**Rabies** is a [viral disease](https://en.wikipedia.org/wiki/Viral_disease) that causes [inflammation of the brain](https://en.wikipedia.org/wiki/Encephalitis) in humans and other [mammals](https://en.wikipedia.org/wiki/Mammals). Early symptoms can include fever and tingling at the site of exposure.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) These symptoms are followed by one or more of the following symptoms: violent movements, uncontrolled excitement, fear of water, an inability to move parts of the body, confusion, and [loss of consciousness](https://en.wikipedia.org/wiki/Loss_of_consciousness).[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) Once symptoms appear, the result is nearly always death.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) The time period between contracting the disease and the start of symptoms is usually one to three months, but can vary from less than one week to more than one year.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) The time depends on the distance the virus must travel along [peripheral nerves](https://en.wikipedia.org/wiki/Peripheral_nervous_system) to reach the [central nervous system](https://en.wikipedia.org/wiki/Central_nervous_system).[

Rabies is caused by [*lyssaviruses*](https://en.wikipedia.org/wiki/Lyssavirus), including the [rabies virus](https://en.wikipedia.org/wiki/Rabies_virus) and [Australian bat lyssavirus](https://en.wikipedia.org/wiki/Australian_bat_lyssavirus).[[3]](https://en.wikipedia.org/wiki/Rabies#cite_note-The_Department_of_Health-3) It is spread when an infected animal scratches or bites another animal or human.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) Saliva from an infected animal can also transmit rabies if the saliva comes into contact with the eyes, mouth, or nose.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) Globally, [dogs](https://en.wikipedia.org/wiki/Dog) are the most common animal involved.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) More than 99% of rabies cases in countries where dogs commonly have the disease are the direct result of [dog bites](https://en.wikipedia.org/wiki/Dog_bites).[[6]](https://en.wikipedia.org/wiki/Rabies#cite_note-Tint2010-6) In the [Americas](https://en.wikipedia.org/wiki/Americas), [bat](https://en.wikipedia.org/wiki/Bat) bites are the most common source of rabies infections in humans, and less than 5% of cases are from dogs.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1)[[6]](https://en.wikipedia.org/wiki/Rabies#cite_note-Tint2010-6) Rodents are very rarely infected with rabies.[[6]](https://en.wikipedia.org/wiki/Rabies#cite_note-Tint2010-6) The disease can only be diagnosed after the start of symptoms.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1)

Animal control and vaccination programs have decreased the risk of rabies from dogs in a number of regions of the world.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) Immunizing people before they are exposed is recommended for those at high risk, including those who work with bats or who spend prolonged periods in areas of the world where rabies is common.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) In people who have been exposed to rabies, the [rabies vaccine](https://en.wikipedia.org/wiki/Rabies_vaccine) and sometimes [rabies immunoglobulin](https://en.wikipedia.org/wiki/Rabies_immunoglobulin) are effective in preventing the disease if the person receives the treatment before the start of rabies symptoms.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) Washing bites and scratches for 15 minutes with soap and water, [povidone iodine](https://en.wikipedia.org/wiki/Povidone_iodine), or detergent may reduce the number of viral particles and may be somewhat effective at preventing transmission.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1)[[7]](https://en.wikipedia.org/wiki/Rabies#cite_note-7) As of 2016 only fourteen people had survived a rabies infection after showing symptoms.[[8]](https://en.wikipedia.org/wiki/Rabies#cite_note-8)[[9]](https://en.wikipedia.org/wiki/Rabies#cite_note-9)[[10]](https://en.wikipedia.org/wiki/Rabies#cite_note-ManojMukherjee2016-10)

Rabies caused about 17,400 deaths worldwide in 2015.[[4]](https://en.wikipedia.org/wiki/Rabies#cite_note-GBD2015De-4) More than 95% of human deaths from rabies occur in [Africa](https://en.wikipedia.org/wiki/Africa) and [Asia](https://en.wikipedia.org/wiki/Asia).[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) About 40% of deaths occur in children under the age of 15.[[11]](https://en.wikipedia.org/wiki/Rabies#cite_note-11) Rabies is present in more than 150 countries and on all continents but Antarctica.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) More than 3 billion people live in regions of the world where rabies occurs.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) A number of countries, including Australia and Japan, as well as much of Western Europe, do not have rabies among dogs.[[12]](https://en.wikipedia.org/wiki/Rabies#cite_note-12)[[13]](https://en.wikipedia.org/wiki/Rabies#cite_note-13) Many islands do not have rabies at all.[[14]](https://en.wikipedia.org/wiki/Rabies#cite_note-14) It is classified as a [neglected tropical disease](https://en.wikipedia.org/wiki/Neglected_tropical_disease).[[15]](https://en.wikipedia.org/wiki/Rabies#cite_note-NTD2017-15)

**Signs and symptoms**

The [period](https://en.wikipedia.org/wiki/Incubation_period) between infection and the first [symptoms](https://en.wikipedia.org/wiki/Influenza-like_illness) (incubation period) is typically 1–3 months in humans.[[16]](https://en.wikipedia.org/wiki/Rabies#cite_note-Giesen2015-16) [Incubation periods](https://en.wikipedia.org/wiki/Incubation_period) as short as four days and longer than six years have been documented, depending on the location and severity of the contaminated wound and the amount of virus introduced.[[16]](https://en.wikipedia.org/wiki/Rabies#cite_note-Giesen2015-16) Initial signs and symptoms of rabies are often nonspecific such as fever and headache.[[16]](https://en.wikipedia.org/wiki/Rabies#cite_note-Giesen2015-16) As rabies progresses and causes [inflammation of the brain and/or meninges](https://en.wikipedia.org/wiki/Meningoencephalitis), signs and symptoms can include slight or partial [paralysis](https://en.wikipedia.org/wiki/Paralysis), [anxiety](https://en.wikipedia.org/wiki/Anxiety), [insomnia](https://en.wikipedia.org/wiki/Insomnia), [confusion](https://en.wikipedia.org/wiki/Confusion), [agitation](https://en.wikipedia.org/wiki/Psychomotor_agitation), abnormal behavior, [paranoia](https://en.wikipedia.org/wiki/Paranoia), terror, and [hallucinations](https://en.wikipedia.org/wiki/Hallucination), progressing to [delirium](https://en.wikipedia.org/wiki/Delirium), and [coma](https://en.wikipedia.org/wiki/Coma).[[5]](https://en.wikipedia.org/wiki/Rabies#cite_note-Robbins-5)[[16]](https://en.wikipedia.org/wiki/Rabies#cite_note-Giesen2015-16) The person may also have hydrophobia.[[1]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO2013-1) Death usually occurs 2 to 10 days after first symptoms. Survival is almost unknown once symptoms have presented,[[16]](https://en.wikipedia.org/wiki/Rabies%22%20%5Cl%20%22cite_note-Giesen2015-16) even with the administration of proper and intensive care.[[17]](https://en.wikipedia.org/wiki/Rabies#cite_note-Expert_Review_of_Anti-infective_Therapy-17)

**Hydrophobia**

Hydrophobia ("fear of water") is the historic name for rabies.[[18]](https://en.wikipedia.org/wiki/Rabies#cite_note-18) It refers to a set of symptoms in the later stages of an infection in which the person has difficulty swallowing, shows panic when presented with liquids to drink, and cannot quench their thirst. Any mammal infected with the virus may demonstrate hydrophobia.[[19]](https://en.wikipedia.org/wiki/Rabies#cite_note-NHS-19)

Saliva production is greatly increased, and attempts to drink, or even the intention or suggestion of drinking, may cause excruciatingly painful spasms of the muscles in the throat and [larynx](https://en.wikipedia.org/wiki/Larynx). This can be attributed to the fact that the virus multiplies and assimilates in the [salivary glands](https://en.wikipedia.org/wiki/Salivary_gland) of the infected animal with the effect of further transmission through biting. The ability to transmit the virus would decrease significantly if the infected individual could swallow saliva and water.[[20]](https://en.wikipedia.org/wiki/Rabies#cite_note-20)

Hydrophobia is commonly associated with furious rabies, which affects 80% of rabies-infected people. The remaining 20% may experience a paralytic form of rabies that is marked by muscle weakness, loss of sensation, and paralysis; this form of rabies does not usually cause fear of water.[[19]](https://en.wikipedia.org/wiki/Rabies#cite_note-NHS-19)

Cause

Rabies is caused by a number of [*lyssaviruses*](https://en.wikipedia.org/wiki/Lyssavirus) including the [rabies virus](https://en.wikipedia.org/wiki/Rabies_virus) and [Australian bat lyssavirus](https://en.wikipedia.org/wiki/Australian_bat_lyssavirus).[[3]](https://en.wikipedia.org/wiki/Rabies#cite_note-The_Department_of_Health-3)

The rabies virus is the [type species](https://en.wikipedia.org/wiki/Type_species) of the [*Lyssavirus*](https://en.wikipedia.org/wiki/Lyssavirus) [genus](https://en.wikipedia.org/wiki/Genus), in the family[*Rhabdoviridae*](https://en.wikipedia.org/wiki/Rhabdoviridae), order [*Mononegavirales*](https://en.wikipedia.org/wiki/Mononegavirales). Lyssavirions have helical symmetry, with a length of about 180 [nm](https://en.wikipedia.org/wiki/Nanometre) and a cross-section of about 75 nm.[[21]](https://en.wikipedia.org/wiki/Rabies#cite_note-Sherris-21) These virions are [enveloped](https://en.wikipedia.org/wiki/Viral_envelope) and have a single-stranded [RNA](https://en.wikipedia.org/wiki/RNA) genome with [negative sense](https://en.wikipedia.org/wiki/Negative-sense#Negative-sense). The genetic information is packed as a [ribonucleoprotein](https://en.wikipedia.org/wiki/Ribonucleoprotein) complex in which RNA is tightly bound by the viral nucleoprotein. The [RNA genome](https://en.wikipedia.org/wiki/RNA_genome) of the virus encodes five genes whose order is highly conserved: nucleoprotein (N), phosphoprotein (P), matrix protein (M), glycoprotein (G), and the viral RNA polymerase (L).[[22]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid15885837-22)

Once within a muscle or nerve cell, the virus undergoes replication. The trimeric spikes on the exterior of the membrane of the virus interact with a specific cell receptor, the most likely one being the [acetylcholine](https://en.wikipedia.org/wiki/Acetylcholine) receptor. The cellular membrane pinches in a procession known as [pinocytosis](https://en.wikipedia.org/wiki/Pinocytosis) and allows entry of the virus into the cell by way of an [endosome](https://en.wikipedia.org/wiki/Endosome). The virus then uses the acidic environment, which is necessary, of that endosome and binds to its membrane simultaneously, releasing its five proteins and single strand RNA into the cytoplasm.[[23]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_PEP-23)

The L protein then transcribes five mRNA strands and a positive strand of RNA all from the original negative strand RNA using free nucleotides in the cytoplasm. These five mRNA strands are then translated into their corresponding proteins (P, L, N, G and M proteins) at free ribosomes in the cytoplasm. Some proteins require post-translative modifications. For example, the G protein travels through the rough [endoplasmic reticulum](https://en.wikipedia.org/wiki/Endoplasmic_reticulum), where it undergoes further folding, and is then transported to the [Golgi apparatus](https://en.wikipedia.org/wiki/Golgi_apparatus), where a sugar group is added to it ([glycosylation](https://en.wikipedia.org/wiki/Glycosylation)).[[23]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_PEP-23)

Where there are enough proteins, the viral polymerase will begin to synthesize new negative strands of RNA from the template of the positive strand RNA. These negative strands will then form complexes with the N, P, L and M proteins and then travel to the inner membrane of the cell, where a G protein has embedded itself in the membrane. The G protein then coils around the N-P-L-M complex of proteins taking some of the host cell membrane with it, which will form the new outer envelope of the virus particle. The virus then buds from the cell.[[23]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_PEP-23)

From the point of entry, the virus is [neurotropic](https://en.wikipedia.org/wiki/Neurotropic_virus), traveling along the neural pathways into the [central nervous system](https://en.wikipedia.org/wiki/Central_nervous_system). The virus usually first infects muscle cells close to the site of infection, where they are able to replicate without being 'noticed' by the host's immune system. Once enough virus has been replicated, they begin to bind to [acetylcholine receptors](https://en.wikipedia.org/wiki/Acetylcholine_receptor) (p75NR) at the neuromuscular junction.[[24]](https://en.wikipedia.org/wiki/Rabies#cite_note-24) The virus then travels through the nerve cell axon via retrograde transport, as its P protein interacts with [dynein](https://en.wikipedia.org/wiki/Dynein), a protein present in the cytoplasm of nerve cells. Once the virus reaches the cell body it travels rapidly to the central nervous system (CNS), replicating in motor neurons and eventually reaching the brain.[[5]](https://en.wikipedia.org/wiki/Rabies#cite_note-Robbins-5) After the brain is infected, the virus travels centrifugally to the peripheral and autonomic nervous systems, eventually migrating to the salivary glands, where it is ready to be transmitted to the next host.[[25]](https://en.wikipedia.org/wiki/Rabies#cite_note-Baer1991-25):317

**Transmission**

*Main article:* [*Rabies transmission*](https://en.wikipedia.org/wiki/Rabies_transmission)

All [warm-blooded](https://en.wikipedia.org/wiki/Warm-blooded) species, including humans, may become infected with the rabies virus and develop symptoms. [Birds](https://en.wikipedia.org/wiki/Bird) were first artificially infected with rabies in 1884; however, infected birds are largely, if not wholly, asymptomatic, and recover.[[26]](https://en.wikipedia.org/wiki/Rabies#cite_note-serological-26) Other bird species have been known to develop rabies [antibodies](https://en.wikipedia.org/wiki/Antibody), a sign of infection, after feeding on rabies-infected mammals.[[27]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid16498885-27)[[28]](https://en.wikipedia.org/wiki/Rabies#cite_note-Owls-28)

The virus has also adapted to grow in cells of [cold-blooded](https://en.wikipedia.org/wiki/Poikilotherm) vertebrates.[[29]](https://en.wikipedia.org/wiki/Rabies#cite_note-29)[[30]](https://en.wikipedia.org/wiki/Rabies#cite_note-30) Most animals can be infected by the virus and can transmit the disease to humans. Infected [bats](https://en.wikipedia.org/wiki/Bat),[[31]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid13858519-31)[[32]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid14431118-32) [monkeys](https://en.wikipedia.org/wiki/Monkey), [raccoons](https://en.wikipedia.org/wiki/Raccoon), [foxes](https://en.wikipedia.org/wiki/Fox), [skunks](https://en.wikipedia.org/wiki/Skunk), [cattle](https://en.wikipedia.org/wiki/Cattle), [wolves](https://en.wikipedia.org/wiki/Wolf), [coyotes](https://en.wikipedia.org/wiki/Coyotes), [dogs](https://en.wikipedia.org/wiki/Dog), [mongooses](https://en.wikipedia.org/wiki/Mongoose) (normally either the small Asian mongoose or the yellow mongoose)[[33]](https://en.wikipedia.org/wiki/Rabies#cite_note-33) and [cats](https://en.wikipedia.org/wiki/Cat) present the greatest risk to humans.

Rabies may also spread through exposure to infected [bears](https://en.wikipedia.org/wiki/Bears), [domestic farm animals](https://en.wikipedia.org/wiki/Livestock), [groundhogs](https://en.wikipedia.org/wiki/Groundhog), [weasels](https://en.wikipedia.org/wiki/Weasel), and other [wild carnivorans](https://en.wikipedia.org/wiki/Carnivora). However, [lagomorphs](https://en.wikipedia.org/wiki/Lagomorphs), such as [hares](https://en.wikipedia.org/wiki/Hare) and [rabbits](https://en.wikipedia.org/wiki/Rabbit), and small [rodents](https://en.wikipedia.org/wiki/Rodent) such as [chipmunks](https://en.wikipedia.org/wiki/Chipmunk), [gerbils](https://en.wikipedia.org/wiki/Gerbil), [guinea pigs](https://en.wikipedia.org/wiki/Guinea_pig), [hamsters](https://en.wikipedia.org/wiki/Hamster), [mice](https://en.wikipedia.org/wiki/Mice), [rats](https://en.wikipedia.org/wiki/Rat), and [squirrels](https://en.wikipedia.org/wiki/Squirrel), are almost never found to be infected with rabies and are not known to transmit rabies to humans.[[34]](https://en.wikipedia.org/wiki/Rabies#cite_note-34) Bites from mice, rats, or squirrels rarely require rabies prevention because these rodents are typically killed by any encounter with a larger, rabid animal, and would, therefore, not be carriers.[[35]](https://en.wikipedia.org/wiki/Rabies#cite_note-35) The [Virginia opossum](https://en.wikipedia.org/wiki/Virginia_opossum) is resistant but not immune to rabies.[[36]](https://en.wikipedia.org/wiki/Rabies#cite_note-36)

The virus is usually present in the nerves and [saliva](https://en.wikipedia.org/wiki/Saliva) of a symptomatic rabid animal.[[37]](https://en.wikipedia.org/wiki/Rabies#cite_note-37)[[38]](https://en.wikipedia.org/wiki/Rabies#cite_note-38) The route of [infection](https://en.wikipedia.org/wiki/Infection) is usually, but not always, by a bite. In many cases, the infected animal is exceptionally aggressive, may attack without provocation, and exhibits otherwise uncharacteristic behavior.[[39]](https://en.wikipedia.org/wiki/Rabies#cite_note-39) This is an example of a viral pathogen [modifying the behavior of its host](https://en.wikipedia.org/wiki/Behavior-altering_parasites_and_parasitoids) to facilitate its transmission to other hosts.

Transmission between humans is extremely rare. A few cases have been recorded through [transplant surgery](https://en.wikipedia.org/wiki/Organ_transplant).[[40]](https://en.wikipedia.org/wiki/Rabies#cite_note-40) The only well-documented cases of rabies caused by human-to-human transmission occurred among eight recipients of transplanted corneas and among three recipients of solid organs.[[41]](https://en.wikipedia.org/wiki/Rabies#cite_note-41) In addition to transmission from cornea and organ transplants, bite and non-bite exposures inflicted by infected humans could theoretically transmit rabies, but no such cases have been documented, since infected humans are usually hospitalized and necessary precautions taken. Casual contact, such as touching a person with rabies or contact with non-infectious fluid or tissue (urine, blood, feces) does not constitute an exposure and does not require post-exposure prophylaxis. Additionally, as the virus is present in sperm or vaginal secretions, spread through sex may be possible.[[42]](https://en.wikipedia.org/wiki/Rabies#cite_note-42)

After a typical human infection by bite, the virus enters the [peripheral nervous system](https://en.wikipedia.org/wiki/Peripheral_nervous_system). It then travels along the [afferent nerves](https://en.wikipedia.org/wiki/Afferent_nerve_fiber) toward the [central nervous system](https://en.wikipedia.org/wiki/Central_nervous_system).[[43]](https://en.wikipedia.org/wiki/Rabies#cite_note-43) During this phase, the virus cannot be easily detected within the host, and vaccination may still confer cell-mediated immunity to prevent symptomatic rabies. When the virus reaches the [brain](https://en.wikipedia.org/wiki/Brain), it rapidly causes [encephalitis](https://en.wikipedia.org/wiki/Encephalitis), the prodromal phase, which is the beginning of the symptoms. Once the patient becomes symptomatic, treatment is almost never effective and mortality is over 99%. Rabies may also inflame the [spinal cord](https://en.wikipedia.org/wiki/Spinal_cord), producing [transverse myelitis](https://en.wikipedia.org/wiki/Transverse_myelitis).[[44]](https://en.wikipedia.org/wiki/Rabies#cite_note-LynnNewton2012-44)[[45]](https://en.wikipedia.org/wiki/Rabies#cite_note-45)

Diagnosis

Rabies can be difficult to diagnose, because, in the early stages, it is easily confused with other diseases or with aggressiveness.[[46]](https://en.wikipedia.org/wiki/Rabies#cite_note-Merck-46) The [reference method](https://en.wikipedia.org/wiki/Gold_standard_%28test%29) for diagnosing rabies is the fluorescent antibody test (FAT), an [immunohistochemistry](https://en.wikipedia.org/wiki/Immunohistochemistry) procedure, which is recommended by the [World Health Organization](https://en.wikipedia.org/wiki/World_Health_Organization) (WHO).[[47]](https://en.wikipedia.org/wiki/Rabies#cite_note-47) The FAT relies on the ability of a detector molecule (usually fluorescein isothiocyanate) coupled with a rabies-specific antibody, forming a conjugate, to bind to and allow the visualisation of rabies antigen using fluorescent microscopy techniques. Microscopic analysis of samples is the only direct method that allows for the identification of rabies virus-specific antigen in a short time and at a reduced cost, irrespective of geographical origin and status of the host. It has to be regarded as the first step in diagnostic procedures for all laboratories. Autolysed samples can, however, reduce the sensitivity and specificity of the FAT.[[48]](https://en.wikipedia.org/wiki/Rabies#cite_note-Fooks_AR_2009-48) The [RT PCR](https://en.wikipedia.org/wiki/Reverse_transcription_polymerase_chain_reaction) assays proved to be a sensitive and specific tool for routine diagnostic purposes,[[49]](https://en.wikipedia.org/wiki/Rabies#cite_note-49) particularly in decomposed samples[[50]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid12034539-50) or archival specimens.[[51]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid17881871-51) The diagnosis can be reliably made from brain samples taken after death. The diagnosis can also be made from saliva, urine, and cerebrospinal fluid samples, but this is not as [sensitive](https://en.wikipedia.org/wiki/Sensitivity_and_specificity) and reliable as brain samples.[[48]](https://en.wikipedia.org/wiki/Rabies#cite_note-Fooks_AR_2009-48) Cerebral inclusion bodies called [Negri bodies](https://en.wikipedia.org/wiki/Negri_bodies) are 100% diagnostic for rabies infection but are found in only about 80% of cases.[[21]](https://en.wikipedia.org/wiki/Rabies#cite_note-Sherris-21) If possible, the animal from which the bite was received should also be examined for rabies.[[52]](https://en.wikipedia.org/wiki/Rabies#cite_note-Ly2009-52)

Some [light microscopy](https://en.wikipedia.org/wiki/Light_microscopy#Optical_microscopy) techniques may also be used to diagnose rabies at a tenth of the cost of traditional fluorescence microscopy techniques, allowing identification of the disease in less-developed countries.[[53]](https://en.wikipedia.org/wiki/Rabies#cite_note-53) A test for rabies, known as LN34, is easier to run on a dead animal's brain and might help determine who does and does not need post-exposure prevention.[[54]](https://en.wikipedia.org/wiki/Rabies%22%20%5Cl%20%22cite_note-CDC2018New-54) The test was developed by the CDC in 2018.[[54]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC2018New-54)

**Differential diagnosis**

The [differential diagnosis](https://en.wikipedia.org/wiki/Differential_diagnosis) in a case of suspected human rabies may initially include any cause of [encephalitis](https://en.wikipedia.org/wiki/Encephalitis), in particular infection with viruses such as [herpesviruses](https://en.wikipedia.org/wiki/Herpesviridae), [enteroviruses](https://en.wikipedia.org/wiki/Enteroviruses), and [arboviruses](https://en.wikipedia.org/wiki/Arboviruses) such as [West Nile virus](https://en.wikipedia.org/wiki/West_Nile_virus). The most important viruses to rule out are [herpes simplex virus](https://en.wikipedia.org/wiki/Herpes_simplex_virus) type one, [varicella zoster virus](https://en.wikipedia.org/wiki/Varicella_zoster_virus), and (less commonly) enteroviruses, including [coxsackieviruses](https://en.wikipedia.org/wiki/Coxsackie_virus), [echoviruses](https://en.wikipedia.org/wiki/Echovirus), [polioviruses](https://en.wikipedia.org/wiki/Poliovirus), and human [enteroviruses](https://en.wikipedia.org/wiki/Enterovirus) 68 to 71.[[55]](https://en.wikipedia.org/wiki/Rabies#cite_note-55)

New causes of viral encephalitis are also possible, as was evidenced by the 1999 outbreak in Malaysia of 300 cases of encephalitis with a mortality rate of 40% caused by [Nipah virus](https://en.wikipedia.org/wiki/Nipah_virus), a newly recognized [paramyxovirus](https://en.wikipedia.org/wiki/Paramyxovirus).[[56]](https://en.wikipedia.org/wiki/Rabies#cite_note-refDiseasesOfSwine-56) Likewise, well-known viruses may be introduced into new locales, as is illustrated by the outbreak of encephalitis due to West Nile virus in the eastern United States.[[57]](https://en.wikipedia.org/wiki/Rabies#cite_note-57) Epidemiologic factors, such as season, geographic location, and the patient's age, travel history, and possible exposure to bites, rodents, and ticks, may help direct the diagnosis.

Prevention

Almost all human cases of rabies were fatal until a vaccine was developed in 1885 by [Louis Pasteur](https://en.wikipedia.org/wiki/Louis_Pasteur) and [Émile Roux](https://en.wikipedia.org/wiki/%C3%89mile_Roux). Their original vaccine was harvested from infected rabbits, from which the virus in the nerve tissue was weakened by allowing it to dry for five to ten days.[[58]](https://en.wikipedia.org/wiki/Rabies#cite_note-58) Similar nerve tissue-derived vaccines are still used in some countries, as they are much cheaper than modern cell culture vaccines.[[59]](https://en.wikipedia.org/wiki/Rabies#cite_note-pmid15069272-59)

The human diploid cell rabies vaccine was started in 1967. Less expensive purified chicken embryo cell vaccine and purified [vero cell](https://en.wikipedia.org/wiki/Vero_cell) rabies vaccine are now available.[[52]](https://en.wikipedia.org/wiki/Rabies#cite_note-Ly2009-52) A [recombinant vaccine](https://en.wikipedia.org/wiki/Recombinant_vaccine) called V-RG has been used in Belgium, France, Germany, and the United States to prevent outbreaks of rabies in undomesticated animals.[[60]](https://en.wikipedia.org/wiki/Rabies#cite_note-Reece_2006-60) Immunization before exposure has been used in both human and nonhuman populations, where, as in many jurisdictions, domesticated animals are required to be vaccinated.[[61]](https://en.wikipedia.org/wiki/Rabies#cite_note-61)

The Missouri Department of Health and Senior Services Communicable Disease Surveillance 2007 Annual Report states the following can help reduce the risk of contracting rabies:[[62]](https://en.wikipedia.org/wiki/Rabies%22%20%5Cl%20%22cite_note-62)

* Vaccinating dogs, cats, and ferrets against rabies
* Keeping pets under supervision
* Not handling wild animals or strays
* Contacting an animal control officer upon observing a wild animal or a stray, especially if the animal is acting strangely
* If bitten by an animal, washing the wound with soap and water for 10 to 15 minutes and contacting a healthcare provider to determine if post-exposure prophylaxis is required

September 28 is [World Rabies Day](https://en.wikipedia.org/wiki/World_Rabies_Day), which promotes the information, prevention, and elimination of the disease.[[63]](https://en.wikipedia.org/wiki/Rabies#cite_note-63)

**Vaccinating other animals**

In Asia and in parts of the Americas and Africa, dogs remain the principal host. Mandatory vaccination of animals is less effective in rural areas. Especially in developing countries, pets may not be privately kept and their destruction may be unacceptable. Oral vaccines can be safely distributed in baits, a practice that has successfully reduced rabies in rural areas of [Canada](https://en.wikipedia.org/wiki/Canada), [France](https://en.wikipedia.org/wiki/France), and the [United States](https://en.wikipedia.org/wiki/United_States). In [Montreal](https://en.wikipedia.org/wiki/Montreal), Quebec, Canada, baits are successfully used on raccoons in the Mount-Royal Park area. Vaccination campaigns may be expensive, and cost-benefit analysis suggests baits may be a cost-effective method of control.[[64]](https://en.wikipedia.org/wiki/Rabies#cite_note-64) In [Ontario](https://en.wikipedia.org/wiki/Ontario), a dramatic drop in rabies was recorded when an aerial bait-vaccination campaign was launched.[[65]](https://en.wikipedia.org/wiki/Rabies#cite_note-Grambo-65)

The number of recorded human deaths from rabies in the United States has dropped from 100 or more annually in the early 20th century to one or two per year due to widespread vaccination of domestic dogs and cats and the development of human vaccines and immunoglobulin treatments. Most deaths now result from bat bites, which may go unnoticed by the victim and hence untreated.[[66]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_Epi-66)

**Treatment**

[Treatment after exposure](https://en.wikipedia.org/wiki/Postexposure_prophylaxis) can prevent the disease if administered promptly, generally within 10 days of infection.[[21]](https://en.wikipedia.org/wiki/Rabies#cite_note-Sherris-21) Thoroughly washing the wound as soon as possible with soap and water for approximately five minutes is effective in reducing the number of viral particles.[[67]](https://en.wikipedia.org/wiki/Rabies#cite_note-67) [Povidone-iodine](https://en.wikipedia.org/wiki/Povidone-iodine) or alcohol is then recommended to reduce the virus further.[[68]](https://en.wikipedia.org/wiki/Rabies#cite_note-68)

In the US, the [Centers for Disease Control and Prevention](https://en.wikipedia.org/wiki/Centers_for_Disease_Control_and_Prevention) recommends people receive one dose of human rabies [immunoglobulin](https://en.wikipedia.org/wiki/Immunoglobulin) (HRIG) and four doses of rabies vaccine over a 14-day period.[[69]](https://en.wikipedia.org/wiki/Rabies#cite_note-69) The immunoglobulin dose should not exceed 20 units per kilogram body weight. HRIG is expensive and constitutes most of the cost of post exposure treatment, ranging as high as several thousand dollars.[[70]](https://en.wikipedia.org/wiki/Rabies#cite_note-70) As much as possible of this dose should be injected around the bites, with the remainder being given by deep intramuscular injection at a site distant from the vaccination site.[[23]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_PEP-23)

The first dose of rabies vaccine is given as soon as possible after exposure, with additional doses on days 3, 7 and 14 after the first. Patients who have previously received pre-exposure vaccination do not receive the immunoglobulin, only the postexposure vaccinations on days 0 and 3.[[71]](https://en.wikipedia.org/wiki/Rabies#cite_note-71)

The pain and side effects of modern [cell-based vaccines](https://en.wikipedia.org/wiki/Cell-based_vaccine) are similar to flu shots. The old nerve-tissue-based vaccinations that require multiple painful injections into the abdomen with a large needle are inexpensive, but are being phased out and replaced by affordable World Health Organization intradermal-vaccination regimens.[[52]](https://en.wikipedia.org/wiki/Rabies#cite_note-Ly2009-52)

Intramuscular vaccination should be given into the [deltoid](https://en.wikipedia.org/wiki/Deltoid_muscle), not the [gluteal area](https://en.wikipedia.org/wiki/Gluteal_muscles), which has been associated with vaccination failure due to injection into fat rather than muscle. In infants, the lateral thigh is recommended.[[72]](https://en.wikipedia.org/wiki/Rabies#cite_note-72)

Awakening to find a bat in the room, or finding a bat in the room of a previously unattended child or mentally disabled or intoxicated person, is an indication for [post-exposure prophylaxis](https://en.wikipedia.org/wiki/Post-exposure_prophylaxis) (PEP). The recommendation for the precautionary use of PEP in bat encounters where no contact is recognized has been questioned in the medical literature, based on a [cost–benefit analysis](https://en.wikipedia.org/wiki/Cost%E2%80%93benefit_analysis).[[73]](https://en.wikipedia.org/wiki/Rabies#cite_note-73) However, a 2002 study has supported the protocol of precautionary administering of PEP where a child or mentally compromised individual has been alone with a bat, especially in sleep areas, where a bite or exposure may occur without the victim being aware.[[74]](https://en.wikipedia.org/wiki/Rabies#cite_note-74) Begun with little or no delay, PEP is 100% effective against rabies.[[75]](https://en.wikipedia.org/wiki/Rabies#cite_note-Lite2009-75) In the case in which there has been a significant delay in administering PEP, the treatment should be administered regardless, as it may still be effective.[[23]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_PEP-23) Every year, more than 15 million people get vaccination after potential exposure. While this works well, the cost is significant.[[76]](https://en.wikipedia.org/wiki/Rabies#cite_note-76)

**Prognosis**

In unvaccinated humans, rabies is almost always fatal after [neurological](https://en.wikipedia.org/wiki/Neurological) symptoms have developed.[[81]](https://en.wikipedia.org/wiki/Rabies#cite_note-WHO_factsheet-81)

[Vaccination](https://en.wikipedia.org/wiki/Vaccination) after exposure, PEP, is highly successful in preventing the disease if administered promptly, in general within 6 days of infection. Begun with little or no delay, PEP is 100% effective against rabies.[[75]](https://en.wikipedia.org/wiki/Rabies#cite_note-Lite2009-75) In the case of significant delay in administering PEP, the treatment still has a chance of success.[[23]](https://en.wikipedia.org/wiki/Rabies#cite_note-CDC_Rabies_PEP-23)