



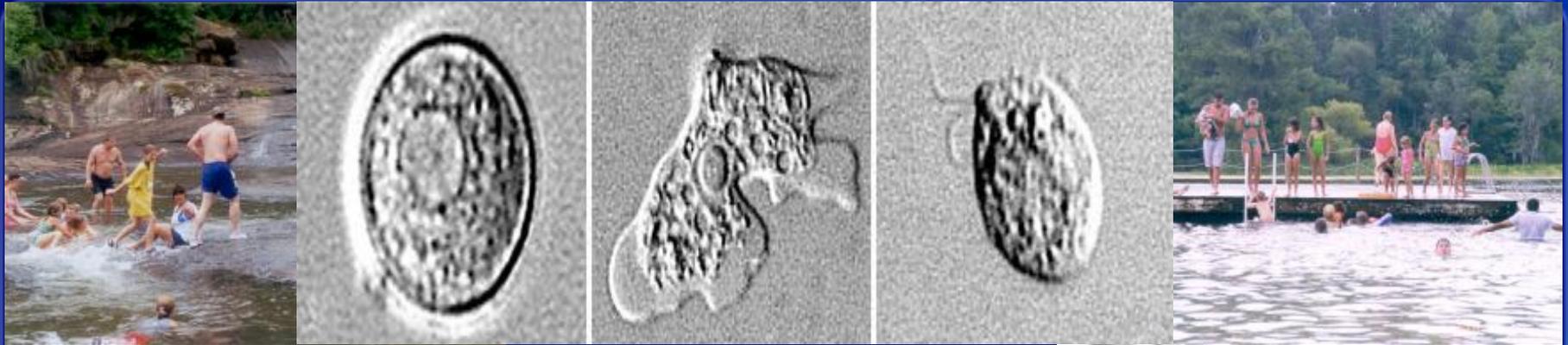
The Changing Epidemiology of *Naegleria fowleri* and PAM in the United States

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Waterborne Disease Prevention Branch

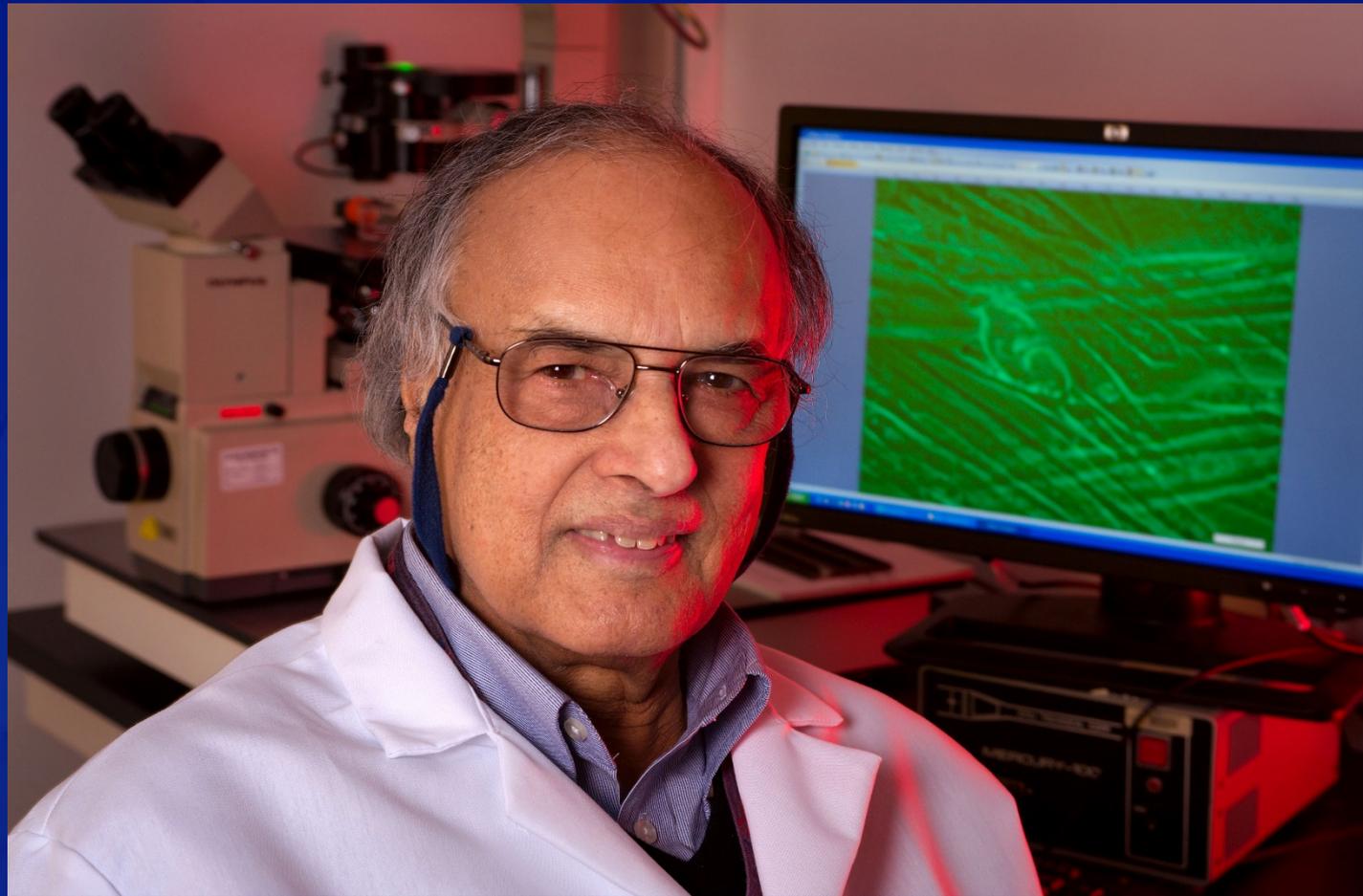
Amoeba Summit – Florida Hospital for Children

September 11, 2015



HISTORY OF FREE-LIVING AMEBA WORK AT CDC

Dr. Govinda Visvesvara



Dr. Michael Beach

Chief, Waterborne Disease Prevention Branch,
Associate Director for Healthy Water, CDC



Why does CDC have a Free-living Ameba Program?

- ❑ **Devastating impact**
 - Patients and their families
 - The public – undermines confidence in activities such as swimming and using drinking water; effects on tourism
- ❑ **Limited clinical, state and local public health experience**
 - CDC is the front line resource for diagnostics, sampling, medical consultation, & communications
- ❑ **Expanding geographic range (*Naegleria*)**
- ❑ **Transplant issues (*Balamuthia*)**
- ❑ **Eye & contact lens issues (*Acanthamoeba*)**

Free-living Ameba Laboratory

- ❑ Diagnostic expertise
 - Capable of diagnosing *Naegleria*, *Balamuthia*, *Acanthamoeba*, and *Sappinia* infections
 - Most U.S. *Naegleria* and *Balamuthia* infections diagnosed as well as many international
 - CLIA certified
- ❑ Drug testing
- ❑ Environmental sampling and testing
- ❑ DNA-based detection and “typing”

Free-living Ameba Clinical Consultations

- ❑ CDC staff available 24/7
- ❑ Arrange for diagnostic testing
 - DPDx telediagnosis
- ❑ Provide treatment recommendations
- ❑ Facilitate the use of investigational drug miltefosine
- ❑ Discussion of treatment and educational needs with national clinical groups

Free-living Ameba Epidemiology

- ❑ Disease tracking and investigation expertise
 - Voluntary case reporting
 - Epi-aid investigations: *Naegleria* cases, *Balamuthia* transplant clusters, *Acanthamoeba* keratitis outbreaks
- ❑ CSTE position statement to make amebic encephalitis nationally notifiable
- ❑ Assessment of organ transplant risk

Naegleria Health Communications

CDC Home
Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People.™

Al-Z Index: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Naegleria fowleri - Primary Amebic Meningoencephalitis (PAM)

Naegleria fowleri

Parasites Home

General Information
Illness
Pathogen & Environment
Sources of Infection
Diagnosis & Detection
Treatment
Prevention & Control
Public Health & Medical Professionals
Publications, Data, & Statistics
CDC at Work: Naegleria fowleri
Policy & Recommendations

Related Links
Parasites A-Z Index
Parasites Glossary
Index of Water-Related Topics
Laboratory Diagnostic Assistance (DPDx)
Healthy Water
Healthy Swimming
Neglected Tropical Diseases

Explore **Naegleria fowleri**

General Information Frequently asked questions (in English and Español)...	Illness Symptoms and outcomes...
Pathogen & Environment Cause of infection, survival in the environment...	Sources of Infection Who gets it and how...
Diagnosis & Detection Testing for patients and for environmental samples...	Treatment Medication...
Prevention & Control How to stay healthy...	Resources for Health & Medical Professionals Diagnosis and treatment...
Publications, Data, & Statistics Articles, references...	CDC at Work What CDC contributes...

References

- Yoder JS, Eddy BA, Viveiros GS, Capwell L, Beach M. The epidemiology of primary amebic meningoencephalitis in the USA, 1982-2008. *J Epidemiol Infect.* 2010;138(7):948-53.
- Viveiros GS. *Free-living amoebae as opportunistic agents of human disease.* [PDF - 12 pages] *J Neuroparasitol.* 2010;1.
- Muramatsu-Gabay F, Cabral G. The unique response to *Naegleria fowleri* amoeba and pathogenesis of infection. *J Parasit Immunol Med Microbiol.* 2007;51:243-59.

***About the Term "Amoeba"**
In U.S. English, the single-celled living organism described here is an amoeba. The word amoeba, with an "a", is used as part of a scientific genus name (such as *Amoeba* or *Acanthamoeba*). In British English, both the generic organism term and genus names are spelled amoebae with an "e".

****Rare Disease**
There is no universal definition of a "rare disease" but the U.S. Rare Disease Act of 2002 *defined* a rare disease as affecting less than 200,000 people in the U.S., and this definition has been adopted by the National Institutes of Health, Office of Rare Diseases.

Left: EM image of *Naegleria fowleri* in its cyst stage. Center: EM image of *Naegleria fowleri* in its amoeboid trophozoite stage. Right: EM image of *Naegleria fowleri* in its flagellated stage. Credit: DPDx and GS Viveiros.

Contact Us
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Contact CDC-INFO

Email page link
Print page
Get email updates

Naegleria website

Facts About *Naegleria fowleri* and Primary Amebic Meningoencephalitis

***Naegleria fowleri* is found around the world, often in warm or hot freshwater (lakes, rivers, and hot springs).**

***Naegleria fowleri* infections are very rare but severe. From 2002 to 2011, 32 infections were reported in the U.S. All were fatal.**

- Naegleria fowleri* is a warm water-loving amoeba found around the world, often in warm or hot freshwater (lakes, rivers, and hot springs).
- Naegleria fowleri* amoeba can travel up the nose and into the brain. This causes the disease primary amebic meningoencephalitis (PAM), which destroys brain tissue and causes brain swelling and death.
- Of 123 people known to be infected in the U.S. since 1962, only one person has survived.

Symptoms

Infections can be mild at first, but they worsen quickly.

- Usually start about 5 days after infection (but can range from 1-7 days)
- Can include headache, fever, nausea, or vomiting
- Later symptoms can include stiff neck, confusion, lack of attention to people and surroundings, loss of balance, seizures, and hallucinations
- After symptoms start, the disease causes death within about 5 days (but can range from 1-12 days)

You cannot be infected with *Naegleria fowleri* by drinking contaminated water, and the infection cannot spread from one person to another.

Spread

Infections are spread through the nose.

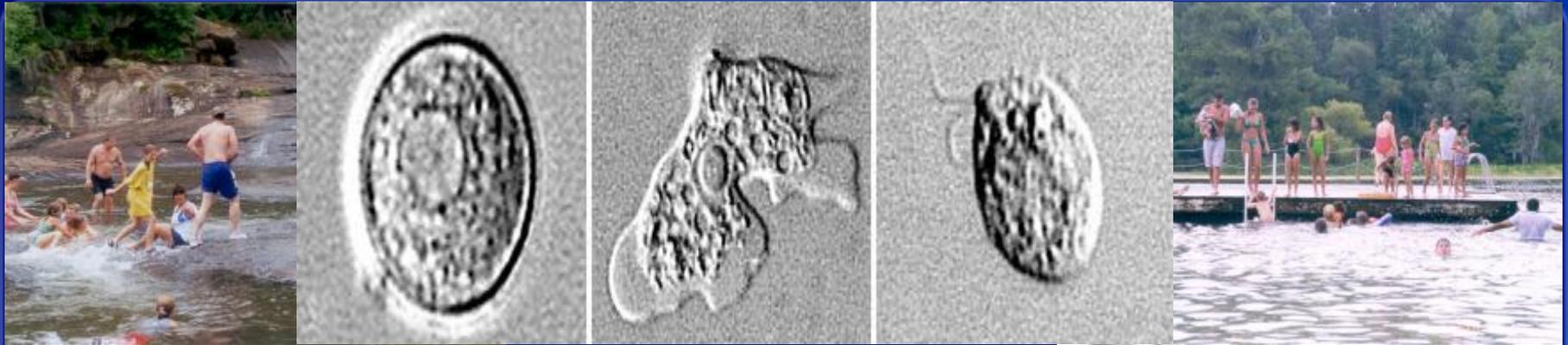
People are infected when water containing the amoeba enters the body through the nose. Recreational water-associated infection most often occurs when people go swimming or diving during the summer in warm freshwater places, like lakes and rivers. Sometimes infections occur after people put their head under water in hot springs.

Infection has also happened when people cleanse their nasal passages during religious practices or when they use a neti pot or other device to rinse their sinuses through the nose.

National Center for Emerging and Zoonotic Infectious Diseases
Division of Foodborne, Waterborne, and Environmental Diseases



Naegleria factsheet
(available on website)



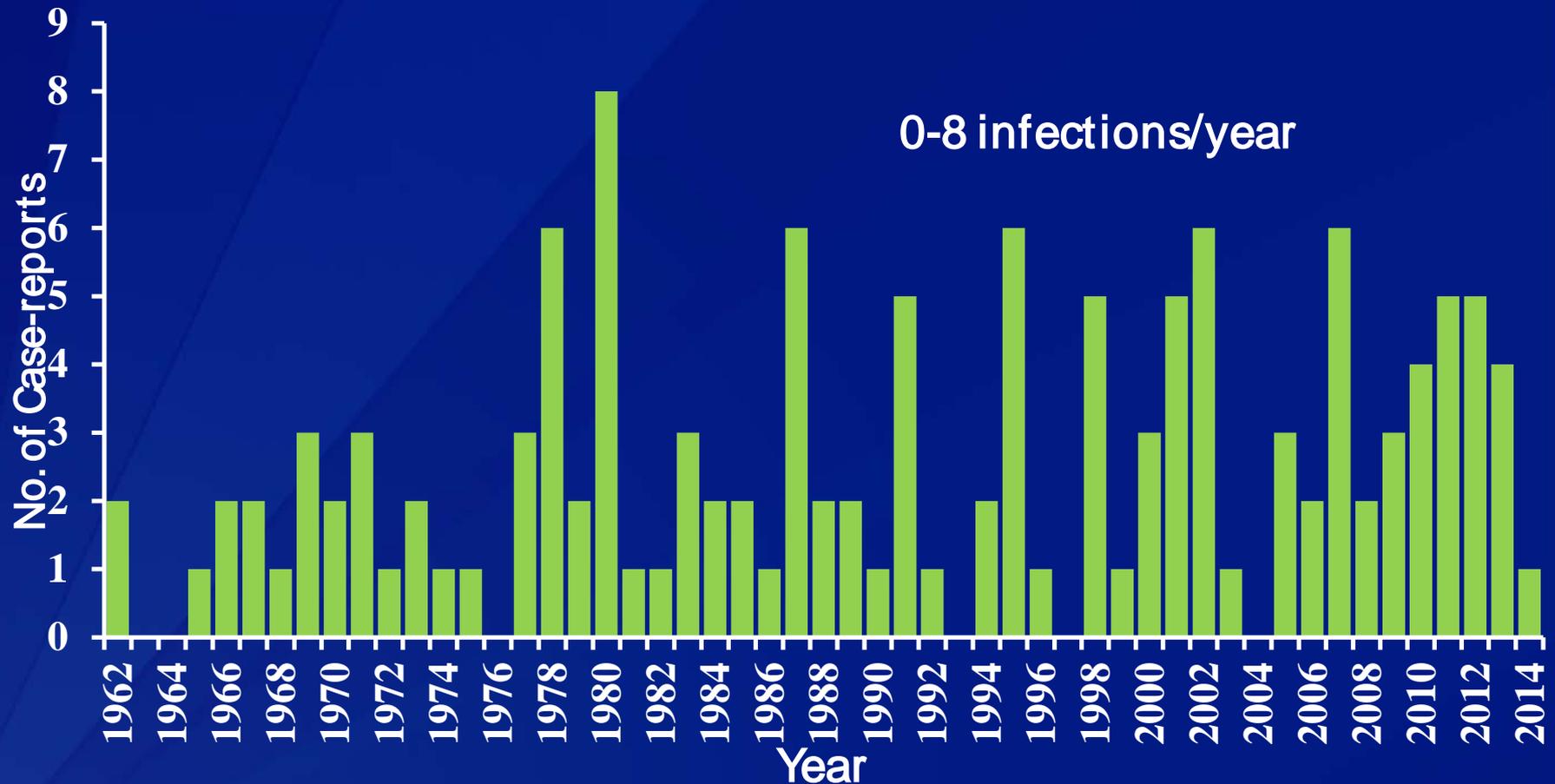
NAEGLERIA SURVEILLANCE AND EPIDEMIOLOGY

FLA Surveillance and Data Collection

- ❑ Not nationally notifiable
 - Reportable in several states (FL, TX, LA, OK)
- ❑ CDC learns of cases because of laboratory diagnostics and clinical guidance
- ❑ Case report form completed, once lab-confirmed
 - Demographics, exposure history, medical history, treatment, outcome

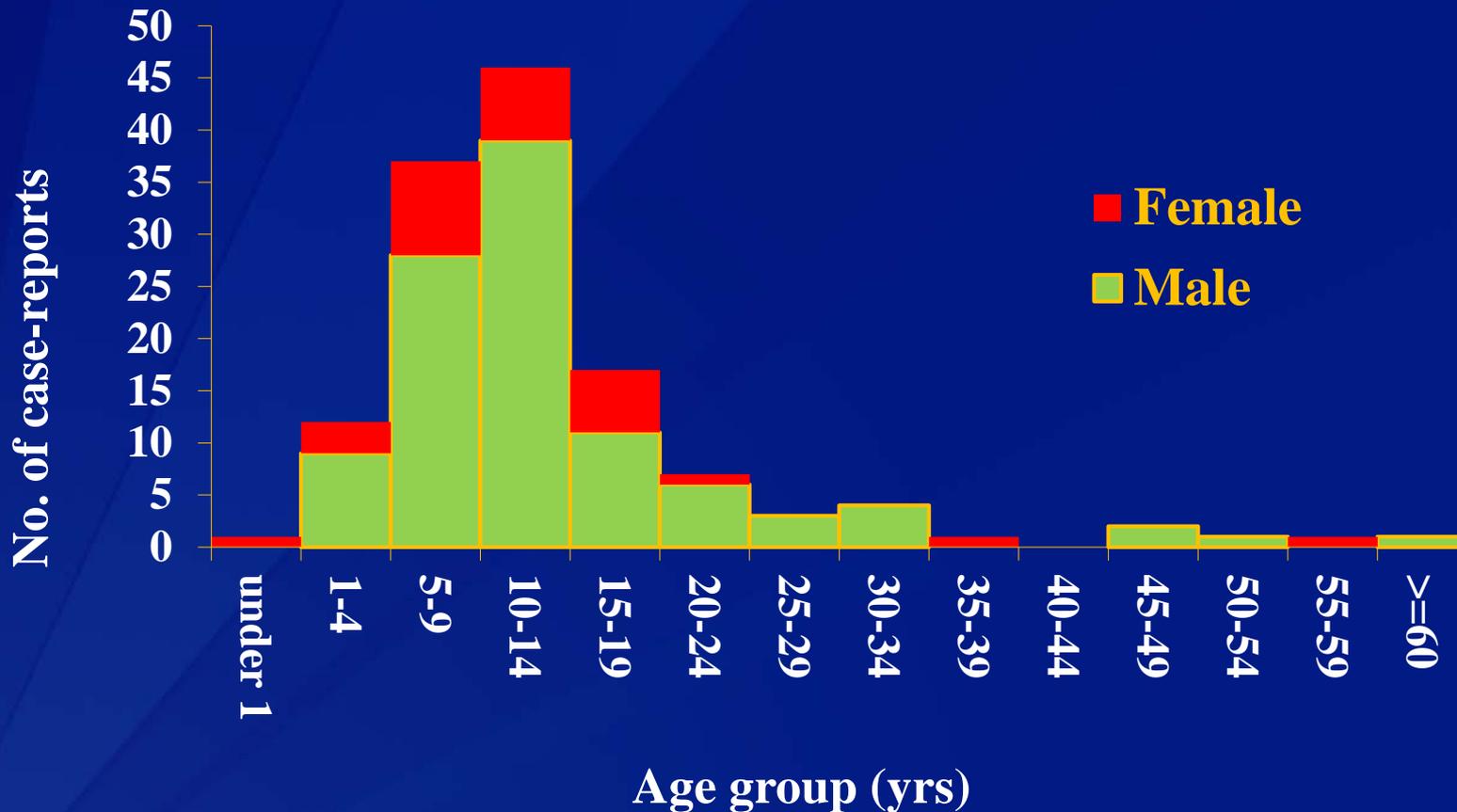


Number of Case-reports of Primary Amebic Meningoencephalitis, by Year: United States, 1962–2014



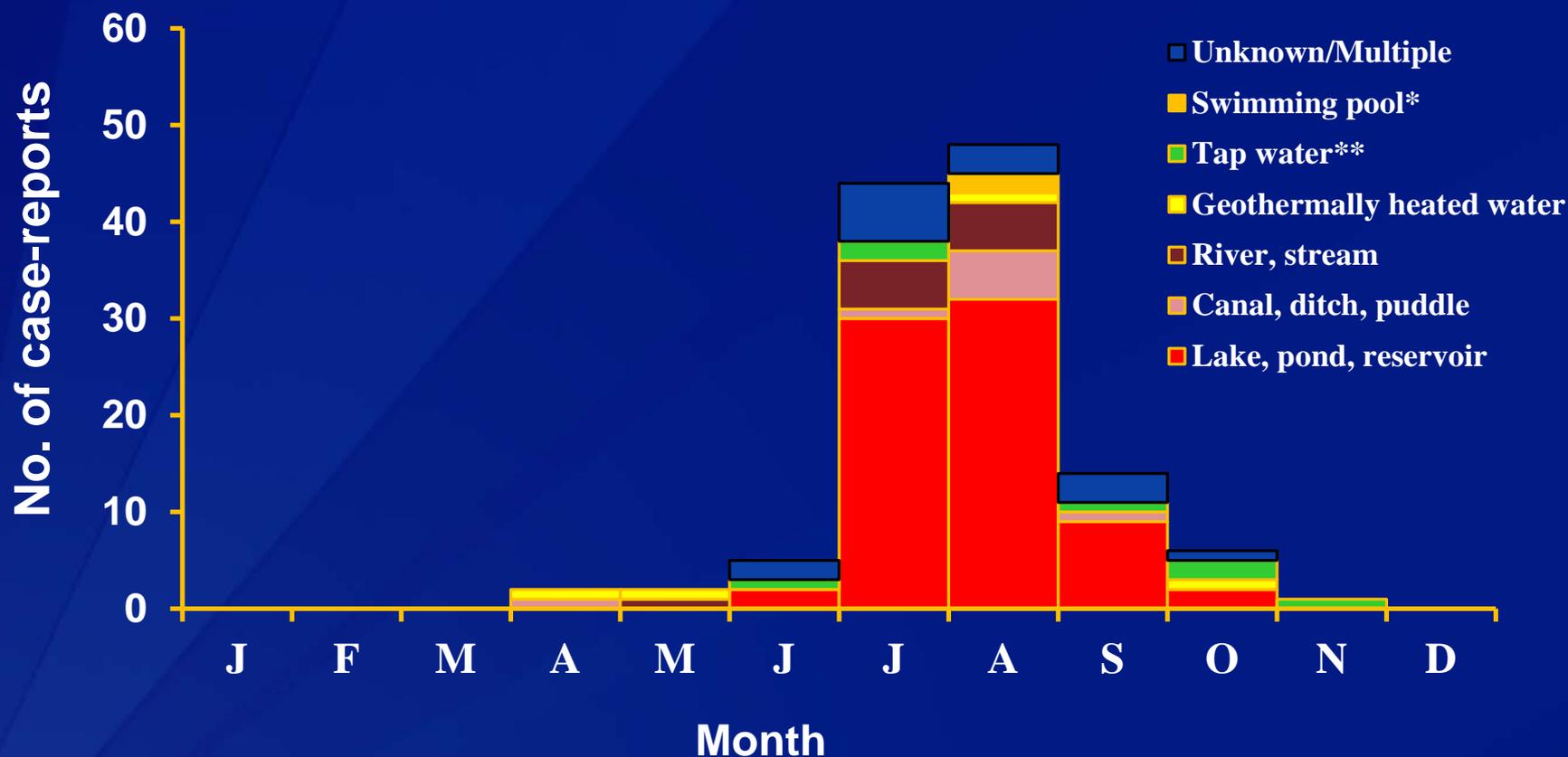
N=133; Year of exposure unknown for one case

Number of Case-reports of Primary Amebic Meningoencephalitis by Age Group and Gender—United States, 1962–2014



N=133; median age = 11; 77.4% male

Number of case-reports of Primary Amebic Meningoencephalitis, by month of illness onset and probable water exposure — United States, 1962–2014



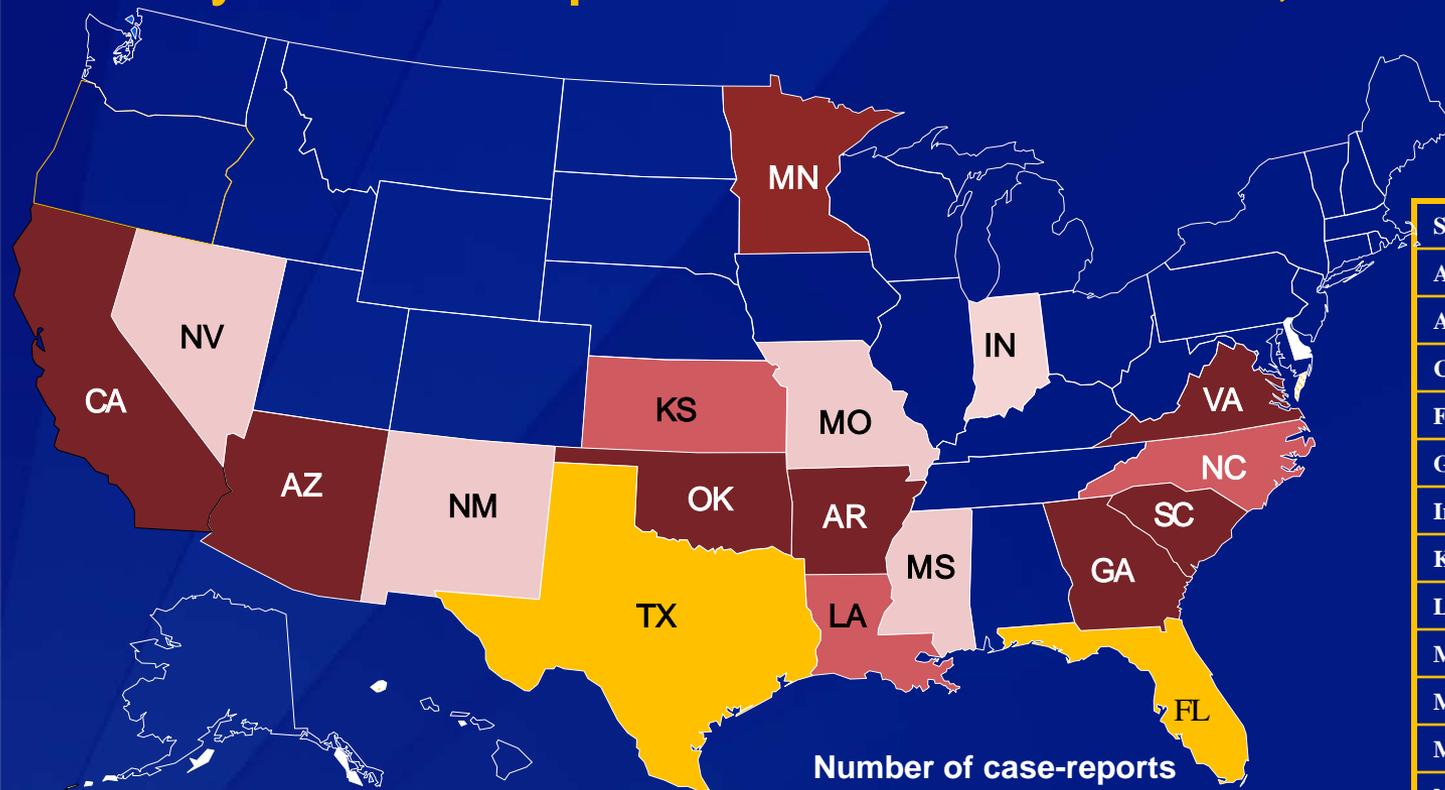
• N=122

• No information is available on the design, maintenance, or operation of these pools.

** Water was forced up the nose during use.

Month of illness onset unknown for 11 cases. Of those case-reports missing the month of exposure, probable water exposures included lake, pond, reservoir (N=5), unknown/multiple (N=5), and geothermal water (N=1)

Number of Case-reports of Primary Amebic Meningoencephalitis Caused by *Naegleria fowleri* (N=133) by State of Exposure* — United States, 1962–2014



Number of case-reports



State (Abbreviation)	# of Cases
Arizona (AZ)	7
Arkansas (AR)	6
California (CA)	7
Florida (FL)	34
Georgia (GA)	5
Indiana	1
Kansas (KS)	2
Louisiana (LA)	4
Minnesota (MN)	2
Mississippi (MS)	1
Missouri (MO)	1
Nevada (NV)	1
New Mexico (NM)	1
North Carolina (NC)	4
Oklahoma (OK)	6
South Carolina (SC)	7
Texas (TX)	32
Virginia (VA)	7

- State of exposure unknown for 4 cases.
- Does not include one case from USVI.



GEOGRAPHIC DISTRIBUTION

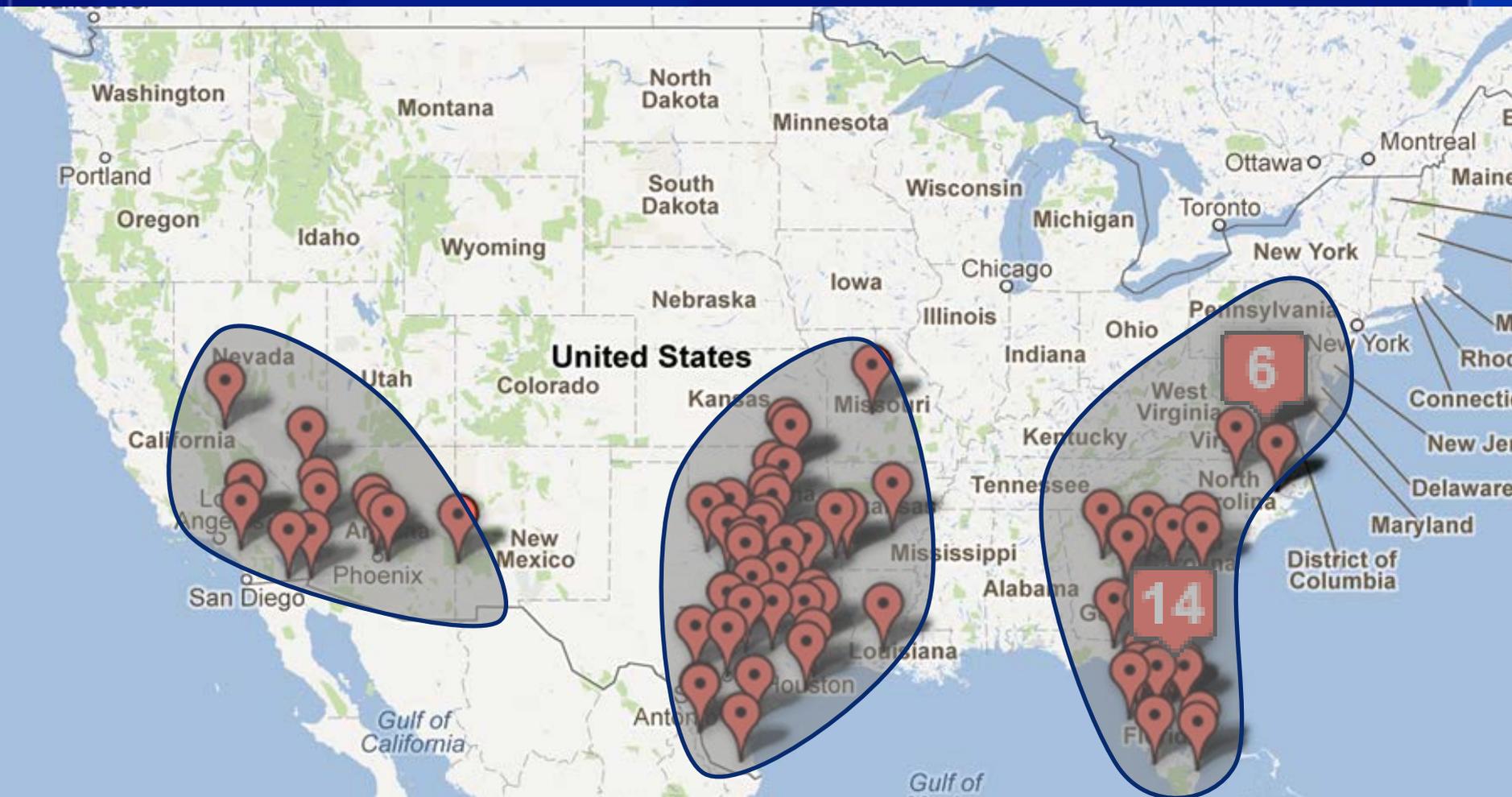
Number of PAM Case-Reports by State of Exposure: United States, 1962–2009



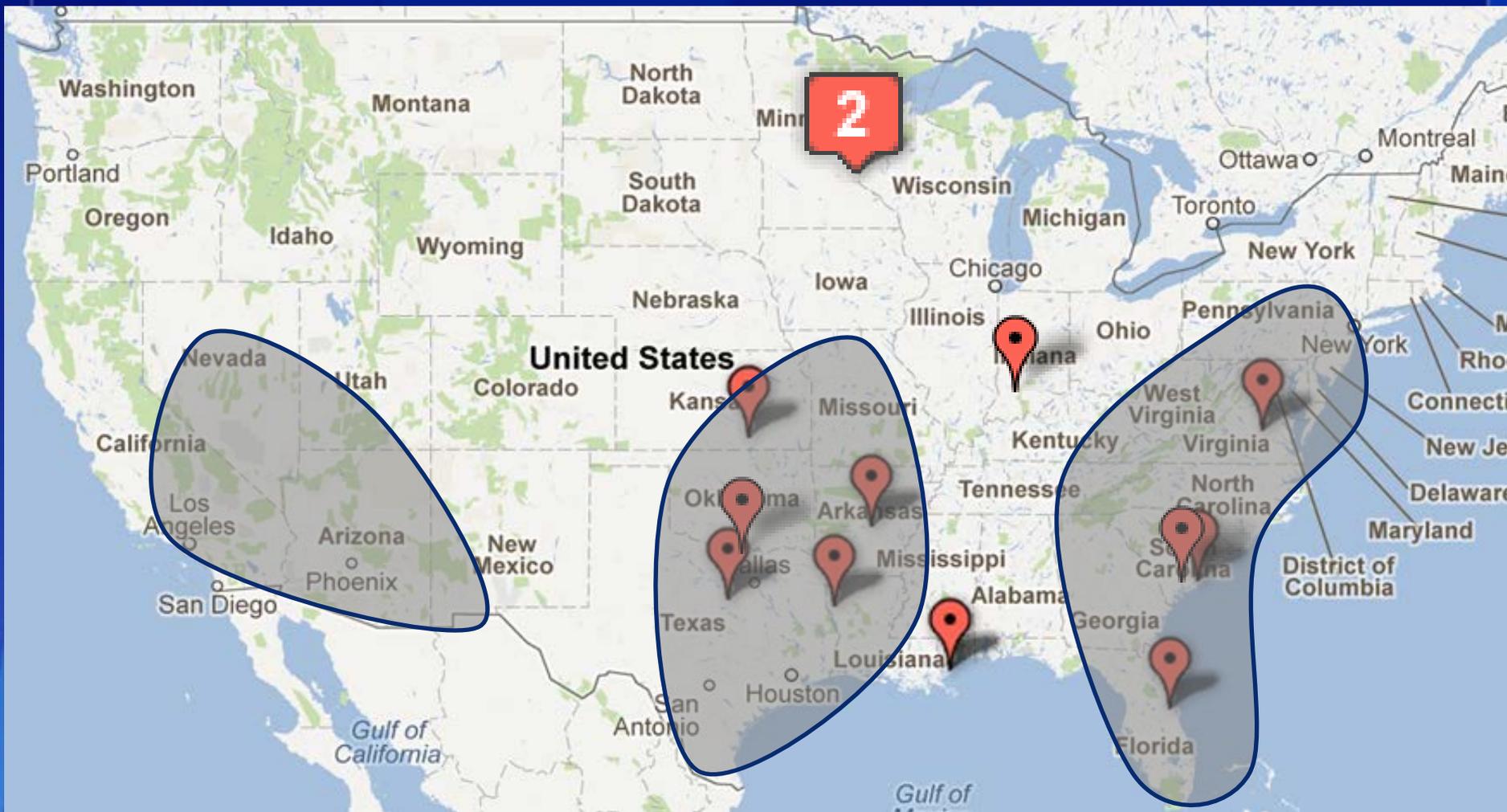
Number of PAM Case-Reports by State of Exposure: United States, 1962–2009



Number of PAM Case-Reports by State of Exposure: United States, 1962–2009



Number of PAM Case-Reports by State of Exposure: United States, 2010–2012



Changes in geographic range of PAM, 2010–2012?



Changes in geographic range of PAM, 2010–2012?



Changes in geographic range of PAM, 2010–2012?



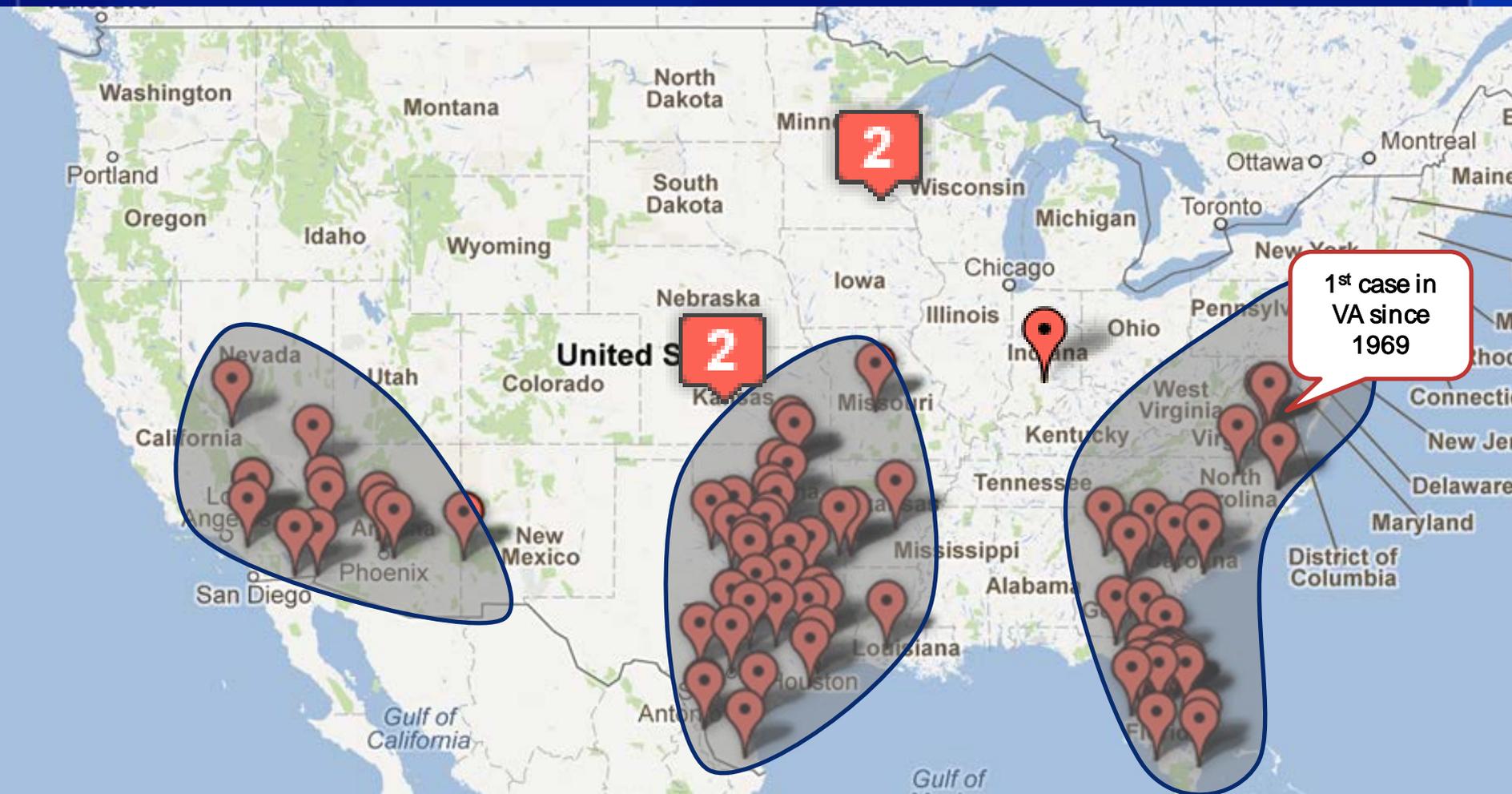
Changes in geographic range of PAM, 2010–2012?



Geographic Range of PAM: 2010-2012

- ❑ First 2 cases in MN
 - 600 miles farther north than previous case in MO
 - During long, unusual heat spell
- ❑ First case reported in KS
- ❑ First case in VA reported since 1969
- ❑ First case in IN

Number of PAM Case-Reports by State of Exposure: United States, 1962–2009, 2010–2014

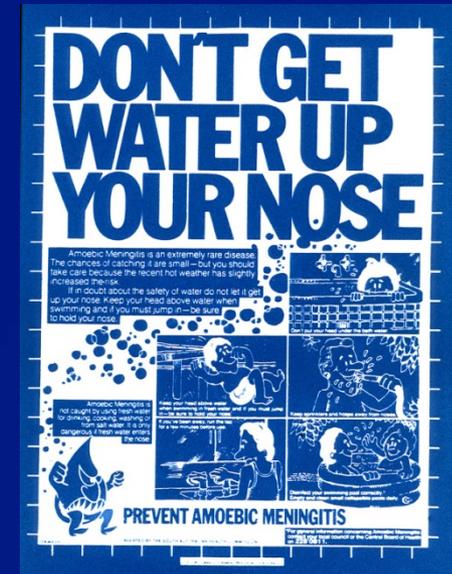


Changing Transmission Routes of PAM



PAM Cases in Australia

- ❑ 1961–1972: 12 PAM cases in S. Australia
 - All occurred during summer
- ❑ 1972: *N. fowleri* isolated in overland pipeline
 - Chlorination instituted –0.5 ppm
 - Chlorine boosting at pumping stations throughout system
- ❑ 1972–1981: No deaths
- ❑ 1981: Single fatal PAM case in city at the end of system
 - Very warm summer
 - *N. fowleri* detected
 - Chlorination added to city at the end of system
- ❑ Continue to monitor for thermophilic amoebae in drinking water



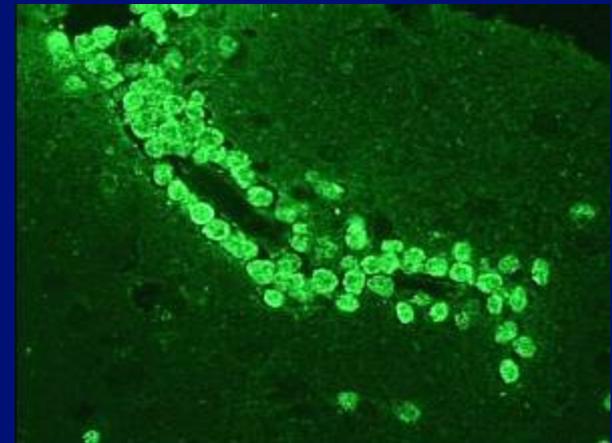
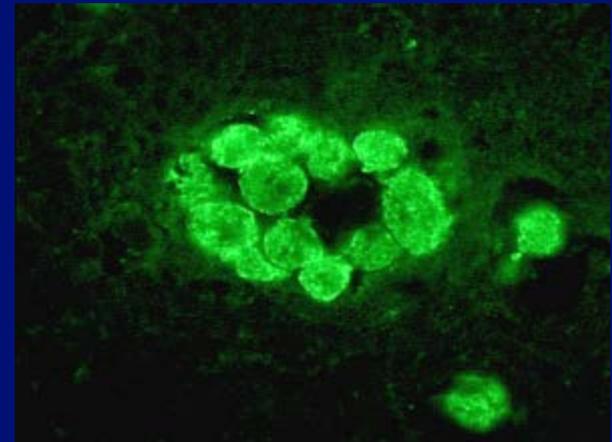
Naegleria fowleri Outbreak: Arizona, 2002



- ❑ October 2002
- ❑ Two 5-year old children died within 8 hours of each other in same town
- ❑ Suspect PAM
- ❑ First instance of simultaneous infections documented
- ❑ What was recreational water contact?

Naegleria fowleri Outbreak: Arizona, 2002

- Epidemiologic investigation
 - Ruled out recreational exposure to freshwater
 - Common exposure to municipal tap water system through water activities (tub and pool)
 - Groundwater wasn't required to be chlorinated or filtered
- *Naegleria* detected in household water samples





Louisiana, 2011

- ❑ **June: Adult male with PAM**
 - No recent recreational water contact based on family interviews

- ❑ **September: Adult female with PAM**
 - Different town (350 miles) than previously reported case
 - No recent recreational water contact based on family interviews

Louisiana, 2011

- ❑ Both cases regular users of neti pots for nasal irrigation
- ❑ Both residential premise plumbing systems positive for *Naegleria fowleri*
 - Hot water heaters set to low heat settings
 - FLA in premise plumbing common (~79% of 467 households in OH study)
- ❑ Municipal water system samples negative



Nasal Irrigation and Neti Pots

- ❑ At least 1 death in 1970's in Australia due to rinsing of nasal passages in shower
- ❑ Deaths in healthy young adults in Pakistan likely from Muslim ritual ablutions: putting water up nose
- ❑ Neti pots
 - Ancient yogic cleansing method
 - Used for nasal irrigation during illness and on regular basis
 - Recommended by Dr. Oz/Oprah in 2007
 - Sales apparently increased 3-4-fold
 - Millions sold per year
- ❑ Lesson: use boiled, sterile, distilled water-NOT tap water

U.S. Virgin Islands, 2012



- ❑ 47 year-old Muslim male from St. Thomas, USVI died
- ❑ Patient's cerebrospinal fluid (CSF) showed motile amebae
- ❑ No recreational water exposure and practiced ritual ablution including nasal rinsing
- ❑ Water sources
 - Home
 - Untreated groundwater from well
 - Untreated rainwater from cistern
 - Both connected to premise plumbing system
 - Mosque
 - Treated municipal water (desalinated and chlorinated)

Ritual Ablution

- ❑ Mandatory Islamic cleansing
- ❑ Preparation for prayer
- ❑ 5 times per day
- ❑ Methodical cleansing
- ❑ May include nasal rinsing



Environmental Investigation in Mosque

Sample	Chlorine (mg/L)	<i>N. fowleri</i> PCR
Ablution fountain (water)	0.02	Negative
Ablution fountain (swab)	Not tested	Negative
Mosque filter	Not tested	Negative



Environmental Investigation in Home

Sample	Chlorine (mg/L)	<i>N. fowleri</i> PCR
Shower head (water)	<0.02	Positive
Hot water heater (water)	<0.02	Positive
Shower head	Not tested	Positive



Naegleria in Pakistan

- ❑ 2008–2009: 13 fatal *N. fowleri* infections in Karachi, Pakistan
 - Limited recreational water exposure
 - All performed ritual ablution
- ❑ 2010: 1 death; exposure through nasal cleansing
- ❑ 2012: Reportedly 22 deaths
 - Very little information on exposures
 - Tap water testing
- ❑ 2013: Reportedly two deaths in May
- ❑ 2014: 10 cases reported so far

Louisiana, 2013



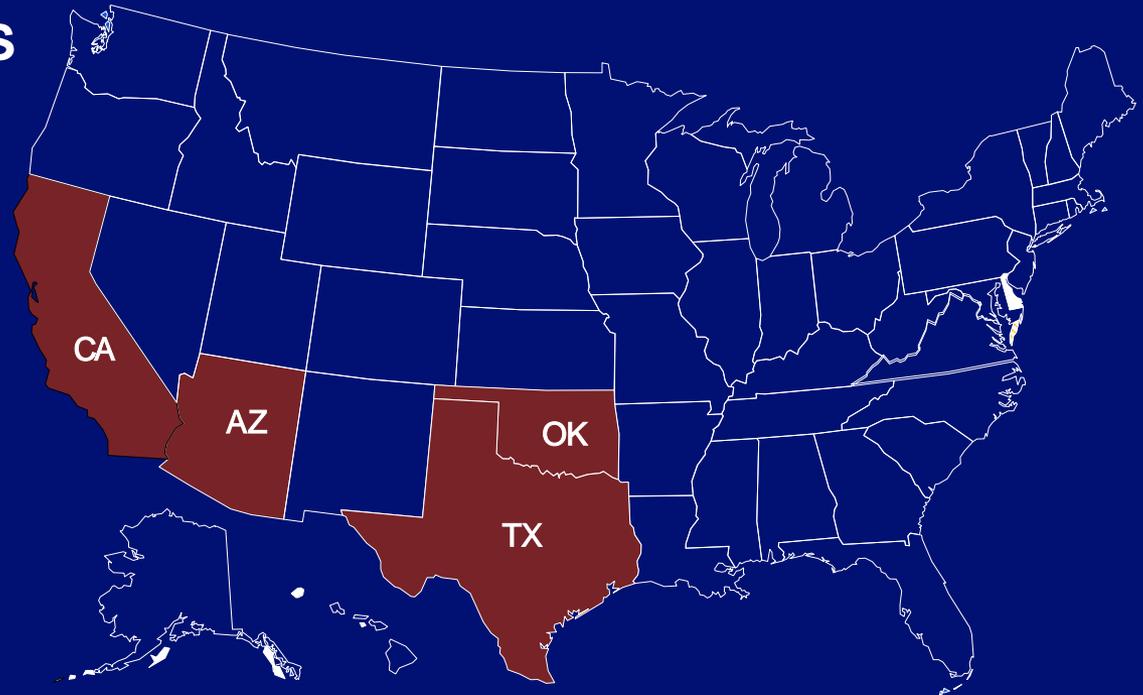
- ❑ 4 y/o child diagnosed with PAM on autopsy
- ❑ No contact with lake, pond, river, etc.
- ❑ Played all day on slip-n-slide
 - Increased risk for water going up nose
- ❑ Water samples, hoses, slip-n-slide shipped to CDC
- ❑ *Naegleria* in residential plumbing system, hot water heater, hoses supplying slip-n-slide
- ❑ Same parish as 2011 neti pot-associated infection
 - Tested municipal water system (negative in 2011), positive in 2013

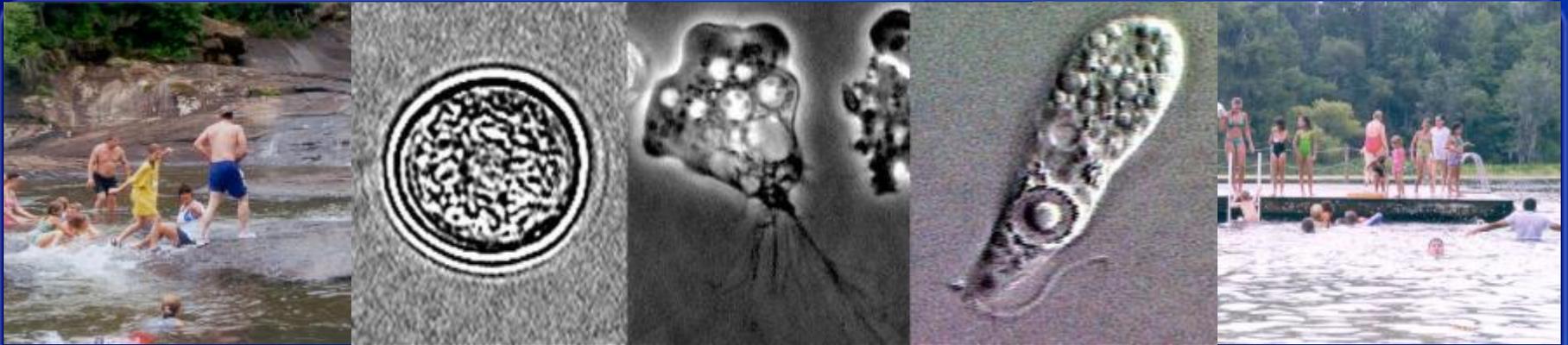
Changing Epidemiology of PAM: 2010-2013

- ❑ First cases reported in northern states (MN, KS, and IN)
- ❑ First cases associated with tap water and neti pot use
- ❑ First case associated with ritual nasal cleansing
- ❑ First death associated with water from a treated drinking water system

Summer 2015 Update

- ❑ 5 confirmed cases, 5 deaths
- ❑ 4 lake exposures, 1 untreated pool
- ❑ 3 females, 2 males
- ❑ Median age: 21





CDC ASSISTANCE

Miltefosine is available through CDC

- Promising treatment for FLA
 - *In vitro* activity
 - Successfully treated a few *Acanthamoeba* and *Balamuthia* cases
- Approved in the U.S. March 2014 for leishmaniasis treatment
- Previously only available under Emergency Investigational New Drug (IND) protocol from FDA
- Available under CDC's expanded access IND since summer 2013



Sending Miltefosine - The Logistics

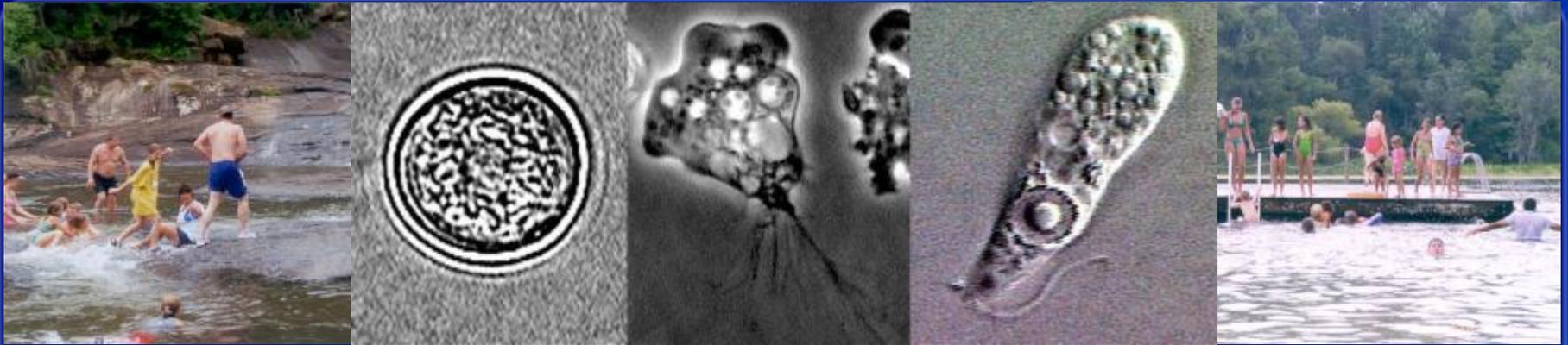
- ❑ Discuss case and determine need for drug
- ❑ Get information needed to ship and calculate dose
 - Determine how quickly drug should be shipped – FedEx overnight vs. next flight out of Atlanta
- ❑ FDA IND paperwork
 - Form 1572
 - Treating physician CV

PAM and Organ Transplantation

- ❑ Risk of transmission via organ transplant is not zero
- ❑ Evidence of *Naegleria* outside the CNS
- ❑ Seek permission to do autopsies in PAM patients
- ❑ Encourage pathologists to consult with CDC prior to performing autopsy

Next Steps and Future Directions

- ❑ **Laboratory:** whole genome sequencing to compare clinical to environmental *Naegleria* strains; development of point-of-care diagnostics
- ❑ **Environmental:** water sampling in both natural water bodies and drinking water systems, predictive modeling – what lakes put people at higher risk?
- ❑ **Epi:** make amebic encephalitis nationally notifiable
- ❑ **Communications:** online CME course, health promotion materials



CONCLUSIONS

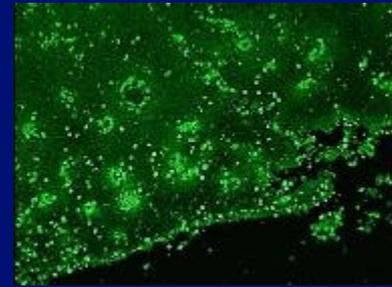
Conclusions

- ❑ **Geographic range shifting northward**
 - Also seen with other climate sensitive pathogens such as *Vibrio*, harmful algal blooms
 - Climate change indicator?
- ❑ **Drinking water (via neti pots, nasal rinsing) is now playing a role in transmission**
 - Ability to colonize premise plumbing, similar to other thermophilic, environmental organisms (*Legionella*, *Pseudomonas*, NTM/MAC)
 - Effect on drinking water policy?
- ❑ **Miltefosine is available through CDC—please call us!**

CDC Service



- 24/7 diagnostic and clinical assistance for free-living amoebae
 - DPDx—telediagnosis
(<http://www.dpd.cdc.gov/dpdx/HTML/Contactus.htm>)
 - Clinical sample testing (microscopy, PCR)
 - call EOC 770-488-7100
 - Clinical guidance and support
 - call EOC 770-488-7100



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The findings and conclusions in this presentation have not been formally disseminated by CDC and should not be construed to represent any agency determination or policy.