



Breathing and lung function tests

Tests to measure your breathing

What are breathing tests?

Breathing tests measure how well your lungs are working. These tests are used to find the cause of problems such as feeling out of breath. They are sometimes called lung function tests. They measure things like:

- how much air you can take into your lungs
- how quickly you can blow air out of your lungs
- how well your lungs can take up oxygen
- the strength of your breathing muscles

Your results are compared to what would be expected in healthy people of your age, height, sex and ethnicity.

Your health care professional may also weigh you to **calculate your body mass index (BMI)** (nhs.uk/live-well/healthy-weight/bmi-calculator/). This is a way of measuring whether you're a healthy weight for your height. Being overweight or underweight can affect your breathing, lung function and general health. Being overweight can cause breathlessness.

Your health care professional will also compare your results with any earlier test results, to track your progress. Tests include:

- peak flow test
- spirometry and bronchodilator responsiveness (reversibility) test
- lung volume measurement
- gas transfer test
- respiratory muscle strength
- exhaled carbon monoxide levels
- fractional exhaled nitric oxide testing (FeNO)

Peak flow test

What is a peak flow test?

The peak flow test measures how fast you can breathe out after you've taken a full breath in. Your peak flow score is sometimes called your peak expiratory flow (PEF).

Your GP or nurse should ask you to do a peak flow test at your annual asthma review. You may also be asked to monitor your own peak flow at home regularly, as part of your asthma action plan. These results are kept in a **peak flow diary** (www.asthma.org.uk/86e2a328/globalassets/health-advice/resources/adults/your-peak-flow-diary.pdf) to see if your peak flow varies. This can be a feature of asthma, especially if it is not under control.

What happens during a peak flow test?

You take the biggest breath in that you can. Then blow out as fast as you can, into a small, hand-held plastic tube called a peak flow meter. You don't need to empty the lungs completely – just a short, sharp blow, as if you're blowing out a candle. The measurement taken is called your peak flow.

Each time you check your peak flow, you should do 3 blows, with a short rest in between the blows. The best of the 3 is the one that should be recorded.

Your health care professional will make sure that your technique is correct, as this may affect the readings.

What will the results look like?

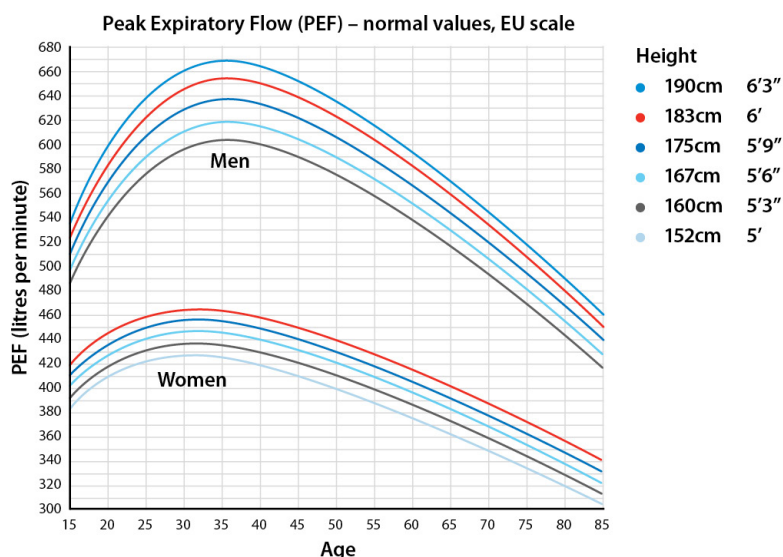
Peak flow scores will vary depending on your age, your height and whether you're a man or a woman. The expected values are higher in younger people, taller people and men.

Peak expiratory flow (PEF) is measured in litres per minute. Normal adult peak flow scores range between around 400 and 700 litres per minute, although scores in older women can be lower and still be normal. The most important thing is whether your score is normal for you. Health care professionals will be looking to compare your scores over time, to see if your results are going up or down.

Your peak flow reading may vary through the day and night. The amount of variation is important as well as the pattern.

Keeping track of your peak flow can help you spot when your symptoms are getting worse and **when you need to take your reliever inhaler** (blf.org.uk/support-for-you/asthma/treatment) or get medical help.

Range of normal values for a peak flow test



Spirometry and bronchodilator responsiveness testing

What is spirometry?

Spirometry measures the amount of air you can breathe out from your lungs and how fast you can blow it out. You'll be asked to take a very deep breath and blow out as fast as you can into a mouthpiece, until no more air comes out.

A spirometry test typically takes 10 to 20 minutes, but may be longer if it includes bronchodilator responsiveness testing.

Types of spirometer

There are various different spirometer devices, but they all measure the same thing. Many GP surgeries now have small, portable spirometers. Some spirometers are more sophisticated and can give more detailed results. These are used in a hospital or clinic.

What is bronchodilator responsiveness testing?

Bronchodilator responsiveness testing is done to see if your lung function gets better with medication, and if so, by how much. It's sometimes called **reversibility testing**. In bronchodilator responsiveness testing, the spirometry test is done before and after you breathe in some medication.

What's spirometry used for?

Spirometry can help tell if your breathing is affected by narrowed or inflamed airways. The results are useful in diagnosing lung conditions such as **COPD** (blf.org.uk/support-for-you/copd) and **asthma** (blf.org.uk/support-for-you/asthma). For some conditions, it can be used to grade how severe your condition is.

How should I prepare for a spirometry test?

You'll be told if there are any particular things you need to do to prepare. You may need to stop taking bronchodilator medication before the test. You should also stop smoking for 24 hours beforehand, if you can.

On the day of your spirometry test, it's a good idea to wear loose, comfortable clothing.

Am I fit to do the test?

Spirometry is usually safe, but there are some conditions where it may cause problems. Tell your healthcare professional if any of these apply to you:

- angina
- heart problems
- recent concussion
- uncontrolled high or low blood pressure
- pulmonary hypertension
- pulmonary embolism
- pneumothorax
- recent surgery on the brain, middle ear, sinuses, eyes, chest or abdomen
- late term pregnancy
- aneurysms

They will often have a checklist to ask you about these. If in doubt, talk to your health care professional.

What happens during the test?

You will be asked some questions before you start, to check you are medically fit to do the test. It is important to put as much effort into the test as you can, so the results are accurate.

You'll be asked to sit comfortably and may have a clip put on your nose to make sure all the air goes into the mouthpiece. You will be shown how to blow into the spirometer before starting. You may be asked to blow 3 or more times into the spirometer, to check the readings are similar each time.

Normally, you will first be asked to breathe in deeply and out gently. Once your health care professional is happy with the results, you will move on to the next part of the test. You will have to breathe in again deeply, this time quite fast, and then breathe out as fast and as hard as you can until your lungs are empty.

Your health care professional may ask you to use your inhaler or other medication, wait 15–20 minutes and then repeat the test. For some drugs the wait may be 45 minutes between tests. This is called a **bronchodilator responsiveness test** or **reversibility test** and it's done to see if the medication improves your breathing. If you use inhalers, you should bring them to your appointment.

Occasionally, people feel a little light-headed and dizzy following the test. This usually lasts only a few moments. Let the person performing the test know, to make sure that you have time to recover.

What will the results look like?

Spirometry usually measures:

- how much air you can blow out in a relaxed manner, like a gentle sigh out, until your lungs are completely empty. This is called your **slow vital capacity** or **VC**
- the amount of air you can blow out in one second. With healthy lungs and airways, you can normally blow out most of the air from your lungs in one second. This is called your **forced expiratory volume** in one second, or **FEV1**
- the total amount of air you can blow out in one complete breath after taking a deep breath in. You will be asked to blow out as hard and as fast as you can until your lungs are completely empty. This is called your **forced vital capacity** or **FVC**

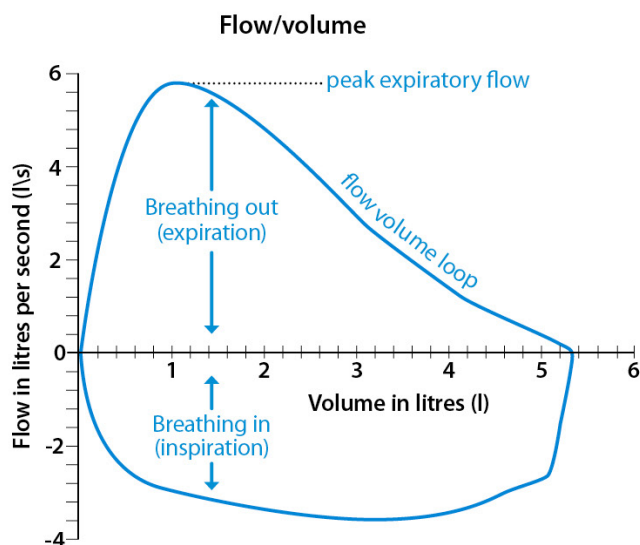
Your health care professional will look at how much air you can blow out in the first second (**FEV1**) and compare this to the total amount (**FVC**). This will give a percentage of air you can blow out in the first second.

Your results will look different depending on the type of spirometer used. Normally, your health care professional will compare your measurements with the normal range of values. The curves drawn by the spirometer showing the pattern of airflow are also important to help understand your results.

Understanding spirometry and narrow airways

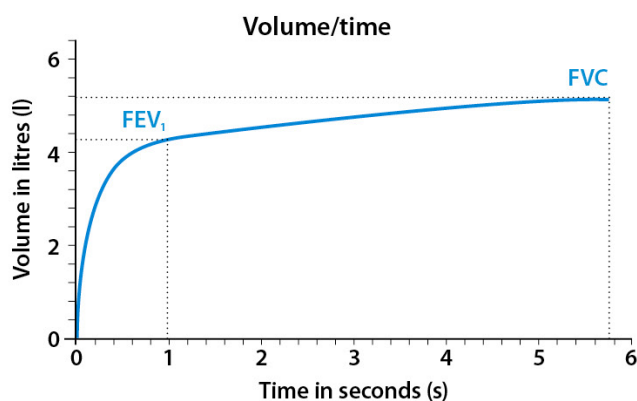
Think of a 5-lane motorway that has been reduced to 3 lanes due to roadworks. The traffic will take longer to travel through that stretch of motorway. In the same way, if your airway is narrower than normal, it will take you longer to empty your lungs of air. A spirometer records how much air you can breathe out in one second. That will be less if your airways are narrower than someone of your sex, age, height and ethnicity with healthy airways. It can also compare that result to how much air you breathed out, to measure how much your airways are blocked. In someone with healthy airways, at least 70% of the total air they breathe out would be breathed out in one second.

An example of a (normal) spirometry result for a hospital spirometer



These two graphs show:

- peak expiratory flow
- volume loop when breathing in and out
- volume / time



	Min	Ref	Max	Best	%Ref	SR
FEV1 [L]	3.76	4.31	4.99	4.31	100	0.0
FVC [L]	4.71	5.35	5.81	5.35	100	0.0
VC [L]	4.82	5.47	5.92	5.47	100	0.0
FEV1/VC [%]	68.1	78.8	-	78.8	100	0.0

Normal range

Your best effort

The table below the graphs shows the normal range of values for:

- forced expiratory volume (FEV1). That's the volume of air breathed out in one second, measured in litres
- forced vital capacity (FVC). That's the total volume of air breathed out in one breath, measured in litres
- vital capacity (VC). That's the total volume of air you can breathe out when relaxed, measured in litres
- the percentage of air blown out in the first second. This is calculated by dividing your FEV1 by your VC and multiplying by 100. In normal, healthy lungs, this will be 70% or above.

If your best effort is below the minimum value (Min), your result is below what it is expected it to be. This information and the shape of the loop will help your health care professional understand your results.

Patterns on a spirometry reading

A spirometry reading usually shows one of three main patterns. These depend on how much air you can breathe out and what proportion you can get out in the first second.

- normal pattern
- obstructive pattern
- restrictive pattern

Normal pattern

The normal range is calculated by the spirometer based on your height, age, sex and ethnicity. If your lungs and airways are healthy, you can blow out most of your breath in the first second. This pattern tells your doctor that your spirometry test is normal when compared to the expected results for you.

Obstructive pattern

An obstructive pattern is typical if you have a lung condition that narrows your airways, such as COPD or asthma. This means that the air flows out of your lungs more slowly than it should (low FEV1) with less than 70% of the total amount in the first second.

Spirometry can help to assess if inhaled medication or inhalers can open up your airways by bronchodilator responsiveness testing (sometimes known as reversibility testing). Usually, medication causes a bigger change in scores if you have **asthma** (blf.org.uk/support-for-you/asthma) than **COPD** (blf.org.uk/support-for-you/copd). People with COPD have an FEV1/FVC ratio lower than 70%. To decide how mild or severe your airflow obstruction is, the criteria below are used. It's important to remember that people with the same degree of airflow obstruction may be more or less breathless than each other. This is a guide:

Grade of airflow obstruction	
mild	FEV1 is 80% or more of the predicted value. If you have mild COPD, your spirometry test results can be normal after you take medication
moderate	FEV1 is 50-79% of the predicted value after medication
severe	FEV1 is 30-49% of the predicted value after medication
very severe	FEV1 is below 30% of the predicted value after medication

Restrictive pattern

With a restrictive pattern, the total amount of air you can breathe in is reduced but the speed you can breathe out is preserved. In this situation, both the FEV1 and FVC will be lower than predicted, but the ratio between the two will not be reduced.

A restrictive pattern can be caused by various conditions that affect:

- the tissue of your lungs, or
- the capacity of your lungs to expand and hold a normal amount of air, such as **pulmonary fibrosis** (blf.org.uk/support-for-you/pulmonary-fibrosis)

If your results show a restrictive pattern, you may have a **lung volume test** (blf.org.uk/support-for-you/breathing-tests/lung-volume-test) to check if you have a low lung volume.

This pattern can also be seen in people who

- are significantly overweight
- have an abnormal curvature of the spine, or
- have weak breathing muscles.

Combined patterns

Some patients may have a combination of obstructive and restrictive patterns. This happens when both the total amount of air and how fast you can blow out are reduced. It happens in severe **emphysema** (blf.org.uk/support-for-you/copd/treatment/surgery) or **cystic fibrosis** (blf.org.uk/support-for-you/cystic-fibrosis), and can also happen if someone is obese.

Lung volume test

What is a lung volume test?

A lung volume test is a way of measuring the total amount of air in your lungs, and how much air is left after you have breathed out as far as you can.

What's it used for?

A lung volume test helps your health care professional to find out more about what's happening in your lungs. It can tell them if your lung condition is restrictive or obstructive:

- If you have an obstructive lung condition, there is a narrowing of the airways inside your lungs. Your lungs never empty of air completely and more air than normal stays in your lungs after you breathe out. Examples of obstructive conditions are **COPD**, **asthma**, bronchitis and **bronchiectasis** (blf.org.uk/support-for-you/bronchiectasis).
- If you have a restrictive lung condition, you cannot fill your lungs fully with air. That's because your lungs are restricted from expanding fully, as they have lost their elasticity. Examples of restrictive conditions are pulmonary fibrosis and sarcoidosis. Sometimes this may also be seen in people who have a curvature of the spine or changes to shape of their ribcage, or in people who are obese.

What happens during a lung volume test?

To measure your lung volume, you will sit in a sealed, clear box which looks like a shower cubicle. It's sometimes called a body-box which can sound a bit alarming, but it is perfectly safe. You'll wear a clip on your nose to make sure that no air escapes from your nose.

People sometimes worry that they will have to sit in a box. You'll be able to talk via an intercom to the health care professional performing the test throughout. Let them know if you are anxious. The tests only takes about 5 minutes.

During the test you will be asked to pant, taking rapid shallow breaths for a few seconds. You will also be asked to put your hands firmly onto your cheeks, to stop them puffing in and out. You will then breathe in and out normally using a mouthpiece for a short time and then take some slow deep breaths in and out.

The effort you make to breathe causes changes in the pressure inside the box, as well as within your lungs. You will not feel any pressure changes, as they are very small. Changes in pressure inside the box are measured, and used to calculate your lung volume.

It can take a few goes to get the technique for the test right. Don't worry, the health care professionals are very experienced at helping people to do this. The lung volume test is usually repeated 3 to 5 times to check that you are getting a consistent result. You may be asked to practise the breathing technique before the actual measurement starts.

The method used to measure lung volumes may vary depending on your condition or the equipment that is available at your hospital.

What will the results look like?

Lung volume is measured in litres. Your predicted total lung capacity (TLC) is based on your age, height, sex and ethnicity, so results will differ from person to person. Normal results typically range between 80% and 120% of the prediction.

If your lung volume results fall outside of this normal range, this may suggest you have an obstructive or restrictive lung condition.

High lung volume

When the lung volume is higher than normal, this may mean there is too much gas in your lungs - called lung hyperinflation. This is when gas gets trapped in the lungs and makes them inflate too much. Lung hyperinflation can happen with obstructive conditions like **COPD**, bronchitis and **bronchiolitis** (blf.org.uk/support-for-you/bronchiolitis).

In people with COPD, if the tests show that there is a lot of trapped gas, bronchodilators may help to reduce this.

If you have chronic bronchitis or **bronchiectasis**, tests will indicate mucus in the airways. In this case, physiotherapy is the solution.

Low lung volume

If your lung volume is lower than normal, this may be a sign of a restrictive lung condition such as **pulmonary fibrosis** (blf.org.uk/support-for-you/pulmonary-fibrosis) or **sarcoidosis** (blf.org.uk/support-for-you/sarcoidosis).

Gas transfer (TLCO) test

What is a gas transfer test?

A gas transfer test measures how your lungs take up oxygen from the air you breathe. The result of the test is called the transfer factor, or sometimes the diffusing capacity.

A gas transfer test is sometimes known as a TLco test. TLco refers to the transfer capacity of the lung, for the uptake of carbon monoxide (CO).

What's it used for?

A gas transfer test is used to help diagnose and monitor lung conditions including **COPD** and **pulmonary fibrosis**. It may also be used to assess your lungs before surgery, or to see how a person's lungs react when having chemotherapy.

What happens during a gas transfer test?

You breathe in air containing tiny amounts of helium and carbon monoxide (CO) gases. These are

completely harmless at the very low levels used. You will be asked to take in a big breath through a mouthpiece while wearing a nose clip. You then hold your breath for a minimum of 8 seconds, then breathe out steadily into the machine. You will need to do this a few times, with a pause of a few minutes in between. Don't worry if it takes several attempts to get a reliable reading.

The results can be affected by smoking, so if you are a smoker, don't smoke for 24 hours before your test.

What will the results look like?

The gas transfer test tells your doctor how well your lungs can exchange oxygen from the lungs into the blood. The results will depend on your age, height, sex and ethnicity as well as the level of haemoglobin in your blood. Haemoglobin is the protein in red blood cells that carries oxygen.

Typically, a gas transfer test will give 3 results:

- TLco. This shows how efficiently your lungs are working to take oxygen from the air you breathe. It is calculated from 2 other measurements: Kco and VA.
- Kco. This measures how well the airways are performing
- VA (alveolar volume). This estimates the lung surface area available for gas exchange.

Low lung efficiency is when your measured results are less than 80% of the normal predicted values.

Respiratory muscle tests

What is a respiratory muscle test?

Respiratory muscle tests measure how much pressure your breathing muscles can generate when you breathe in or out. There are two types of respiratory muscle test:

- mouth pressure tests
- sniff pressure tests

What happens during a respiratory muscle test?

Sometimes the person carrying out the test will use handheld device with a mouthpiece. Or they might use a fixed piece of equipment in a lung function lab. They will explain how you should breathe for mouth pressure tests and sniff pressure tests. Some people find the mouth pressure test easier and some find the sniff pressure test easier. You will usually have to repeat each test a few times to make sure the results are as good as you can get.

The lung specialist may also ask you to do a **spirometry test** lying down, to see if this makes your lung capacity fall by more than 30% when moving from an upright position to lying down. This is a sign of muscle weakness.

Mouth pressure tests

Mouth pressure tests measure the strength of the muscles that help you breathe in and out.

Checking the strength of the muscles that help you breathe in

You'll be asked to breathe out for as long as you can, and then suck hard on a mouthpiece for at least 1 second. It will feel like sucking a very thick milkshake through a straw. This is the maximal inspiratory pressure (written in your results as P_Imax or MIP).

Checking the strength of the muscles that help you breathe out

To check how strong the muscles are that help you breathe out, you'll be asked to breathe in deeply first and then blow out as hard as you can into a closed off mouthpiece. This is the maximal expiratory pressure (written in your results as P_Emax or MEP).

Sniff pressure test

In a sniff pressure test, a small probe is placed to block one of your nostrils. It measures the pressure while you sniff as hard as you can. The sniff pressure test also looks at the strength of the muscles that help you breathe in. It may be written in your results as SNIP.

What will the results look like?

Normal results will vary from person to person. They will depend on your age and sex. Some sample results are included in the table below. It includes the predicted (normal) values for a male and a female. In this table, the results are shown in cmH₂O (centimetres of water), a unit of measurement that describes pressure.

LLN stands for lower limits of normal. Results below these figures suggest weakness of the muscles involved both breathing in and breathing out.

Exhaled carbon monoxide test

What is carbon monoxide?

Carbon monoxide (CO) is a poisonous gas that you can't see, smell or taste. Carbon monoxide is present in:

- cigarette smoke
- exhaust fumes
- faulty gas boilers

Carbon monoxide is harmful because it stops oxygen from reaching your vital organs. If you're pregnant, it can stop your baby from getting enough oxygen to grow.

What is an exhaled carbon monoxide test?

The exhaled carbon monoxide test measures how much carbon monoxide is in your body. It's a simple and easy test to do.

What's it used for?

Most people with high levels of carbon monoxide are smokers. The exhaled carbon monoxide test is useful tool to monitor smoking and help people to quit. The test can also show if you're being exposed to dangerous levels of carbon monoxide in second-hand smoke, even if you don't smoke yourself. Because carbon monoxide is dangerous for unborn babies, this test is offered to pregnant women as a routine part of their antenatal care.

Carbon monoxide exposure is especially risky if you are pregnant because **it affects a growing baby's access to oxygen**. Your baby needs oxygen to grow and develop.

How should I prepare for the test?

No special preparation is needed.

What happens during an exhaled carbon monoxide test?

You breathe into a cardboard tube attached to a handheld monitor. The monitor then shows the reading on its screen. You will be asked to hold your breath for as long as possible, ideally 15 seconds. Then you will breathe out slowly into the mouthpiece, aiming to empty your lungs completely.

What will the results look like?

The results will be in parts per million (ppm) of carbon monoxide in your breath.

reading	suggests
10 ppm and over	recent exposure to a high level of carbon monoxide. This is a typical reading for smokers
5–9 ppm	recent exposure to a moderate level of carbon monoxide. This may mean that you're a smoker, or that you've been exposed to second-hand smoke
1–4 ppm	recent exposure to a low level of carbon monoxide. It's normal to have a small amount of carbon monoxide in your breath even if you're not a smoker

Help to stop smoking

Stopping smoking is hard, but there's lots of help and support available.

Check out our information and resources on **how to stop smoking** (blf.org.uk/support-for-you/smoking).

If your reading shows a high level of carbon monoxide but you're not a smoker, it's possible that you have a faulty appliance in your home. Contact the National Gas Emergency Service on 0800 111 999.

Fractional exhaled nitric oxide (FeNO) test

What is nitric oxide (NO)?

Nitric oxide (NO) is found in the atmosphere, and is higher in areas with **air pollution**. It is also produced in the body, especially if there is inflammation. A higher level of nitric oxide measured in your breath may be a sign of **asthma**.

What is a fractional exhaled nitric oxide (FeNO) test?

A fractional exhaled nitric oxide test is a simple test to see how much nitric oxide is in your breath. It's often called a FeNO ("fee-no") test for short.

What is the FeNO test used for?

If you have a breathing condition, your airways may be inflamed. The FeNO test can be useful to help your doctor understand if you have asthma. The measurements may also help your health care professional check if the medication you are taking is working.

Only certain types of asthma may be identified with a FeNO test. Your doctor will talk to you about your clinical history, and you'll need to have other tests too, such as **spirometry** and a **peak flow test**.

How should I prepare?

Smoking before the FeNO test can affect the result, so avoid smoking beforehand if you can.

Nitrate rich food, such as green leafy vegetables and beetroot, caffeine and alcohol can also affect the result, so do not eat or drink these for an hour or so before the test.

What happens during a FeNO test?

You breathe into a plastic mouthpiece or a cardboard tube attached to a handheld monitor. The monitor shows the reading on its screen.

You will breathe in deeply, with your mouth open, and then breathe out little by little until your lungs are empty. The breath out will normally take 10 seconds in adults (6 seconds in children). Some devices will make a sound to help keep the flow at the right level throughout the test.

You may have to do the same measurement up to 3 times.

What will the results look like?

The results will be in parts per billion (ppb) of nitric oxide in your breath. Your health care professional will also check your symptoms, such as cough, wheeze and shortness of breath.

More than 40ppb of nitric oxide indicates that your airways are inflamed, and it's likely that you have **asthma**.

Get in touch with us to find support near you.

Helpline: **03000 030 555**

Monday to Friday, 9am-5pm

Ringing our helpline will cost the same as a local call.

helpline@blf.org.uk

blf.org.uk

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We value feedback on our information. To let us know your views, and for the most up to date version of this information and references, call the helpline or visit **blf.org.uk**