

# 70 Blood Pressure

## Blood pressure

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Blood pressure (BP) is the pressure of circulating blood against the walls of blood vessels. Most of this pressure results from the heart pumping blood through the circulatory system. When used without qualification, the term "blood pressure" refers to the pressure in a brachial artery, where it is most commonly measured. Blood pressure is usually expressed in terms of the systolic pressure (maximum pressure during one heartbeat) over diastolic pressure (minimum pressure between two heartbeats) in the cardiac cycle. It is measured in millimetres of mercury (mmHg) above the surrounding atmospheric pressure, or in kilopascals (kPa). The difference between the systolic and diastolic pressures is known as pulse pressure, while the average pressure during a cardiac cycle is known as mean arterial pressure.

Blood pressure is one of the vital signs—together with respiratory rate, heart rate, oxygen saturation, and body temperature—that healthcare professionals use in evaluating a patient's health. Normal resting blood pressure in an adult is approximately 120 millimetres of mercury (16 kPa) systolic over 80 millimetres of mercury (11 kPa) diastolic, denoted as "120/80 mmHg". Globally, the average blood pressure, age standardized, has remained about the same since 1975 to the present, at approximately 127/79 mmHg in men and 122/77 mmHg in women, although these average data mask significantly diverging regional trends.

Traditionally, a health-care worker measured blood pressure non-invasively by auscultation (listening) through a stethoscope for sounds in one arm's artery as the artery is squeezed, closer to the heart, by an aneroid gauge or a mercury-tube sphygmomanometer. Auscultation is still generally considered to be the gold standard of accuracy for non-invasive blood pressure readings in clinic. However, semi-automated methods have become common, largely due to concerns about potential mercury toxicity, although cost, ease of use and applicability to ambulatory blood pressure or home blood pressure measurements have also influenced this trend. Early automated alternatives to mercury-tube sphygmomanometers were often seriously inaccurate, but modern devices validated to international standards achieve an average difference between two standardized reading methods of 5 mm Hg or less, and a standard deviation of less than 8 mm Hg. Most of these semi-automated methods measure blood pressure using oscillometry (measurement by a pressure transducer in the cuff of the device of small oscillations of intra-cuff pressure accompanying heartbeat-induced changes in the volume of each pulse).

Blood pressure is influenced by cardiac output, systemic vascular resistance, blood volume and arterial stiffness, and varies depending on person's situation, emotional state, activity and relative health or disease state. In the short term, blood pressure is regulated by baroreceptors, which act via the brain to influence the nervous and the endocrine systems.

Blood pressure that is too low is called hypotension, pressure that is consistently too high is called hypertension, and normal pressure is called normotension. Both hypertension and hypotension have many causes and may be of sudden onset or of long duration. Long-term hypertension is a risk factor for many diseases, including stroke, heart disease, and kidney failure. Long-term hypertension is more common than long-term hypotension.

## Blood pressure measurement

*Arterial blood pressure is most commonly measured via a sphygmomanometer, which historically used the height of a column of mercury to reflect the circulating*

Arterial blood pressure is most commonly measured via a sphygmomanometer, which historically used the height of a column of mercury to reflect the circulating pressure. Blood pressure values are generally reported in millimetres of mercury (mmHg), though modern aneroid and electronic devices do not contain mercury.

For each heartbeat, blood pressure varies between systolic and diastolic pressures. Systolic pressure is peak pressure in the arteries, which occurs near the end of the cardiac cycle when the ventricles are contracting. Diastolic pressure is minimum pressure in the arteries, which occurs near the beginning of the cardiac cycle when the ventricles are filled with blood. An example of normal measured values for a resting, healthy adult human is 120 mmHg systolic and 80 mmHg diastolic (written as 120/80 mmHg, and spoken as "one-twenty over eighty"). The difference between the systolic and diastolic pressures is referred to as pulse pressure (not to be confused with pulse rate/heart rate) and has clinical significance in a wide variety of situations. It is generally measured by first determining the systolic and diastolic pressures and then subtracting the diastolic from the systolic. Mean arterial pressure is the average pressure during a single cardiac cycle and, although it is possible to measure directly using an arterial catheter, it is more commonly estimated indirectly using one of several different mathematical formulas once systolic, diastolic, and pulse pressures are known.

Systolic and diastolic arterial blood pressures are not static but undergo natural variations from one heartbeat to another and throughout the day (in a circadian rhythm). They also change in response to stress, nutritional factors, drugs, disease, exercise, and momentarily from standing up. Sometimes the variations are large. Hypertension refers to arterial pressure being abnormally high, as opposed to hypotension, when it is abnormally low. Along with body temperature, respiratory rate, and pulse rate, blood pressure is one of the four main vital signs routinely monitored by medical professionals and healthcare providers.

Measuring pressure invasively, by penetrating the arterial wall to take the measurement, is much less common and usually restricted to a hospital setting.

### Sphygmomanometer

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A sphygmomanometer ( SFIG-moh-m?-NO-mi-t?r), also known as a blood pressure monitor, blood pressure machine, or blood pressure gauge, is a device used to measure blood pressure, composed of an inflatable cuff to collapse and then release the artery under the cuff in a controlled manner, and a mercury or aneroid manometer to measure the pressure. Manual sphygmomanometers are used with a stethoscope when using the auscultatory technique.

A sphygmomanometer consists of an inflatable cuff, a measuring unit (the mercury manometer, or aneroid gauge), and a mechanism for inflation which may be a manually operated bulb and valve or a pump operated electrically.

### Hypertension

*high blood pressure, is a long-term medical condition in which the blood pressure in the arteries is persistently elevated. High blood pressure usually*

Hypertension, also known as high blood pressure, is a long-term medical condition in which the blood pressure in the arteries is persistently elevated. High blood pressure usually does not cause symptoms itself. It is, however, a major risk factor for stroke, coronary artery disease, heart failure, atrial fibrillation, peripheral arterial disease, vision loss, chronic kidney disease, and dementia. Hypertension is a major cause of premature death worldwide.

High blood pressure is classified as primary (essential) hypertension or secondary hypertension. About 90–95% of cases are primary, defined as high blood pressure due to non-specific lifestyle and genetic factors. Lifestyle factors that increase the risk include excess salt in the diet, excess body weight, smoking, physical inactivity and alcohol use. The remaining 5–10% of cases are categorized as secondary hypertension, defined as high blood pressure due to a clearly identifiable cause, such as chronic kidney disease, narrowing of the kidney arteries, an endocrine disorder, or the use of birth control pills.

Blood pressure is classified by two measurements, the systolic (first number) and diastolic (second number) pressures. For most adults, normal blood pressure at rest is within the range of 100–140 millimeters mercury (mmHg) systolic and 60–90 mmHg diastolic. For most adults, high blood pressure is present if the resting blood pressure is persistently at or above 130/80 or 140/90 mmHg. Different numbers apply to children. Ambulatory blood pressure monitoring over a 24-hour period appears more accurate than office-based blood pressure measurement.

Lifestyle changes and medications can lower blood pressure and decrease the risk of health complications. Lifestyle changes include weight loss, physical exercise, decreased salt intake, reducing alcohol intake, and a healthy diet. If lifestyle changes are not sufficient, blood pressure medications are used. Up to three medications taken concurrently can control blood pressure in 90% of people. The treatment of moderately high arterial blood pressure (defined as >160/100 mmHg) with medications is associated with an improved life expectancy. The effect of treatment of blood pressure between 130/80 mmHg and 160/100 mmHg is less clear, with some reviews finding benefit and others finding unclear benefit. High blood pressure affects 33% of the population globally. About half of all people with high blood pressure do not know that they have it. In 2019, high blood pressure was believed to have been a factor in 19% of all deaths (10.4 million globally).

## Hypotension

*as low blood pressure, is a cardiovascular condition characterized by abnormally reduced blood pressure. Blood pressure is the force of blood pushing*

Hypotension, also known as low blood pressure, is a cardiovascular condition characterized by abnormally reduced blood pressure. Blood pressure is the force of blood pushing against the walls of the arteries as the heart pumps out blood and is indicated by two numbers, the systolic blood pressure (the top number) and the diastolic blood pressure (the bottom number), which are the maximum and minimum blood pressures within the cardiac cycle, respectively. A systolic blood pressure of less than 90 millimeters of mercury (mmHg) or diastolic of less than 60 mmHg is generally considered to be hypotension. Different numbers apply to children. However, in practice, blood pressure is considered too low only if noticeable symptoms are present.

Symptoms may include dizziness, lightheadedness, confusion, feeling tired, weakness, headache, blurred vision, nausea, neck or back pain, an irregular heartbeat or feeling that the heart is skipping beats or fluttering, and fainting. Hypotension is the opposite of hypertension, which is high blood pressure. It is best understood as a physiological state rather than a disease. Severely low blood pressure can deprive the brain and other vital organs of oxygen and nutrients, leading to a life-threatening condition called shock. Shock is classified based on the underlying cause, including hypovolemic shock, cardiogenic shock, distributive shock, and obstructive shock.

Hypotension can be caused by strenuous exercise, excessive heat, low blood volume (hypovolemia), hormonal changes, widening of blood vessels, anemia, vitamin B12 deficiency, anaphylaxis, heart problems, or endocrine problems. Some medications can also lead to hypotension. There are also syndromes that can cause hypotension in patients including orthostatic hypotension, vasovagal syncope, and other rarer conditions.

For many people, excessively low blood pressure can cause dizziness and fainting or indicate serious heart, endocrine or neurological disorders.

For some people who exercise and are in top physical condition, low blood pressure could be normal.

A single session of exercise can induce hypotension, and water-based exercise can induce a hypotensive response.

Treatment depends on the cause of the low blood pressure. Treatment of hypotension may include the use of intravenous fluids or vasopressors. When using vasopressors, trying to achieve a mean arterial pressure (MAP) of greater than 70 mmHg does not appear to result in better outcomes than trying to achieve an MAP of greater than 65 mmHg in adults.

#### Pulse pressure

*Pulse pressure is the difference between systolic and diastolic blood pressure. It is measured in millimeters of mercury (mmHg). It represents the force*

Pulse pressure is the difference between systolic and diastolic blood pressure. It is measured in millimeters of mercury (mmHg). It represents the force that the heart generates each time it contracts. Healthy pulse pressure is around 40 mmHg. A pulse pressure that is consistently 60 mmHg or greater is likely to be associated with disease, and a pulse pressure of 50 mmHg or more increases the risk of cardiovascular disease. Pulse pressure is considered low if it is less than 25% of the systolic. (For example, if the systolic pressure is 120 mmHg, then the pulse pressure would be considered low if it were less than 30 mmHg, since 30 is 25% of 120.) A very low pulse pressure can be a symptom of disorders such as congestive heart failure.

#### Hemodynamics

*regulation of the pH, osmotic pressure and temperature of the whole body, and the protection from microbial and mechanical harm. Blood is a non-Newtonian fluid*

Hemodynamics or haemodynamics are the dynamics of blood flow. The circulatory system is controlled by homeostatic mechanisms of autoregulation, just as hydraulic circuits are controlled by control systems. The hemodynamic response continuously monitors and adjusts to conditions in the body and its environment. Hemodynamics explains the physical laws that govern the flow of blood in the blood vessels.

Blood flow ensures the transportation of nutrients, hormones, metabolic waste products, oxygen, and carbon dioxide throughout the body to maintain cell-level metabolism, the regulation of the pH, osmotic pressure and temperature of the whole body, and the protection from microbial and mechanical harm.

Blood is a non-Newtonian fluid, and is most efficiently studied using rheology rather than hydrodynamics. Because blood vessels are not rigid tubes, classic hydrodynamics and fluids mechanics based on the use of classical viscometers are not capable of explaining haemodynamics.

The study of the blood flow is called hemodynamics, and the study of the properties of the blood flow is called hemorheology.

#### Hypertensive disease of pregnancy

*pregnancy, also known as maternal hypertensive disorder, is a group of high blood pressure disorders that include preeclampsia, preeclampsia superimposed on chronic*

Hypertensive disease of pregnancy, also known as maternal hypertensive disorder, is a group of high blood pressure disorders that include preeclampsia, preeclampsia superimposed on chronic hypertension, gestational hypertension, and chronic hypertension.

Maternal hypertensive disorders occurred in about 20.7 million women in 2013. About 10% of pregnancies globally are complicated by hypertensive diseases. In the United States, hypertensive disease of pregnancy affects about 8% to 13% of pregnancies. Rates have increased in the developing world. They resulted in 29,000 deaths in 2013, down from 37,000 deaths in 1990. They are one of the three major causes of death in pregnancy (16%) along with post partum bleeding (13%) and puerperal infections (2%).

Hypertensive disorders during pregnancy, such as gestational hypertension, preeclampsia, and eclampsia, are a major contributor to maternal and fetal illness and death on a worldwide scale. Around 5-10% of pregnancies are affected by these conditions, with preeclampsia being responsible for up to 14% of maternal deaths globally. The effects of HDP are significant, but there is still a limited understanding of its root causes. Studies show an interconnection of genetic, immunological, and environmental elements. Accurately pinpointing particular risk factors has stifled researchers because of the varied nature of Hypertensive disorders of pregnancy. All types of HDP can be caused by a variety of factors, as mentioned above, and can occur in irregular manners.

### Prehypertension

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Prehypertension, also known as high normal blood pressure and borderline hypertensive (BH), is a medical classification for cases where a person's blood pressure is elevated above optimal or normal, but not to the level considered hypertension (high blood pressure). Prehypertension is now referred to as "elevated blood pressure" by the American College of Cardiology (ACC) and the American Heart Association (AHA). The ACC/AHA define elevated blood pressure as readings with a systolic pressure from 120 to 129 mm Hg and a diastolic pressure under 80 mm Hg. Readings greater than or equal to 130/80 mm Hg are considered hypertension by ACC/AHA and if greater than or equal to 140/90 mm Hg by ESC/ESH. and the European Society of Hypertension defines "high normal blood pressure" as readings with a systolic pressure from 130 to 139 mm Hg and a diastolic pressure 85-89 mm Hg.

Classification of blood pressure is based upon two or more readings at two or more separate occasions, and compared to out-of-office blood pressure readings if possible.

### Sepsis

*reduced blood flow. The presence of low blood pressure, high blood lactate, or low urine output may suggest poor blood flow. Septic shock is low blood pressure*

Sepsis is a potentially life-threatening condition that arises when the body's response to infection causes injury to its own tissues and organs.

This initial stage of sepsis is followed by suppression of the immune system. Common signs and symptoms include fever, increased heart rate, increased breathing rate, and confusion. There may also be symptoms related to a specific infection, such as a cough with pneumonia, or painful urination with a kidney infection. The very young, old, and people with a weakened immune system may not have any symptoms specific to their infection, and their body temperature may be low or normal instead of constituting a fever. Severe sepsis may cause organ dysfunction and significantly reduced blood flow. The presence of low blood pressure, high blood lactate, or low urine output may suggest poor blood flow. Septic shock is low blood pressure due to sepsis that does not improve after fluid replacement.

Sepsis is caused by many organisms including bacteria, viruses, and fungi. Common locations for the primary infection include the lungs, brain, urinary tract, skin, and abdominal organs. Risk factors include being very young or old, a weakened immune system from conditions such as cancer or diabetes, major trauma, and burns. A shortened sequential organ failure assessment score (SOFA score), known as the quick

SOFA score (qSOFA), has replaced the SIRS system of diagnosis. qSOFA criteria for sepsis include at least two of the following three: increased breathing rate, change in the level of consciousness, and low blood pressure. Sepsis guidelines recommend obtaining blood cultures before starting antibiotics; however, the diagnosis does not require the blood to be infected. Medical imaging is helpful when looking for the possible location of the infection. Other potential causes of similar signs and symptoms include anaphylaxis, adrenal insufficiency, low blood volume, heart failure, and pulmonary embolism.

Sepsis requires immediate treatment with intravenous fluids and antimicrobial medications. Ongoing care and stabilization often continues in an intensive care unit. If an adequate trial of fluid replacement is not enough to maintain blood pressure, then the use of medications that raise blood pressure becomes necessary. Mechanical ventilation and dialysis may be needed to support the function of the lungs and kidneys, respectively. A central venous catheter and arterial line may be placed for access to the bloodstream and to guide treatment. Other helpful measurements include cardiac output and superior vena cava oxygen saturation. People with sepsis need preventive measures for deep vein thrombosis, stress ulcers, and pressure ulcers unless other conditions prevent such interventions. Some people might benefit from tight control of blood sugar levels with insulin. The use of corticosteroids is controversial, with some reviews finding benefit, others not.

Disease severity partly determines the outcome. The risk of death from sepsis is as high as 30%, while for severe sepsis it is as high as 50%, and the risk of death from septic shock is 80%. Sepsis affected about 49 million people in 2017, with 11 million deaths (1 in 5 deaths worldwide). In the developed world, approximately 0.2 to 3 people per 1000 are affected by sepsis yearly. Rates of disease have been increasing. Some data indicate that sepsis is more common among men than women, however, other data show a greater prevalence of the disease among women.

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