World Journal of Pharmaceutical Science and Research
www.wjpsronline.com
Review Article
ISSN: 2583-6579
SJIF Impact Factor: 6.916
Year - 2026
Volume: 5; Issue: 4
Page: 182-191

AMOEBIC MENINGOENCEPHALITIS: A REVIEW

Rafa Maaroof T. P., Safa K. V., Riza Nafeesa, Raniya Sherin P., Vismaya Babu K. K.*

Dept. of Pharmacology, College of Pharmacy, Kannur Medical College, Anjarakandy.

Article Received: 7 February 2026 | | ***Article Revised: 28 February 2026*** | | ***Article Accepted: 20 March 2026***

Corresponding Author: Vismaya Babu K. K.
Associate Professor, Dept. of Pharmacology, College of Pharmacy, Kannur Medical College, Anjarakandy.
DOI: https://doi.org/10.5281/zenodo.19333093

How to cite this Article: Rafa Maaroof T. P., Safa K. V., Riza Nafeesa, Raniya Sherin P., Vismaya Babu K. K. (2026) AMOEBIC MENINGOENCEPHALITIS: A REVIEW. World Journal of Pharmaceutical Science and Research, 5(4), 182-191.

ABSTRACT

Amoebic meiningoencephalitis is a fatal infection affecting the brain by protozoa Naegleria fowleri, Acanthamoeba species and Balamuthiamandrillaris. Both the symptoms of meningitis and encephalitis occur within few days of exposure and progress into a life threatening condition. Fatality has reported within two weeks of showing the signs and symptoms. The early diagnosis of the disease is a challenge and with early medical intervention only this disease can be constrained. Multiple antimicrobial combination has proved to cure the disease when it is identified on an early stage. This review focuses on the pathophysiology, diagnosis and treatment algorithm of amoebic meningoencephalitis focuses on recent cases reported in Kerala.

KEYWORDS: Amoebic meningoencephalitis, Naegleria fowleri, Early diagnosis, Antimicrobial therapy.

INTRODUCTION

Amoebic meningoencephalitis is a rare but fatal infection caused by Naegleria fowleri, commonly known as " brain eating amoeba". 1-12 days after exposure to the free living amoeba, the initial signs of the infection appears as sudden high fever, nausea, vomiting, severe headache which results in stiff neck, seizures and ultimately leads to coma.

Naegleria fowleri is a thermophilic organism that commonly blooms in unchlorinated or poorly maintained waterbodies such as in swimming pools, hot springs, freshwater lakes, rivers, soil, pond, water heaters, pipe connected to tap water. Infection occurs when water contaminated with Naegleria fowleri enters the nose, travels through cribriform plate and reaches the brain leading to infection in meningitis. Malcolm fowler and Rodney Carter reported first case of amoebic meningoencephalitis in 1965 at Adelaide children's hospital, Australia. In India, the first confirmed case was reported in 1971 and another documented case was in 1986 in Chennai. Alappuzha district of kerala, reported its first confirmed fatality in march, 2016.

ETIOLOGY

Naegleria fowleri generally populates at a temperature above 30° C and can survive upto 45°C. The habitat of the amoeba include soil, fresh water lakes, fountains, untreated drinking water, thermal water and water parks. Except for Antartica, the N.fowleri has been confirmed in almost all continents making it a widely distributed parasite. The infection generally affects immune competent children and young adults who especially engage themselves in water related activities like swimming or diving in fresh or untreated water bodies. The male to female ratio of infection is 2:1and commonly observed in first 3 decade of life.

PATHOPHYSIOLOGY

Depending upon its surrounding environment, the free living amoeba exists in three different forms; inactive cyst , transitory flagellate and trophozoites. The active trophozoite form of the amoeba which can feed and reproduce are responsible for causing the amoebic meningoencephalitis infection in other organisms.

The infection causing trophozoites enters the nasal cavity of the host organism through the water contaminated with N.fowleri. It secrete various enzyme like protease and degrade mucousal barrier. After its introduction into the host, it directly attaches itself to the nasal mucosa from where it migrates along the olfactory nerves through the cribriform plate. This migration of the trophozoites continues until it reaches the olfactory bulb. From there they enters the brain via the olfactory nerve bundles, where they undergo rapid multiplication leading to extensive cerebral damage and tissue inflammation, haemorrhage.

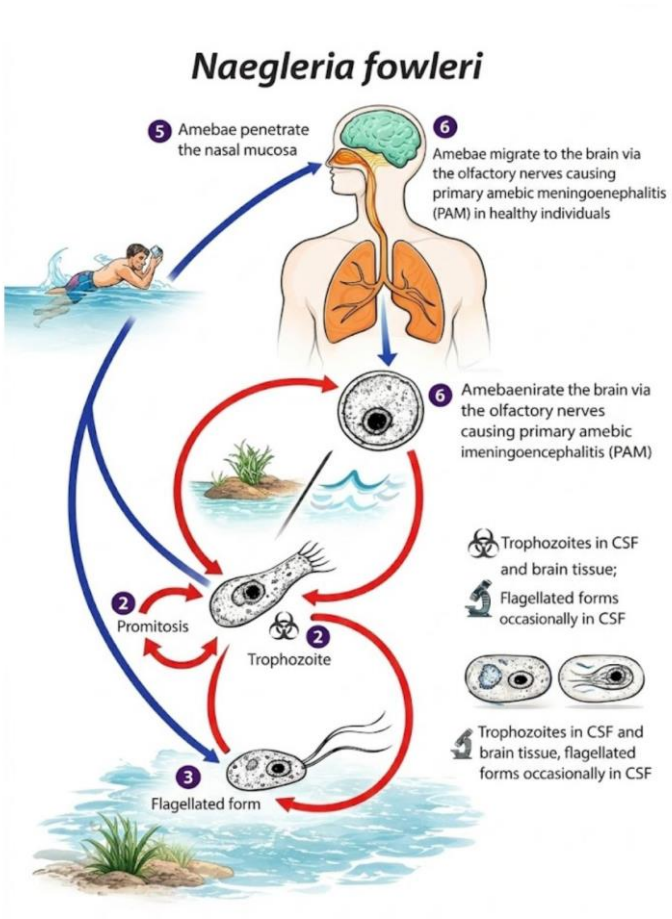

Figure 1: Pathophysiology of amoebic meningoencephalitis caused by Naeglaria fowleri.

CLINICALFEATURES

Amoebic meningoencephalitis is an infectious disease affecting the brain.

It can be of two types depending upon the causative agent;

- Granulomatous amoebic encephalitis(GAE)
- Primary amoebic meningoenephalitis (PAM)

Granulomatous amoebic encephalitis(GAE)

GAE is a chronic disease caused by Acanthamoeba species and Balamuthiamandrillaris.

This disease has a slow onset and primarily affects a person who has weak immune system such as in a person affected with :

- Human immunodeficiency virus (HIV)
- Cancer treatment
- Genetic disorder

GAE is transmitted through skin lesions or inhalation of the cysts of the Acanthamoeba species and Balamuthiamandrillaris.

Symptoms of GAE includes;

- Focal Seizure
- Hemiparesis
- Memory loss
- Sensory disturbances
- Aphasia

Primary amoebic meningoencephalitis (PAM)

The causative agent of PAM is Naegleria fowleri and an infection caused by this amoeba usually possess severe sufferings, disability or may even lead to death. PAM is an infection that has a high mortality rate.

Transmission

The amoeba generally enters through the nasal mucosa when contaminated water is inhaled or such water is used for nasal irrigation or sinus rinsing.

Incubation period

The incubation period of PAM is normally 5 days while the symptoms begins to show up 1-15 days after exposure to the contaminated water.

The disease progresses rapidly after the symptoms are developed and within 1-2 weeks of symptom onset, death occurs. The probability of infection is projected at 1 case per 2.6 million exposures to N.fowleri.

SYMPTOMS

Initial symptoms

- Severe headache
- Fever

- Nausea and vomiting
- Photophobia
- Stiff neck

Advanced symptoms

- Altered mental confusion
- Cranial nerve palsies
- Quadriparesis
- Tremors
- Papilledema
- Coma
- Seizure
- Anorexia

CASES OF AMOEBIC MENINGOENCEPHALITIS IN KERALA

The incidence of PAM in Kerala is highly related to its geographic conditions the state has 44 rivers and several other waterbodies that could be a habitat for N.fowleri. The growth of the amoeba in the waters are also related to the recent climatic changes which includes rise in temperature, drought and excessive rainfall which resulted in the frequent flooding that causes the migration of the amoeba from one water body to the other. The use of bore wells and low maintained water has been another reason for the PAM infection. The primary source of exposure to the amoeba is bathing or swimming in the local and low maintained ponds and lakes.

Religious rituals as well as occupation of the people of kerala has also contributed to the incidence of PAM in Kerala. In the last few decades, infrequent cases of PAM has been reported in various part of kerala. However, there has been a spike in PAM cases in Kerala in the last few decades. In 2023, there were 2 cases reported with 2 deaths. In 2024, the number of reported cases raised to 39 along with 9 confirmed deaths. Late 2025 has seen the most severe outbreak of PAM in Kerala with 170+ confirmed cases and 42 death. Trivandrum district has reported the most cases all these years.

Table 1: Number of cases and mortality of amoebic meningoencephalitis cases in different districts of kerala.

year	Number of case	Number of death	District
2016	1	1	Alappuzha
2019	1	1	Malappuram
2020	2	2	Malappuram
2022	1	1	Thrisur
2023	2	2	Kasaragode, Alappuzha
2024	39	9	Malappuram, Thrisur, Kannur, Kozhikkode. Palakkad Trivandrum
2025	170+	42	Trivandrum,Kozhikode, Malappuram,Kollam, Palakkad

DIAGNOSIS

Clinical suspicion of PAM is by;

- sudden and severe headache

- fever
- altered mental status
- history of swimming in warm freshwater
- rapid progression of symptom
- presence of focal neurological deficits
- rapid deterioration

The diagnosis of PAM is difficult due to non specific symptom and exceptional diseases

➢ **Lumbar puncture**

This technique is carried out to obtain the cerebro spinal fluid (CSF) that is required for the analysis of PAM.

In conditions like the amoebic meningoencephalitis the CSF analysis shows an elevated WBC count (>1000 cells / µl), neutrophilic predominance (PMN >50-80%), Higher protein level, Low glucose and the presence of the amoeba.

➢ **Microscopic examination (wet mount preparation)**

The direct assessment of the CSF under the microscope helps to detect the living and motile trophozoites. The Wright stain is used for this examination. Normally, 50-70% of the motile trophozoites can be identified in the case of PAM by this method. This method does not always give accurate results due to the low concentration of the amoeba.

➢ **Polymerase chain reation (PCR)**

The PCR is used to detect the Naegleria fowleri DNA present in the CSF. It can be considered as the confirmatory test for amoebic meningoencephalitis as it presents more accurate and rapid diagnosis.

➢ **Imaging studies**

This technique does not indicate the presence of the amoeba but are used to rule out other causes of the symptoms as well as to evaluate brain swelling. Imaging studies can be conducted by making use of CT or MRI scannings.

➢ **Immunofluorecence or immunohistochemistry**

This method is used to detect the antigen of the naegleria fowleri present in the CSF. This technique is used only when other methods give unreliable results.

➢ **Definitive diagnosis**

The isolation of N.fowleri from the CSF or the brain tissues in non-nutrient agar medium with E.coli can be used for diagnosis of PAM.

➢ **ELISA**

ELISA is carried out detect the antibodies against N.fowleri in the CSF.

LABORATORIES UNDERTAKING PAM TESTING IN KERALA

- Water quality testing lab

The kerala water authority (kwa) has set up about 82 water testing labs across kerala which is crucial for testing the quality of water.

- State Public Health Laboratory (SPHL), Trivandrum
- Government Medical College Microbiology Department Thiruvananthapuram and Kozhikode

- Environment Surveillance Centres

The Kerala State Pollution Control Board And The Department Of Environmental Science of the University Of Kerala are also incharge of testing of water resources.

TREATMENT

Currently the treatment options available for PAM caused by N.fowleri remains uncertain as no studies evaluating the efficacy of the drugs have been performed. The infrequent prevalence and the sudden and severe onset of the disease along with the delay in diagnosis of the condition have greatly affected the evaluation of the drug regimens. Present day diagnostic and therapeutic facilities are based on in vitro studies as well as case reports. Combination of drugs are preferred for therapy as monodrug therapy are ineffective. The combination of drugs recommended are 5 or 6 antibiotic or antifungal agents having invitro activity against the N.fowleri. No significant increase in the survival rate have been shown even after the administration of combination drugs.

Current treatment regimen consists of Amphotericin B and Miltefosine along with other complimentary treatments to improve the survival rates.Other medications which can be included in the combination therapy are; Azithromycin, Rifampin, Azole agents like fluconazole, voriconazole or posaconazole.

AMPHOTERICIN B

1.5 mg/kg/day can be given intravenously or intrathecally as the first line drug for PAM. Administration of amphotericin B should be intiated as soon as the diagnosis has been made. Amphotericin B which is a polyene binds irreversibly to ergosterol that causes disruption of the cell membrane ultimately leading to the cell death.

MILTEFOSINE

It is considered as the “Gold Standard” anti parasitic agent in the case of amoebic meningoencephalitis caused by N. fowleri. Miltefosine is primarily used as the first line drug for Leishmaniasis. An IV or oral dose of miltefosine is administerd in combination with amphotericin B. It act by inhibiting the growth of N.fowleri by disrupting the lipid meatabolism and thereby affecting the membrane fluidity.

Dose: For patients with body weight less than 45 kg – 50 mg orally BD
For patients greater than or equal to 45kg – 50mg orally TD

RIFAMPIN (Rifampicin)

10 mg /kg/day IV or oral in three divided doses or every 24 hours.

FLUCONAZOLE

10 mg /kg/day IV or orally

AZITHROMYCIN

500 mg IV or orally.

The duration of the therapy ranges from 9-30 days as the exact duration of the treatment is uncertain. An early diagnosis followed by immediate therapy with amphotericin b has resulted in approximately 11 survival cases of PAM. The synergistic activity of amphotericin b and azole (fluconzaole) , rifampin and rifampicin are the most frequently

used dosage regimen. Intrathecal administration of amphotericin b is considered most appropriate as the ability of the drug to cross the blood brain barrier is limited after iv administration. Amphotericin B administered intrathecally effectively reaches the sub arachnoid space and ultimately exerts its amoebicidal acitivity.

SUPPORTIVECARE

Along with the pharmacotherapy , intensive supportive care are necessary for suppressing intracranial pressure and cerebral oedema as it is difficult to recommend a particular dosage regimen. For managing cerebral oedema, highdose of dexamethasone (0.15 mg/ kg) is given every six hours. Mannitol or hypertonic saline are used for preventing brain herniation which is the major cause of death in patients with PAM. Another supportiVe care includes the therapeutic hypothermia in which the patient's body is made to cool down to 32-34$^{\circ}C$ to lower the metabolic rate and to reduce the brain oxygen demand.

DRUGS UNDER INVESTIGATION FOR TREATMENT

Nitroxoline is under investigation for treatment on infection caused by free living amoeba. it is approved in Europe and under IND application of USA. Other drugs include Corifungin, Camptothecin, Terbinafine, Benzoxaboroles, Amlodipine as they show amoebicidal effects.

SURVIVAL RATES IN KERALA

Kerala reported a survival rate of about 97% out of the 36 cases reported among which the survival of the 14 year old from Kozhikode district has been a significant milestone as he was the first ever Indian to recover from amoebic meningoencephalitis. In 2025 kerala reported a survival rate of 24%(19 death out of 69 cases) which far higher than the 3-4% survival rate globally.

CASE REPORT-REMARKABLE SURVIVAL OF A 14 YEAR OLD

Afnan Jasim,an 14 year old male from Kozhikode district was taken to the emergency department of government medical college with severe frontal head ache, spiking temperature(103$^{\circ}F$)and continuous vomiting.

External exposure: The patient had gone for a swim in a local nearby pond five days prior to onset of symptoms.
Initial assessment: The patient was lethargic on admission to the hospital and had a glassgow coma scale(GCS) value of 12. Physical examination of the patient showed positive brudzinski and kernig signs which indicated that patient had severe meningeal irritation.

The patient was later transferred to baby memorial hospital Kozhikode due to worsened condition and the was treatment was carried out under Dr.Abdulrauf ,consultant intensive care paediatrician diagnosed the presence of N.Fowleri in CSF within 24 hours of admission to hospital.

Diagnosis: Lumbar puncture was performed on patient for CSFanalysis.In CSF analysis, showed elevated protein level(50.8mg\dl),Low glucose level(44mg\dl). The wet mount examination of CSF showed motile trophozoites of N.fowleri confirmed by real time PCR within 6 hours.

Treatment protocol: The patient was given liposomal Amphotericin B and miltefosine administered to spinewhich directly effected the growth of infection. And additional to these drug, supportive care, Azithromycin and Fluconazole was given for synergistic action.

Treatment Effect: After 3 days of admission, the condition of patient improved. Trophozoites were not detected in the CSF analysis on day 5.On day 14 the patient was removed from ICU as patient was responding but showed some memory impairment. The patient was discharged on 28 day after testing on CSF and result found to be negative. But the doctor prescribed medicine continuation to1 month for complete recovery.

KEY FACTOR THAT LED TO SURVIVAL OF THE PATIENT

Golden hour diagnosis: the patient was diagnosed within 24 hours of symptoms. This was achieved with the help of rapid PCR testing that saved atleast 48 hours of brain tissue destruction.

Availability of miltefosine: The state had already imported miltefosine from Germany to maintain as a buffer stock in 2024-2025.This drug was not so expensive and was used for treatment of rare diseases in India.

With the help of rapid diagnosis followed by successful therapy, the patient became the first ever Indian to survive the amoebic meningoencephalitis. This made him amongst the total 11 survivors globally.

PREVENTIVE MEASURES TAKEN BY KERALA GOVERNMENT

1. **Jalamanu Jeevan Campaign**

- Recognizing the upcoming threat to public health caused by N. fowleri, the government of kerala launched a mass state wide campaign named “water is ife”(jalmanujeevan).
- The main aim of the campaign was to immediate chlorination and cleaning of ponds, swimming pools, huge water storing tanks and especially stagnant fresh water bodies used by local for bathing.
- This campaign was held with the help of Harithakerala mission along with water resource department, local self government (LSGD), Education department.
- Eg: On detection of amoebic infection in Akkulam tourism village pool was properly sanitized and closed for few days.

2. **Systemic screening and surveillance**

As early detection of the disease was the key for reducing the fatality rate, the health department mandated a compulsory check on the N.fowleri on every patient presented with encephalitis.

3. District wide microbiology lab for detecting amoebic meningo encephalitis.
4. Clinical training for health care workers to identify the symptoms and to implement early treatment.

SPECIAL GUIDELINES IMPLEMENTED BY KERALA GOVERNMENT ON PAM

1. Chidren having ear infection should not bath in pond or stagnant water.
2. If symptoms of PAM occur on history of exposure to water in 14 days, seek immediate treatment.
3. The water theme park and swimming pools should be properly chlorinated to avoid the bloom of amoeba.
4. Do not drain or pour water in to nose from stagnant water bodies or drains.
5. The turbid CSF smple should be analysed by CSF wet mount examination.

6. If patient have symptoms of meningitis and exposure history on water should undergo N.fowleri examination and microbiologist should alert the professionals before examining CSF sample.
7. The confirmed cases of PAM should be treated under multi displinary team including medical board, physicians of different department, microbiologist.
8. Splash pools should be emptied each day.

PREVENTIVE MEASURES ON AMOEBIC MENINGO ENCEPHALITIS

1. The boiled or filtered water should be used for nasal rinsing.
2. The nose clip should be used on diving in to water bodies.
3. Avoid diving in to poorly maintained water bodies.
4. Keep the sprinklers and hoses away fro nose to avoid entry of water to nose.
5. Avoid the stirring or digging the sediments on participating water related activites.
6. The coliform count should be done on natural water bodies

REFERENCES

1. Güémez A, García E. Primary Amoebic Meningoencephalitis by *Naegleriafowleri*: Pathogenesis and Treatments. *Biomolecules*, 2021 Sep 6; 11(9): 1320.
2. Gupta R, Parashar MK, Kale A. Primary Amoebic Meningoencephalitis. *J Assoc Physicians India*, 2015 Apr; 63(4): 69-71. PMID: 26591176.
3. Baig AM. Pathogenesis of amoebic encephalitis: Are the amoebae being credited to an 'inside job' done by the host immune response? *Acta Trop*, 2015 Aug; 148: 72-6.
4. 4.Sijo Asokan, AvinashChoudekar, Makeshkumar V, Rudresh SM, Rand Kamil Abbas, Zahraa Sadoon Hadi, SmithaVijayan, Mostafa Mohammed Atiyah, DivyaRajeswary, Tijo Cherian, Amoebicmeningoencephalitis in Kerala: Insights for strengthening global health preparedness. *Mass Gathering Medicine*, 2025; Volume 4: 100037, ISSN 3050-4562,
5. Jahangeer M, Mahmood Z, Munir N, Waraich UE, Tahir IM, Akram M, Ali Shah SM, Zulfqar A, Zainab R. Naegleriafowleri: Sources of infection, pathophysiology, diagnosis, and management; a review. *ClinExpPharmacol Physiol*, 2020 Feb; 47(2): 199-212.
6. Siddiqui R, Mungroo MR, Anuar TS, Alharbi AM, Alfahemi H, Elmoselhi AB, Khan NA. Antiamoebic Properties of Laboratory and Clinically Used Drugs against Naegleriafowleri and Balamuthiamandrillaris. *Antibiotics (Basel*), 2022 May 31; 11(6): 749.
7. Grace E, Asbill S, Virga K. Naegleriafowleri: pathogenesis, diagnosis, and treatment options. *Antimicrob Agents Chemother*, 2015 Nov; 59(11): 6677-81.
8. Vargas-Zepeda J, Gómez-Alcalá AV, Vásquez-Morales JA, Licea-Amaya L, De Jonckheere JF, Lares-Villa F. Successful treatment of Naegleriafowlerimeningoencephalitis by using intravenous amphotericin B, fluconazole and rifampicin. *Arch Med Res*, 2005 Jan-Feb; 36(1): 83-6.
9. Kaushal V, Chhina DK, Ram S, Singh G, Kaushal RK, Kumar R. Primary amoebic meningoencephalitis due to Naegleriafowleri. *J Assoc Physicians India*, 2008 Jun; 56: 459-62. PMID: 18822627.
10. Government of Kerala, Annexure technical guidelines on prevention, diagnosis and treatment of amoebic meningoencephalitis in Kerala . Retrieved from Kerala.gov.in. https://kerala.gov.in.
11. Directorate of Medical Education, Kerala https://share.google/APLykPqRvhmlmyf11

12. Imran Qureshi, 30 July 2024, Indian teen is rare survivor of brain eating amoeba, article in BBC.
13. Tapatrisha Das, 26 July 2024, Kerala teen survives brain eating amoeba disease. Doctor explains survival rate determining factor of PAM, The Hindustan Times.
14. Kerala State Health Authority.Clinical Guidelines for the management of Amoebic Meningoencephalitis (version 3.1). Thiruvananthapuram: Government press; 2025
15. Sankar P, Moorkoth AP, Khurana S, Mohan A, Vadekkandyil S, Vadakkayil B, Kumar J, Rathor S, Govindan SK, SANKAR P, KHURANA S. Microbiological Profile of Meningoencephalitis Due to Pathogenic Free-Living Amoebae: A Case Series From Kerala, *India. Cureus*, 2026 Feb 19; 18(2).
16. Ghosh R, León-Ruiz M, Dubey S et al., *Naegleriafowleri* in Kerala, India: prevention over panic, *The Lancet*, 2025; 4061945.
17. Jacopo Zattoni, Richard F. Ludueña, Maral Aminpour& Jack A. Tuszynski. (2025) Computational discovery of potential therapeutic agents against brain-eating amoeba (Naegleriafowleri). *PLOS One* 20:7, pages e0327621.
18. Jacopo Zattoni, Richard F. Ludueña, Maral Aminpour& Jack A. Tuszynski. (2025) Computational discovery of potential therapeutic agents against brain-eating amoeba (Naegleriafowleri). *PLOS One* 20:7, pages e0327621.
19. Desai V, Muluneh AG, Moa A. Outbreak of Naegleriafowleri in Kerala, India, 2025. G*lobal Biosecurity.* 2026 Feb 16.
20. Desai V, Muluneh AG, Moa A. Outbreak of Naegleriafowleri in Kerala, India, 2025. *Global Biosecurity*. 2026 Feb 16.
21. Kerala reports more amoebic meningoencephalitis cases, including a death. The Hindu. October 18, 2025.
22. Amoebic meningoencephalitis incidence potentially linked to pollution of waterbodies, rising temperature: Kerala Health Minister. The Hindu. September 30, 2025.