaise (general feeling of being unwell).

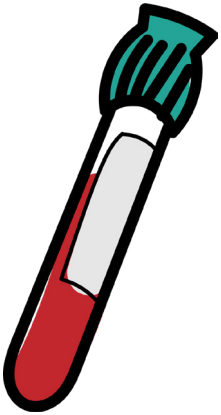
In very young children, a common symptom can just be a reluctance to walk or crawl.

If your child is unwell, it is important to arrange a GP appointment without delay. Symptoms include:

- Raised temperature, cough or sore throat
- Confusion or agitation, especially if it occurs at short notice
- Your child becoming more ill at short notice
- Fast heart beat and/or fast breathing
- Passing very little or no urine
- An increase in pain. If your child is not yet talking, you may see this as reluctance to walk or crawl

Most of the signs or symptoms described above are not uncommon in children. It is very rare for a child with these symptoms to have a serious disease. But, it is important to exclude ALL as soon as possible, so that treatment can start early.

Summary: How is childhood ALL diagnosed?



- Your child's haematology team will perform the following tests to make a diganosis of ALL:
  - Full blood count
  - Bone marrow aspiration or biopsy
  - Lumbar puncture
  - Chromosome abnormalities or gene mutations tests
  - Immunophenotyping
- The results of these tests gives your haematology team information about your child's ALL. For example they can find out how advanced the ALL is and what type of ALL it is. The team should explain each test and its results to you.

How is childhood ALL diagnosed?

Your child's haematology team will conduct the following tests to make a diagnosis of ALL:

Full blood count

A full blood count will:

- Measure the number of red cells, the different types of white cells and platelets in the blood. This tells your haematology team if your child is still producing the right blood cells and how many leukaemia cells they have.
- Examine the blood cells under a microscope using a smear of blood on a glass slide. This will tell your team which cells are abnormal.

Leukaemia cells are different in appearance to normal lymphocytes.

Bone marrow aspiration or biopsy

Bone marrow samples are obtained by aspiration or biopsy. A piece of bone marrow tissue from a bone marrow sample can be examined under the microscope. This will confirm the diagnosis of ALL if it is not obvious from the blood sample.

The haematologist will take your child's bone marrow sample from the hip bone. Your child should have local or, more commonly, general anaesthetic (be put to sleep) and your haematologist will use special biopsy needles. If your child needs any pain relief or you have any concerns, make sure to raise this prior or during the procedure.

Procedure

The bone marrow aspiration is usually done first. The haematology specialists insert a hollow needle into the bone marrow of the hip. They then remove (aspirate) a sample of liquid bone marrow using a syringe attached to the needle. The aspiration takes only a few minutes.

The specialists will take a small core of bone marrow biopsy. They will use a slightly larger surgical needle with a cylindrical blade.

To diagnose B-cell ALL, the bone marrow sample must contain 20% or more of the immature lymphocytes (lymphoblasts).

Lumbar puncture

Your haematology team will do a lumbar puncture to check if leukaemia cells have entered your child's central nervous system. Your child will need further treatment straight after diagnosis if this is the case.

Your child's lumbar puncture and examination of the cerebrospinal fluid will be repeated during treatment.

Procedure

Your doctor will ask your child to lie on their side with their legs pulled up and tucked under the chin. This position makes it easier for inserting the bone marrow needle between the vertebrae in the lower back. Vertebrae are the individual bones that make up the spine. The lumbar puncture needle goes specifically between the L4 and L5 vertebrae in the lumbar region of your child's lower back.

The doctor will clean the skin over your child's lumbar vertebrae and inject a local anaesthetic. Insertion of a thin aspiration needle between the two vertebrae is then carried out. This allows the removal of a sample of cerebrospinal fluid. Your child should not be in pain, but pressure might be felt. Young children are often put to sleep for the procedure.

At the end of the procedure, the doctor will remove the needle and apply a small plaster.

Chromosome abnormalities or gene mutations tests

Children with ALL have chromosome abnormalities and gene mutations. Tests for these abnormalities help the haematology team understand how the ALL might have developed over time. This also helps organise your child's treatment plan.

The following tests help to identify them:

Standard cytogenetic analysis

This involves examining the leukaemia cells in the laboratory while they are dividing. This will show any chromosome abnormalities and gene mutations. Cytogenetic means a study of chromosomes.

Molecular cytogenetic analysis

This method uses a technique called fluorescence in situ hybridisation. It labels small portions of DNA with fluorescent particles. This allows your child's haematology team to:

- Detect sequences of DNA
- Locate a gene on a chromosome
- Determine the number of copies of a gene
- Detect any chromosomal abnormalities

Around 80% of children with ALL have chromosome abnormalities and gene mutations. The remaining patients do not have detectable chromosomes and mutations abnormalities.

For more information on genetics in ALL we have a dedicated booklet. Scan the QR code to order or download the booklet:

Polymerase chain reaction (PCR) test

Polymerase chain reaction (PCR) tests analyse genetic information. The first step in a PCR test is to make millions of copies of the small pieces of the DNA from your child's ALL cells. This is because large amounts of a DNA sample are necessary for genetic analyses. This is an inexpensive and quick process.

A PCR test can detect evidence of the Philadelphia chromosome in particular. Around 3-5% of children with ALL do have the Philadelphia chromosome.

PCR tests throughout the treatment period can also check your child's response to current treatment. Your child's haematology team will adjust the treatment according to your child's results.

Immunophenotyping

Immunophenotyping is a method to detect the proteins found on blood cells. Each type of blood cell has different proteins on its surface. The haematology team can use immunophenotyping to tell which of your child's lymphocytes are affected by looking for the B-cell or T-cell proteins. These proteins are called cluster of differentiation (CD) proteins. Each unique protein has a separate CD number instead of a name. This is because there are so many proteins.

CD proteins for B-cell ALL cells include CD19, CD20, CD22 and CD24. B-cells have different CD proteins to T-cells. This helps to distinguish between B cell ALL and T-cell ALL. CD proteins for T-cell ALL cells include CD1a, CD2, CD4, CD5, CD7 and CD8 protein. This helps to distinguish between B cell ALL and T-cell ALL. Children only have B-cell ALL.

Flow cytometry

In flow cytometry, particles dissolved in a fluid float past at least one laser. The flow cytometer measures the size and structures of thousands of cells in a short amount of time.

Imaging tests

The following tests can help assess the impact of the leukaemia on the organs of your body:

- X-rays
- Ultrasounds
- Computer tomography scans
- Magnetic resonance imaging

There is a lot of information about cancer on the internet and much of it will not be applicable to your child. We suggest you discuss with your child's medical team which sources of information that are relevant and reliable.

Summary: What is the treatment for childhood ALL?

- Your haematology team will start your child's ALL treatment **straight after** their diagnosis. This is because ALL has a **fast progression**.
- The treatment of children with ALL is chemotherapy. Treatment for ALL consists of intensive chemotherapy. This followed by prolonged maintenance treatment with less intensive chemotherapy.
- Targeted agents and immunotherapies can achieve similar results to chemotherapy.
- Teenagers and young adults tend to receive similar treatment to children.
- Stem cell transplants can work for children with high-risk ALL.

What is the treatment for childhood ALL?

Childhood ALL is one of the most treatable cancers in children. The cornerstone of treatment is still chemotherapy. Treatment for ALL is intensive chemotherapy.

Your haematology team will start your child's treatment for ALL straight away after the diagnosis. In general, your child will need to go to hospital and remain there for a few weeks.

Often your child's treatment decisions are discussed at group meetings. These are called multidisciplinary teams (MDTs). This helps bring together the skills of lots of different types of doctors and nurses. The aim is to make sure the selected treatment for your child is the most appropriate.

What are the phases of treatment?

Clinicians divide treatment of ALL into three individual treatment phases:

- Induction of remission and CNS prophylaxis
- Consolidation
- Maintenance (also called remission continuation or post-remission maintenance)

Induction treatment

Induction treatment is the first treatment given straight away after diagnosis. The aim of the induction treatment is to kill as many leukaemia cells as possible.

Induction treatment should promote complete remission. The definition of complete remission is different with each treatment type. In general complete remission means the treatment has removed as many of the leukaemia cells as possible.

Induction treatment consists of a combination of chemotherapy drugs. The haematology team will administer your child's treatment in hospital. Your child should be in hospital for up to eight weeks.

Central nervous system prophylaxis and treatment

The central nervous system (CNS) is made up of the brain and spinal cord. A fluid surrounds these organs to protect them. This is the cerebrospinal fluid (CSF). At diagnosis, leukaemia cells are present in the CSF of around 5% of ALL patients.

The percentage of leukaemia cells in the CNS of these patients at diagnosis is variable. These cells can cause relapse of the ALL seen in up to 30% of cases.

Your child's lumbar puncture may show leukaemia cells in the CNS. In this case, your child will receive intrathecal therapy. This is when the haematologist injects methotrexate into your child's CSF. Methotrexate is a strong chemotherapy. Currently, it is advised that intrathecal therapy is maintained through all the treatment phases of ALL.

Consolidation treatment

Your child should receive consolidation treatment to help reinforce remission. This reduces the risk of a relapse. Relapse is the recurrence of ALL when response to frontline treatment has stopped.

Consolidation therapy consists of higher doses of the drug combinations used for induction.

Maintenance treatment

Your child will receive maintenance treatment after the consolidation treatment. This is to prevent relapse of the ALL. Without maintenance therapy, there is a high chance that the ALL will return.

Maintenance treatment usually consists of low dose chemotherapy with a steroid drug. Your child can receive maintenance treatment as an outpatient. This might mean going to the hospital for treatment on occasions. Sometimes your child can have the treatment at home.

Maintenance treatment lasts for two to three years. How long your child will receive maintenance treatment for depends on many factors.

What are the different kind of drugs my child can receive?

Chemotherapy

A chemotherapy drug is a type of cancer treatment that kills cells within the body. It is a broad term for drugs that can work in lots of different ways.

A common combination of chemotherapies used for ALL is:

- Vincristine
- An anthracycline drug such as daunorubicin, doxorubicin or idarubicin
- Cyclophosphamide or cytarabine
- Asparaginase or pegaspargase (a derived version of asparaginase)

Chemotherapy is often combined with a steroid such as dexamethasone or prednisolone.

Which chemotherapy your child will get varies depending on the stage of their treatment (induction, consolidation or maintenance). Please see our booklets on each stage to understand the process. Scan the QR code to order or download our booklets:

Targeted treatment

Targeted treatments are drugs that target specific proteins on the surface of the leukaemia cells. This means they do not target normal cells so do less damage to normal cells than

chemotherapy. Examples of targeted treatments your child might receive are tyrosine kinase inhibitors (TKIs).

Tyrosine kinase inhibitor

In general, your child might receive a TKI when they have the Philadelphia chromosome. TKIs are drugs that inhibit the tyrosine kinase enzyme which controls the function of a cell. They stop the cell growing and dividing.

Imatinib is an example of an effective TKI, although there are newer ones.

Immunotherapy

Immunotherapy is a treatment that helps your child's immune system to fight the cancer. In general the immune system ignores your child's own cells. Its role is to fight off foreign substances that are not part of your child's body. Although the leukaemia cells come from your child, they are abnormal. Thus, we can encourage the immune system to attack them. There are three types of immunotherapy.

Monoclonal antibodies

Monoclonal antibody drugs attach themselves to particular surface proteins on the leukaemia cells. Your child's immune system can detect these antibodies. These antibodies encourage the body's immune system to kill the leukaemia cells.

Blinatumomab is an example of a monoclonal antibody designed to attach itself to the CD19 protein on B-cells. It is approved for children aged one and older who:

- Are Philadelphia chromosome-negative
- Have not responded to previous treatment

For more information, we have a dedicated booklet on blinatumomab as a treatment for ALL. Scan the QR code to order or download the booklet:

Antibody-drug conjugates

Antibody-drug conjugates are made of a monoclonal antibody linked to a powerful anticancer drug.

The monoclonal antibody part of the antibody-drug conjugate targets specific proteins on the leukaemia cell as described in the last section. The linked anticancer drug then destroys the leukaemia cell directly.

Inotuzumab ozogamicin is an example of antibody-drug conjugate drug. The monoclonal antibody inotuzumab is linked to the anticancer drug ozogamicin. Inotuzumab attaches to the CD22 proteins on the leukaemia cell. Ozogamicin then destroys it.

Inotuzumab ozogamicin has been effective for relapsed ALL patients.

For more information, we have a dedicated booklet on inotuzumab ozogamicin as a treatment for ALL. Scan the QR code to order or download the booklet:

Other antibody-drug conjugates are studied as frontline treatment for newly diagnosed ALL patients. Results are encouraging. They will be added to this booklet if they become approved. For more information about trials, contact our Advocacy Team by emailing advocacy@leukaemiacare.org.uk or calling 08088 010 444.

Chimeric antigen receptor (CAR) T-cell therapies

CAR T-cell therapies are relatively new for ALL treatment. They have shown very positive results when they have been used so far.

The process of creating CAR T-cell therapy is complicated. A haematology specialist will filter out the T-cells from your child's

blood and alter them in a laboratory. These modified T-cells are able to destroy the leukaemia cells when they are put back into your child's blood stream. They do this by looking for specific proteins on leukaemia cells.

Tisagenlecleucel is the first approved CAR T-cell therapy for the treatment of ALL in the UK for children and young adolescents. Tisagenlecleucel kills leukaemia cells carrying the CD19 protein. It is only available to some patients.

Trials of CAR T-cell therapy for patients with a new diagnosis of ALL are ongoing. You can find out more details by speaking to our Advocacy Team. You can email advocacy@leukaemiacare.org.uk, or call **08088 010 444**.

For more information, we have a dedicated booklet on CAR T-cell therapy as a treatment for ALL. Scan the QR code to order or download the booklet:

Stem cell transplant

A stem cell transplant works by replacing the stem cells in your child's bone marrow. This is where blood cells are made including your child's leukaemia cells. The aim of replacing stem cells is to help your child only make normal blood cells again.

Your child can receive a stem cell transplant to reduce the risk of relapse. There are two types of stem cell transplant:

- **Allogeneic stem cell transplants (allo-SCT)** are stem cell transplants that use stem cells from a matching sibling or matching donor.
- **Autologous stem cell transplants** use stem cells from the patient themselves. They are rarely performed for ALL patients.

Some patients who have relapsed may also have an allo-SCT.

Procedure

Before the SCT, your child will receive high-dose chemotherapy. This will kill the leukaemia cells in the bone marrow. This is called myeloablative conditioning.

Your child will then receive the healthy donor stem cells intravenously. These cells migrate to the bone marrow where they form new blood cells. After the SCT, your child will receive drugs to prevent rejection of the donated stem cells. Your child will have to stay in hospital for four to six weeks.

For more information, we have a dedicated booklet on stem cell transplants as a treatment for ALL. Scan the QR code to order or download the booklet:

Treatment for patients who cannot tolerate intensive treatment

The treatments we have described so far in this booklet are very intensive. This means they can cause damage to your child's body. These include standard high-dose chemotherapy treatment used for induction treatment. Standard high-dose chemotherapy is also used to prepare the bone marrow for a stem cell transplant. This means there can be a lot of side effects. The high-dose chemotherapy may not be safe for your child if:

- They are unwell
- They have other health conditions

In all our later treatment booklets, we highlight how treatment is different if you cannot have intensive treatment.

New treatments

Researchers are always developing and testing new drugs for ALL. They are often looking for drugs more specific than standard chemotherapy. These drugs should work better and have fewer side effects.

A particularly busy area of research is clinical trials of CAR T-cell therapies. This is because of the positive results achieved with tisagenlecleucel.

Combinations of chemotherapies and monoclonal antibodies are also being trialled.

Clinical trials

Clinical trials comparing new treatments with existing ones are always in progress. These clinical trials are often available online at **https://clinicaltrials.gov/**. Clinical trials can offer you a chance to access new treatments, but the entry criteria for a trial can be very strict.

The treatment being tested is not guaranteed to be better than existing options. Speak to your child's healthcare team to decide if a trial is right for your child. They may know of a clinical trial featuring a treatment that may benefit your child. They may ask your child to take part in the trial. But the choice is yours.

You can also speak to our Advocacy Team by emailing **advocacy@leukaemiacare.org.uk** or calling **08088 010 444**.

This booklet is only a guide of what you might experience. Your haematology team will give you a copy of your specific treatment plan.

What are the side effects of treatments used for childhood ALL?

Chemotherapy treats the leukaemia cells and normal cells in the same manner. The effect of the chemotherapy on the normal cells is the cause of side effects. Chemotherapy causes more

side effects than targeted treatment. Your child is unlikely to experience every side effect. It is difficult to predict which side effects your child will go through. This is because people react to treatment in different ways.

There are three types of side effects:

1. **Short-term side effects**: these side effects can last for a few days or weeks, but for some, they can last for the duration of treatment.
2. **Long-term side effects**: these are side effects that last for a long period of time (six to 12 months).
3. **Late effects**: these are side effects that develop months or years after treatment has stopped.

For more information about side effects, we have dedicated booklets on the common side effects of treatment and late effects of treatment. Scan the QR code to order or download our booklets:

Common late side effects of chemotherapy or radiotherapy

Common side effects in patients receiving chemotherapy or radiotherapy for the treatment of leukaemia include:

- Increased risk of infection
- Anaemia
- Bleeding
- Fatigue
- Gastrointestinal (nausea, vomiting, diarrhoea and constipation)
- Sore mouth

- Hair loss
- Fertility
- Cognitive or thinking effects
- Heart and lung toxicity

Late and long-term side effects in patients receiving chemotherapy or radiotherapy

Possible late and long-term side effects in patients receiving cancer treatment include:

- Fatigue
- Eye, hearing and mouth changes
- Skin and nail side effects
- Bone and joint issues
- Endocrine and thyroid changes
- Cognitive or thinking effects
- Lung toxicity
- Heart toxicity
- Nerve side effects
- Kidney and urinary toxicity
- Secondary cancers

Measurable residual disease

Measurable residual disease (MRD) measures leukaemia in the body at a molecular level rather than at cellular level. It counts the very small amount of leukaemia present in your child's body that might be missed when your blood is viewed under a microscope.

- If leukaemia cells are still present in your child's body, they are said to be MRD positive

- If your child has no disease is detectable in their body, they are said to be MRD negative

MRD gives a very accurate assessment of remission and an early detection of relapse. It might be measured during or after treatment. Measurement of MRD after treatment will let your child's haematology team about their risk of relapse.

The haematology team will measure your child's MRD using either a blood or bone marrow sample.

Common tests for measuring MRD take place in a laboratory. They include:

- Flow cytometry
- Polymerase chain reaction (PCR) tests

We explain how these tests work in the diagnosis section for your information.

Any tests and their results should be properly explained to you.

Follow-up care

Once your child is in long-term remission, their haematology team will discuss follow-up care.

ALL patients need regular appointments to detect signs of relapse or complications. Experts recommend checks of your child's MRD every three months.

Follow-up appointments will continue for several years. The frequency of appointments will depend on:

- The type of treatment your child is having
- The supportive care your child needs. For example, any support your child needs to manage ongoing side effects

You should report any new or worrying side effects to your child's medical team straight away at your child's follow-up appointments. You should also discuss any emotional or mental

health concerns you have for your child. It is common for the end of treatment to trigger some emotions that your child may need support with.

While your child is in this follow-up phase, it can be helpful to keep in touch with other parents and carers in your position. Our buddy scheme offers one-to-one support and the opportunity to speak to someone in a similar situation to you. Email **support@leukaemiacare.org.uk** or call **08088 010 444** to find out more.

What is the prognosis for childhood ALL?

In the last five decades, the prognosis for children with ALL has greatly improved. Before then, children with ALL were not likely to survive. Today, up to about 90% of children live for five years or more.

As part of this improvement, outcomes for children with T-cell ALL have gotten better. Outcomes for children with T-cell ALL were inferior to those of children with B-cell ALL. New intensive chemotherapy has focused on T-cell ALL. Prognoses for childhood T-cell ALL and B-cell ALL are nearly the same now.

Prognosis for children with ALL will depend on the following factors:

Overall fitness

Children older than one year are robust enough to receive intense chemotherapy.

Risk factors

Children with these risk factors have a poorer prognosis:

- Age less than one year or older than 10 years
- White blood cell count at presentation greater than 50,000 cells/mm^3
- Presence of leukaemia cells in the central nervous system and testes
- Prolonged pre-treatment with corticosteroids needed

Response to treatment

Measurement of MRD after treatment is a good indicator for prognosis of children with ALL.

Children with refractory or relapsed ALL have a poor prognosis.

High-risk genetic subtypes

Children with the following:

- Chromosome 21 (iAMP21). This is common in older children.
- Chromosome arrangement t(12;21)(p13;q22).
- Philadelphia chromosome. The prognosis has improved with treatment of chemotherapy and a TKI.

Extent of disease

Other chromosome and gene changes

- Chromosome arrangements t(12;21)(p13;q22) in children with B-cell ALL. This contains the *ETV6-RUNX1* gene. Children with this gene have a good prognosis.
- ETV6-RUNX1–like chromosome arrangement. The gene profile is similar to that of ETV6-RUNX1 ALL and has a good prognosis.
- NUTM1 B-cell precursor arrangements have an excellent prognosis.

New target immunotherapies include monoclonal antibodies and CAR T-cell therapies. Both have shown considerable promise for improving the prognosis of children with ALL.

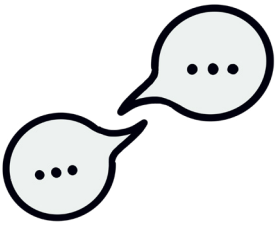
You can discuss your child's prognosis with your child's haematology team at any time.

Summary: Supportive care

Supportive care is available for your child at any time during treatment. Supportive care does not include the medication to treat your child's ALL.

The purpose of supportive care is to prevent, or treat, your child's symptoms of ALL. Supportive care can also reduce the side effects caused by treatment. Your child is likely to need supportive care for treating nausea and vomiting caused by treatment.

The aim of supportive care is to improve quality of life. This is the case even when your child is not receiving treatment.



Talk to your child's healthcare professionals. Supportive care will help your child with any unpleasant physical symptoms or side effects.

Supportive care

Most children with ALL need transfusions of red blood cells and platelets. Your child will have injections of growth factors to help the body to produce more white cells. This will reduce the frequency and severity of infections.

If your child is at school or a playgroup, measles and chickenpox are particular risks. Your child's haematology team will inform you of precautions you can take.

Supportive care

Supportive care improves the quality of life for patients with serious/life-threatening disease.

Infection

Supportive care consists of:

- Prevention of possible infections
- Management of infections with antibiotics, antivirals and antifungals
- Treatment of the side effects caused by ALL treatment

Awareness of infections and support will help your child achieve the best response.

Children should be made aware of their susceptibility to infections. This will enable them to recognise symptoms of infections. Common symptoms of infection include:

- Fever – a raised temperature (38°C or higher)
- Aching muscles
- Diarrhoea
- Headaches
- Excessive tiredness

Children can help reduce their risk of infection by taking simple precautions:

- Frequent washing of hands after the using toilet and being in public areas
- Limiting their time in busy places, especially if there is an epidemic of flu or other illness

It is important to observe the following for your child:

- A well-balanced diet to increase strength and energy
- Cleanliness when preparing food
- Respecting use-by dates

When having treatment, your child may lose weight due to changes in taste or appetite, or treatment side effects. Your child will regain weight when not receiving treatments.

Specific advice on how to protect your child from COVID-19 infection is available on our website. It is constantly updated. Scan the QR code to take you there:

Blood transfusion

Supportive care also includes blood transfusions.

- Infusion of red cells or platelets is useful for children with low levels of these blood cells.
- Growth factor injections after each chemotherapy treatment will help your child produce more white cells.
- Infusion of white blood cells is not performed. It has a high likelihood of side effects.

Follow-up

It is very important that your child has a follow-up programme in place. This will help pick up any late side effects of treatment and deal with them as soon as possible. At the end of treatment, your child will have regular check-ups at the hospital.

- Every month for the first six to 12 months
- Every three to six months for the next four years
- Yearly after that

End of life care

What happens if treatment stops working?

Your child's haematology team might explore other treatment options if treatments for your child's ALL are no longer working. However, they may give you a terminal diagnosis if there are no options left. They will discuss this with you first.

What happens next?

A terminal diagnosis means your team feel there are no more treatment options left that can cure or control your child's ALL. Supportive care to improve quality of life should continue. They will let you know when your child needs end of life care. End of life care may last days, months or years.

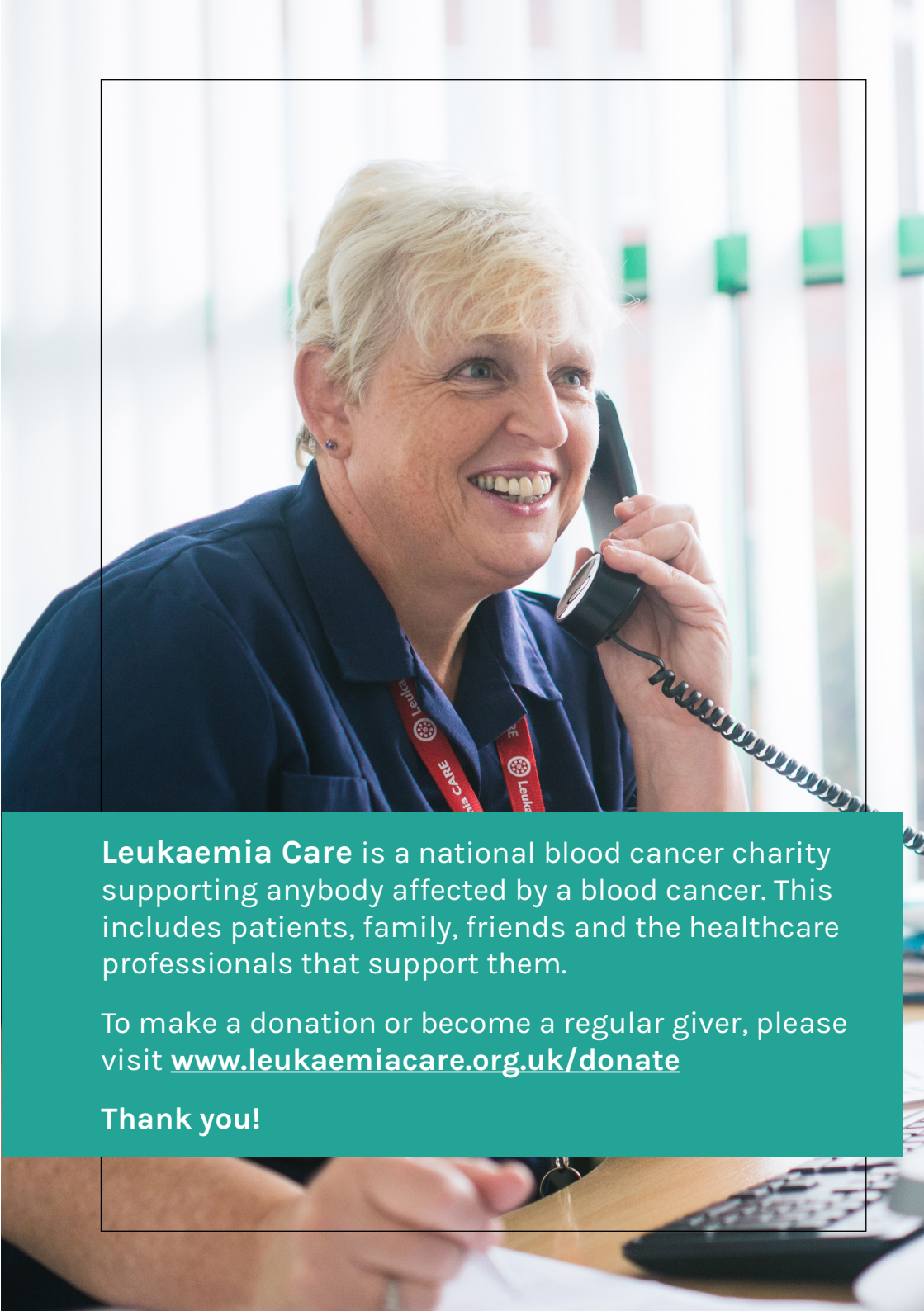
Your child's healthcare team should ask you about your individual wishes for your child's care. They will treat with your child with this in mind. End of life care should help your child live as well as possible until death. The aim is to help your child live a good quality of life, and die with dignity.

Most hospitals have palliative care teams. They have experience in dealing with end of life and related symptoms. You should have access to a community palliative care team if your local hospital does not have one.

Going through this process is often easier if you have made plans in advance. We recommend that you set up a 'living will' for your child in which you can express your wishes for your child's care. You can also consider a 'Do Not Resuscitate' (DNR) order. Creating a living will reduces stress for others if it is in writing and your family is aware.

Your child's haematology team should talk to you about your wishes for your child's future care. Sometimes your choices can be limited by the nature of ALL. For example, blood transfusions and various supportive drugs can only be delivered in hospital. Options should be discussed with you regardless. The team will also provide support to your family, carers and loved ones.

If you would like more information about a terminal diagnosis, or how to prepare for it whilst your child is well, please speak to us on our helpline on **08088 010 444**.



Leukaemia Care is a national blood cancer charity supporting anybody affected by a blood cancer. This includes patients, family, friends and the healthcare professionals that support them.

To make a donation or become a regular giver, please visit **www.leukaemiacare.org.uk/donate**

Thank you!

Useful contacts and further support

There are a number of helpful sources to support you during your diagnosis, treatment and beyond, including:

- Your haematologist and healthcare team
- Your family and friends
- Your psychologist (ask your haematologist or CNS for a referral)
- Reliable online sources, such as Leukaemia Care
- Charitable organisations

Leukaemia Care

Leukaemia Care is the UK's leading leukaemia charity. For over 50 years, we have been dedicated to ensuring that everyone affected receives the best possible diagnosis, information, advice, treatment and support. We are here for everyone affected by leukaemia and related blood cancer types – such as myelodysplastic syndromes (MDS) and myeloproliferative neoplasms (MPN). We believe in improving lives and being a force for change. To do this, we have to challenge the status quo and do things differently.

Helpline: **08088 010 444**
www.leukaemiacare.org.uk
support@leukaemiacare.org.uk

Blood Cancer UK

Leading charity into the research of blood cancers.

0808 2080 888
www.bloodcancer.org.uk

Cancer Research UK

Leading charity dedicated to cancer research.

0808 800 4040
www.cancerresearchuk.org

Macmillan

Provides free practical, medical and financial support for people facing cancer.

0808 808 0000
www.macmillan.org.uk

Maggie's Centres

Offers free practical, emotional and social support to people with cancer and their loved ones.

0300 123 1801
www.maggiescentres.org

Citizens Advice Bureau (CAB)

Offers advice on benefits and financial assistance.

08444 111 444
www.adviceguide.org.uk

How you can help us

If you've been affected by ALL, sharing your story can help others going through a similar situation and help the public to better understand.

Scan the QR to share your story:

Alternatively, you can email our Communications Team at communications@leukaemiacare.org.uk.

We are continually working to make sure our information is up to date and includes everything you need to help feel supported and empowered to advocate for yourself. With this, it is important for us to listen to any feedback you might have about our childhood ALL booklet.

Scan the QR to take you to our shop to leave a review of our booklet:

Alternatively, you can email our Information Team at information@leukaemiacare.org.uk, call our office line on **01905 755 977** or write a letter to our Head Office at **Leukaemia Care, One Birch Court, Blackpole East, Worcester, WR3 8SG**.

Take on a challenge for Leukaemia Care

We have a range of fundraising challenges that you can get involved in to help us continue to provide care and support to those affected by a leukaemia, MDS or an MPN.

Running, swimming, cycling and adrenaline challenges are available to take part in, both in the UK and abroad. There really is something for everyone.

If you're interested in taking part in a challenge, speak to a member of our Fundraising Team by emailing fundraising@leukaemiacare.org.uk or calling **01905 755977**.

Alternatively, scan this QR code to find out all the ways you can get involved with Leukaemia Care:

"It was a pleasure to meet you and to take part in my first half marathon together with the Leukaemia Care team! I'm a scientist and work in immunology research. A dear family member passed away from leukaemia seven years ago this month, so I did this in his memory. I smashed my goal of under two hours with a final time of 1:53! I'm extremely happy, thank you so much for all your hard work and it was great to see you cheering us on along the track. I loved the look of the vests too! See you again, next year maybe!" **- Alexandru Bacita ran London Landmarks for Leukaemia Care in 2022**

Your gift today will ensure that Leukaemia Care can continue to offer support to leukaemia patients and those who love them

Yes, I want to make a regular gift to Leukaemia Care of £5 or £ ☐ a month starting on the 1st ☐ or the 15th ☐ of each month (please tick one).

Please note: the minimum for a direct debit is £2 a month.

Title: .....

First name or initial(s): ..... Surname: .....

Full home address: .....

.....

Postcode: ..... Phone: .....

Email: .....

☐ **Gift Aid Declaration: Please tick here if you want Leukaemia Care to reclaim the tax that you have paid on all your donations you make in the future or have made in the past four years.**

Instruction to your Bank or Building Society to pay by Direct Debit

Name of Account Holder(s): ..... / .....

Bank/Building Society account number: ☐

Branch sort code: ☐

Name and full postal address of you Bank or Building Society: .....

.....

Instruction to your Bank or Building Society: Please pay Leukaemia Care from the account detailed in this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with Leukaemia Care and, if so, details will be passed electronically to my Bank/Building Society.

Signature(s): ..... / .....

Date: ☐

This guarantee should be detached and retained by the payee.

The Direct Debit Guarantee

DIRECT Debit

This Guarantee is offered by all banks and building societies that accept instructions to pay Direct Debits.

The efficiency and security of the scheme is mentioned and protected by your own Bank or Building Society.

If the amounts to be paid or the payment dates change, Leukaemia Care will notify you 10 working days in advance of your account being debited or as otherwise agreed.

If an error is made by Leukaemia Care or your Bank or Building Society, you are guaranteed a full and immediate refund from your branch of the amount paid.

You can cancel a Direct Debit at any time by writing to your Bank or Building Society. Please also send a copy of your letter to us.

Leukaemia Care is the UK's leading leukaemia charity. For over 50 years, we have been dedicated to ensuring that everyone affected receives the best possible diagnosis, information, advice, treatment and support.

Every year, 10,000 people are diagnosed with leukaemia in the UK. We are here to support you, whether you're a patient, carer or family member.

Want to talk?

Helpline: **08088 010 444**
(free from landlines and all major mobile networks)

Office Line: **01905 755977**

www.leukaemiacare.org.uk

support@leukaemiacare.org.uk

Leukaemia Care,
One Birch Court,
Blackpole East,
Worcester,
WR3 8SG

Leukaemia Care is registered as a charity in England and Wales (no. 1183890) and Scotland (no. SC049802).

Company number: 11911752 (England and Wales).

Registered office address: One Birch Court, Blackpole East, Worcester, WR3 8SG

Leukaemia Care
YOUR Blood Cancer Charity

Trusted Information Creator
Patient Information Forum