# *The Brain eating amoeba Naegleria fowleri and Primary Amoebic Meningoencephalitis in a warming world: An overlooked Consequence of Climate Change*

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## Abstract

The choice of "fresh" water bodies for a cooling swim on a hot summer afternoon result in a life-threatening infection caused by a brain eating amoeba known as Naegleria fowleri. Reports of infections caused by this amoeba have recently surfaced reports from both in the United States of America, Australia and India. Naegleria fowleri is a eukaryotic free-living amoeba, which belongs to the Percolozoa phylum. This amoeba has 3 stages in its life cycle namely: a cystic from, a trophozoite form and a flagellate form. The trophozoite being the infectious stage. N. fowleri is typically found throughout our environment from bodies of fresh water to soil. The Ameoba is neurotropic and tracks along the nasal mucosa and via the olfactory nerve through the cribriform plate (which is not completely fused in the younger populous) to ultimately infect the olfactory bulbs and the brain, thus causing (primary amoebic meningoencephalitis) abbreviated as PAM. The treatment of PAM is both supportive and specific. A simple and trivial but proven method to prevent the infection is simply keeping one's head above water when in such open bodies of fresh water. The adequate chlorination of public recreational swimming pools and bodies of water is empirical to aid in the control of the infection. Naegleria fowleri is a rare but deadly infection and the lack of an effective treatment and the associated high mortality rate can only thus be countered by increasing the publics knowledge and awareness surrounding the disease. Countries such as India are making remarkable breakthroughs with lower mortality rates, due to vigorous and intense surveillance, testing and aggressive treatment strategies. India's success in controlling the outbreak should be used as the yardstick for other countries to follow on an international basis when trying to control this infectious Amoeba.

## Introduction

One may need to think twice before diving into so called "fresh" water bodies for a cooling swim on those hot summer afternoons. It could result in a life-threatening infection caused by a brain eating amoeba known as Naegleria fowleri. Naegleri fowleri is both a rare and deadly pathogen, which has recently surfaced with infections being reported both in the United States of America, Australia and India.[1]

## Current cases:

So far 3 cases have been reported in the United States of America in 2025, namely being located in Texas, South Carolina and Missouri. In Texas a female both contracted and succumbed to the infection after she irrigated her nose with tap water. In South Carolina a child was infected via exposure to the amoeba in Lake Murray and the third case is reportedly from Missouri. Although only 3 cases reported this year may not seem like very many, it must be noted that there have only been around 160 documented cases between 1962 to 2025 in the United States of America, furthermore only 4 of these cases have survived. Globally only around 500 cases of human meningoencephalitis caused by Naegleria fowleri have been recorded since the Amoeba's discovery.[2]

India has seen a large rapid rise in cases this year, with 69 confirmed cases currently and 19 deaths, located in the state of Kerala alone, the Southern locality of the state and its dependence on both natural waterbodies and ground water make it particularly vulnerable. Surprisingly although the numbers of infections have kept rising since the detection of Naegleria in Kerala in 2016, the number of deaths has proportionally decreased, this being attributed to aggressive testing, surveillance treatment strategies.[3] Nepal a country

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which boarders India has far fewer cases than the state of Kerala. Nepal has only ever reported a single case of Naegleria fowleri PAM in an elderly immunocompetent man in 2010. Unfortunately, despite treatment the patient did demise. The lack of cases in Nepal may be attributed to the colder and harsher altitudes of the Nepali region.[4]

## Microbiology:

Naegleria fowleri is a eukaryotic free-living amoeba, which belongs to the Percolozoa phylum. This amoeba has 3 stages in its life cycle namely: a cystic from, a trophozoite form and a flagellate form. The trophozoite being the infectious stage. N. fowleri is typically found throughout our environment from bodies of fresh water to soil. Naegleria most commonly don't affect human beings and feed on bacteria within our environment, but when humans are infected the results are most commonly fatal.[5]

## Pathophysiology:

Infections with N. fowleri are rare, but life threatening. The Amoeba usually affects children or young adults due to their unique anatomy as well as the amoeba's unique method of infecting the human body. The Trophozoite form is infectious to humans. The infection is often contracted in the young when swimming or playing or during watersports in fresh bodies of water. The trophozoites enter the nasal cavity when water is flushed or squirted into the nostrils whilst doing these leisure activities. The Ameoba is neurotropic and tracks along the nasal mucosa and via the olfactory nerve through the cribriform plate (which is not completely fused in the younger populous) to ultimately infect the olfactory bulbs and the brain. Once in the neural tissue it causes purulent meningoencephalitis, known as primary amoebic meningoencephalitis (PAM). It must be noted that the infection is not transmissible from human to human.[6]

## Signs and symptoms:

The initial symptoms begin within the first 7 days of the infection, it is characterized by symptoms of a typical meningoencephalitis with pyrexia, nausea and vomiting as well as nuchal stiffness and photophobia. After the initial nonspecific phase, the pyogenic phase begins where pus if formed and ultimately the patient further decompensates, the Glasgow Coma scale (GCS) drops and the infected individual will have intracranial hemorrhages and a coma followed by death will ensue.[7]

## Treatment:

The treatment of PAM is both supportive and specific, there is however no specific and consistently effective drug regimen for the treatment of PAM. Drugs such as Rifampicin, azithromycin, fluconazole, posaconazole, miltefosine and Amphotericin B (which is the most commonly used drug) are employed when trying to combat the infection. Supportive management is the crucial with induced hypothermia, reducing the intracranial pressure (mannitol) and seizure control as well as mechanical ventilation.[8]

## Prevention and control:

A simple and trivial but proven method to prevent the infection is simply keeping one's head above water when in such open bodies of fresh water, the goal is to prevent the water from entering the nasal cavity, so using a nose clip when being involved in such recreational activities has been shown to reduce the rates of infections, furthermore tap water should be sterilized or boiled before using it to flush out ones sinuses or nasal sprays. Legislation for the adequate chlorination of public recreational swimming pools and bodies it to be bolstered to reduce the load of the amoeba within the water body. Global education and awareness programs are a crucial part of prevention of this infection.[9]

## Expert opinion:

Naegleria fowleri is a rare but deadly infection and the lack of an effective treatment and the associated high mortality rate can only thus be countered by increasing the public's knowledge and awareness surrounding the disease. Simple measures when being involved in water sports can drastically reduce the likelihood of the contraction thereof. Thus campaigns and public notices should be bolstered at both a local and national level. Countries such as India are making remarkable breakthroughs with lower mortality rates, due to vigorous and intense surveillance, testing and aggressive treatment strategies. The proof that such strategies are effective is visibly showcased and evident by the success that India is seeing in controlling the outbreak and should be used as the yardstick for other countries to follow on an international basis when trying to control this infectious Amoeba.

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