# Changing the Paradigm for U.S. Water-Related Disease: The One Water Challenge

Michael J. Beach, Ph.D., CDC

# Leading Causes of Death Globally, 2001

1. Ischemic heart disease (7.2 million)
2. Cancer (7.1 million)
3. Cerebrovascular disease (5.5 million)
4. Lower respiratory infection (3.9 million)
5. Unintentional injuries (3.5 million)
6. HIV/AIDS (2.9 million)
7. COPD (2.7 million)
8. Diarrheal Diseases: Unsafe water, sanitation, hygiene (1.7 million)
9. TB (1.6 million)
10. Intentional injuries (suicide, homicide, war) (1.6 million)
11. Malaria (1.1 million)

WHO, 2002

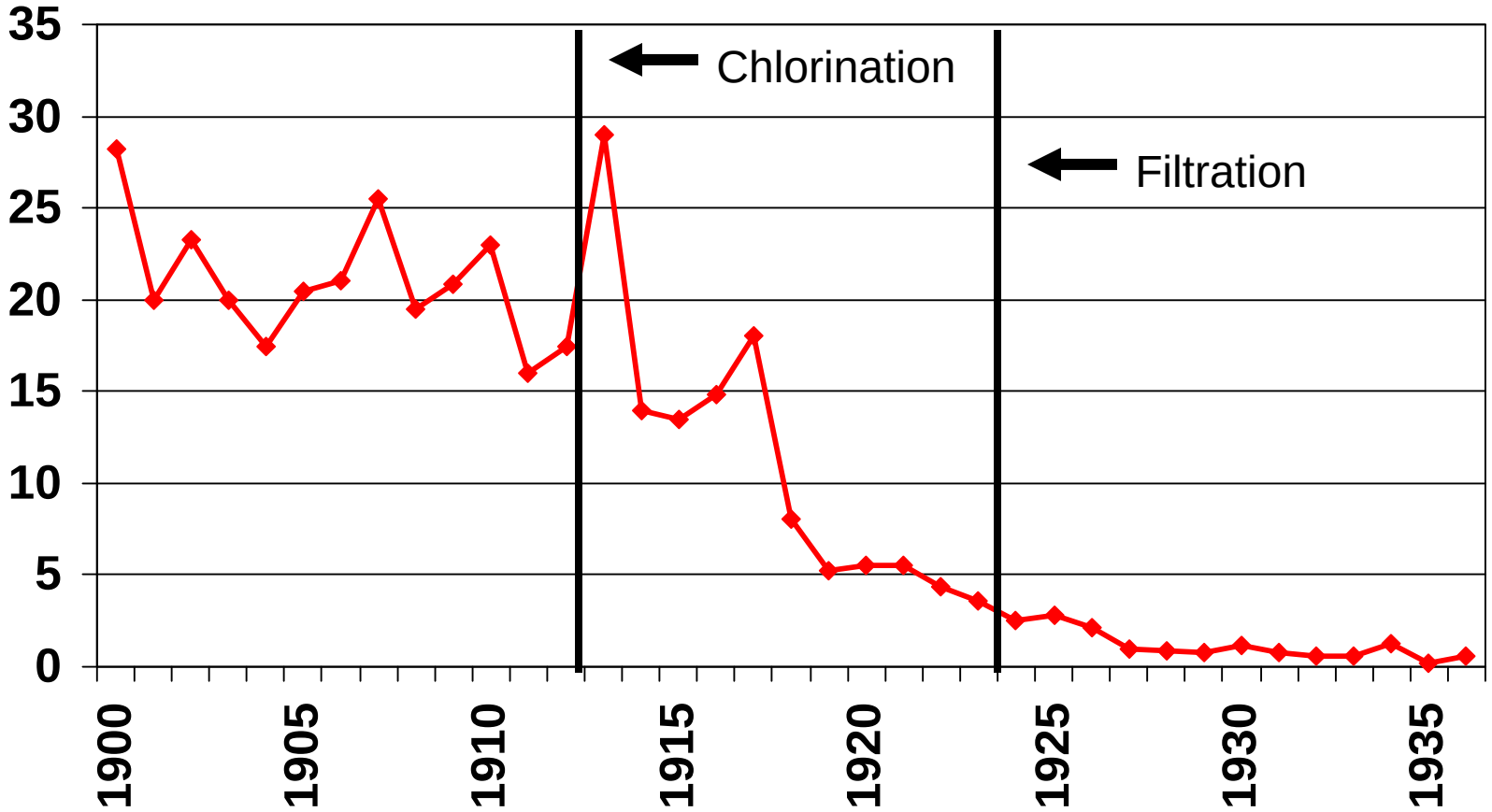
# Drinking Water History

**Sept 25, 1908. First chlorination of a U.S. public water supply in Jersey City, NJ.**

- **Filtration**
- **Disinfection**
- **One of century's greatest public health achievements**

# Detroit

## Typhoid Fever Trend (Mortality per 100,000) and Sanitary Interventions, 1900–1936




Cutler D, Miller G. Demography. 2005;42(1):1-22.

# So We're Done? No More Waterborne Disease Issues in the U.S., Right?

# Moving from an Under-Developed to a Developed World Paradigm of Waterborne Disease



**47 Contract Salmonella From Drinking Water**


**Legionnaires' bug found in hospital cooling tower**

**Tainted Well: Illinois demands answers**

**Sinkhole Opens in Downtown Atlanta**


**Pharmaceuticals Found in Source Water**


**Dallas Spends Summer Fighting Crypto and Crypto Is Winning**

# One Water: The Universe of Water-Related Disease

Wastewater & Re-use

Water Quality

Water Quantity

High-medium income

Low-income

Drinking

Recreational

Other uses

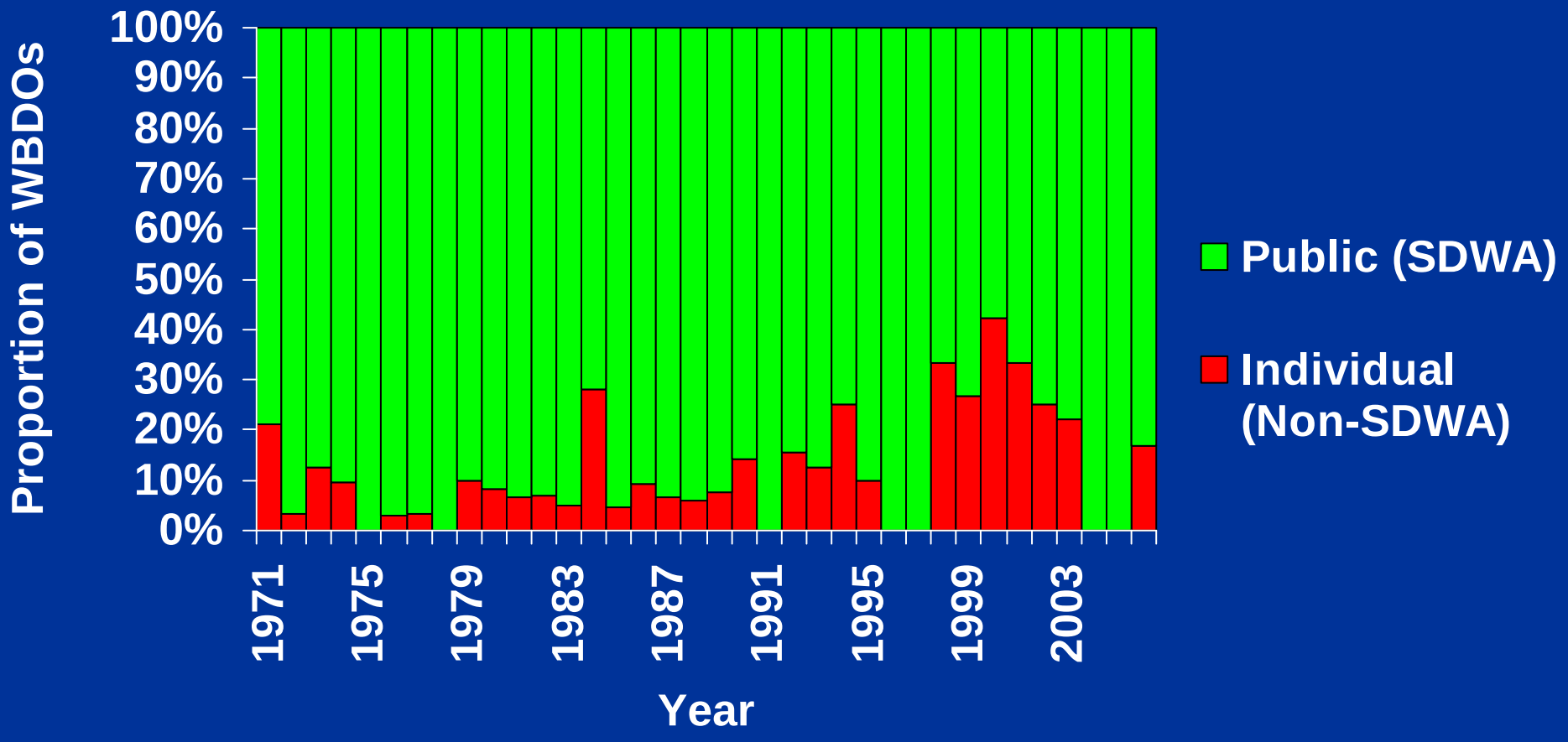
Security & Response

Water, Sanitation, Hygiene

# U.S. Drinking Water Issues

- Private wells, small water systems not under SDWA
  - Serve 15.6 million households (~12% of households, ~45 million people)
  - Prone to poor construction, operation, maintenance, water quality
    - WA 2003: most small systems had ≥ 1 system deficiencies that posed a potential public health hazard
    - AL 2005: 40% of private wells failed bacteriologic testing
    - MI: more private wells than any other state (1.12 million)

# Percentage of Waterborne-Disease Outbreaks in Public and Individual Drinking Water Systems — United States, 1971–2006




Source: CDC, unpublished WBDOSS data (N=762)
Excludes 18 outbreaks occurring in multiple system types at the same time, bottled water, bulk water purchase, and unknown

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# Bass Island, Ohio 2004

- Resort island—900 residents, 500,000 visitors/yr
- >1450 people reporting illness, “sewage poisoning”
- Small treated municipal system and private/public wells
- Cross connections between municipal system and wells
- Wells: 76% coliform positive, 30% E. coli +
- Many residents on septic
- Inadequte dumping of septage on island
- Karst limestone geology
  - “groundwater” is really coming from Lake Erie
- Role of oversight for these small/private systems

O’Reilly et. al, CID 2007;44:506-12

# U.S. Drinking Water Issues

- Aging water and wastewater infrastructure
  - Plants, distribution systems, source water protection, water development
  - > 1 trillion estimate cost
  - CSO's, SSO's
- Example:
  - Aging water distribution systems
  - Most systems in U.S. long overdue for replacement
  - 1000's of annual "water" advisories
  - Leaks, breaks, low pressure events open systems to contamination and health effects

# Contamination of Drinking Water

- Disinfection by-products
- Environmental contaminants
  - Arsenic, radon
- Animal-derived contaminants
  - Non-point source contamination
  - Concentrated animal feeding operations

# Contamination of Drinking Water

- Human-derived contaminants
  - Inorganics
    - Heavy metals, nitrates
  - Organic compounds (volatile, non-volatile)
    - Pesticides, herbicides, solvents
  - Pharmaceuticals and personal care products
    - Wastewater plants not equipped to remove them—health effects unknown at low levels
- Acute health effects well documented
  - Long-term health effects poorly understood

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# Building Issues

- Building distribution systems—premise plumbing
  - Regulation stops in practice at the street
  - Biofilms everywhere
  - Pathogens exploiting human-made habitats
    - Niches for thermophiles
      - *Legionella*, *Mycobacterium avium* complex, *Acanthamoeba*
    - Aerosolization via shower heads, taps
- Cooling
  - Aerosolization of *Legionella*

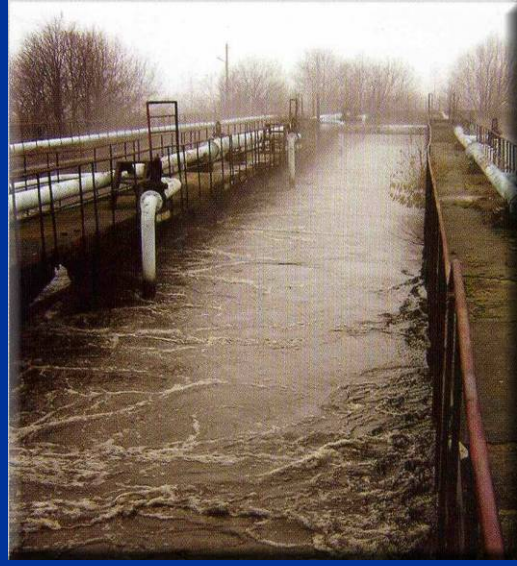
# Other Uses of Water: Challenges

- Food production
  - Agriculture: production, irrigation, processing is one of the major uses of water in the world
    - Eat the food and drink the water from around the world
    - Water suspected in Cyclospora outbreaks 1995+
    - Spinach and E coli O157:H7, 2007
  - Drawing from decreasing water resource that may be more prone to contamination
- Increasing re-use of wastewater & grey water

# Other Water Challenges

- Biofilms
  - Healthcare
    - Medical devices (e.g., catheters), dialysis, therapy pools
  - Drinking/cooling
    - Distribution systems, premise plumbing
  - Recreational
    - Spas, pools
  - Leisure
    - footspas

# U.S. Wastewater Issues



- On-site waste water system failures
- Reuse/recycle inevitabilities
  - Focus on “source to tap”
    - Moving to “toilet to tap”
  - Sludge disposal
    - Farmers encouraged to use as fertilizer
      - Pathogens, chemicals, drugs, hormones, heavy metals
  - Use/management of animal waste

- GA 2007: Farmer got “free” fertilizer from city which contained industrial sewage
  - Grass and > 100 cows killed---contained heavy metals, PCB’s, rat poison




# Recreational Water: Natural Waters

- EPA regulates
- EPA validating new fecal indicators
  - Critical issue is the lack of differentiation between animal and human fecal contamination
  - Many beaches likely closed due to bird contamination
    - Link to human illness is unclear compared to human sewage contamination

# Illness Incidence and Adjusted Cumulative Incidence Ratios (aCIR) Comparing Swimmers With Nonswimmers

Only one reported Great Lakes-associated outbreak since 1978

| Illness | aCIR (95% CI) |
|---|---|
| GI | 1.4 (1.3-1.6) |
| Rash | 1.4 (1.1-1.7) |
| Earache | 1.6 (1.2-2.2) |

Four Great Lakes Beaches. 21,015 interviews
Wade et al., Epidemiol 2008;19: 375–383

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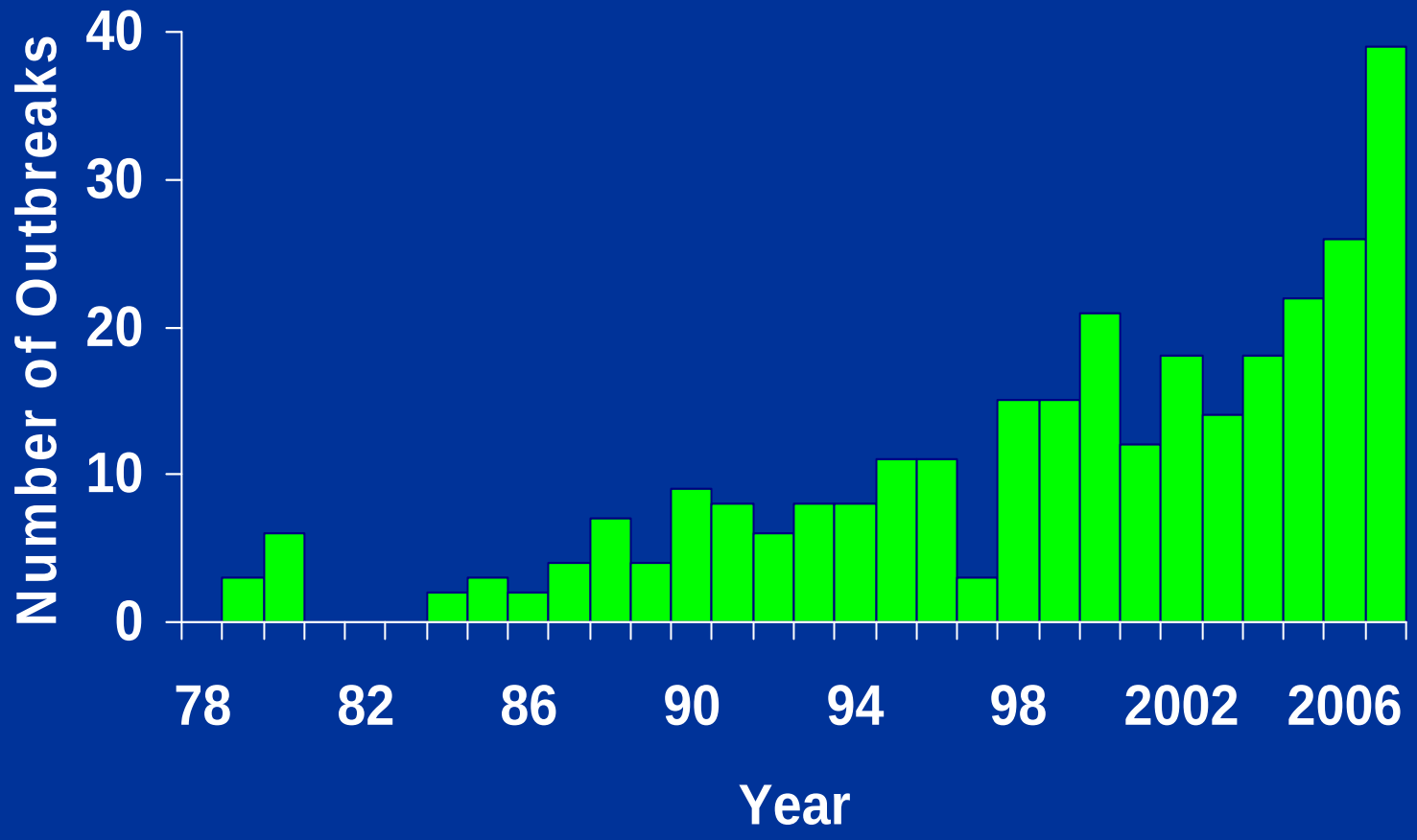
# Recreational Water: Chlorinated Venues

- Little federal regulation
- Disparate regulation at state, local level
- Highest use, highest number of outbreaks
- Little funding for public health research

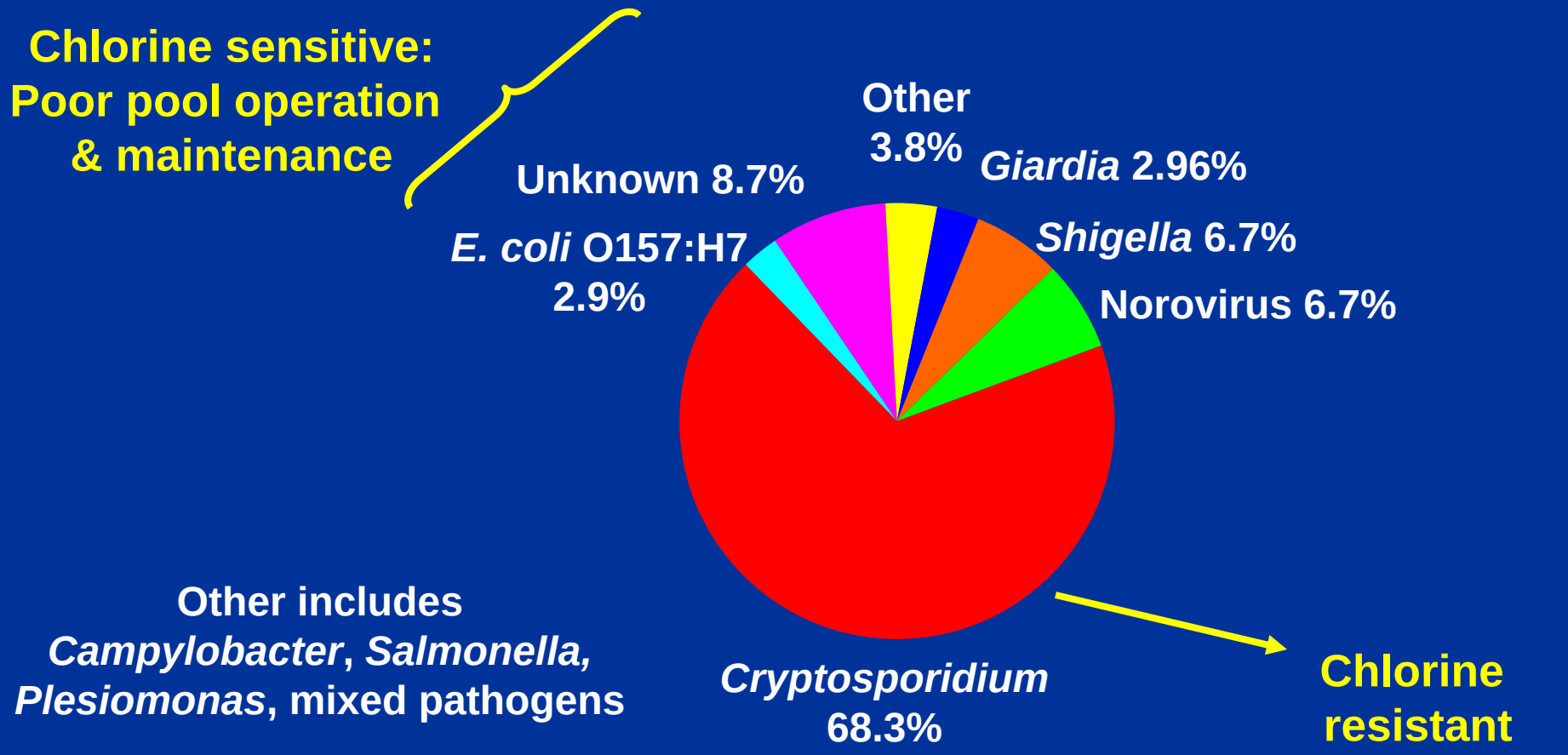
# Recreational Water–Associated Outbreaks of Gastroenteritis — United States, 1978–2007[1,*]




1. Yoder JS *et al*. 2008. MMWR 57(SS-9):1–38.

* N=295 (includes preliminary 2007 data as of 12/29/2008)

# Recreational Water–Associated Outbreaks of Gastroenteritis in Treated Venues* United States, 1997–2006**

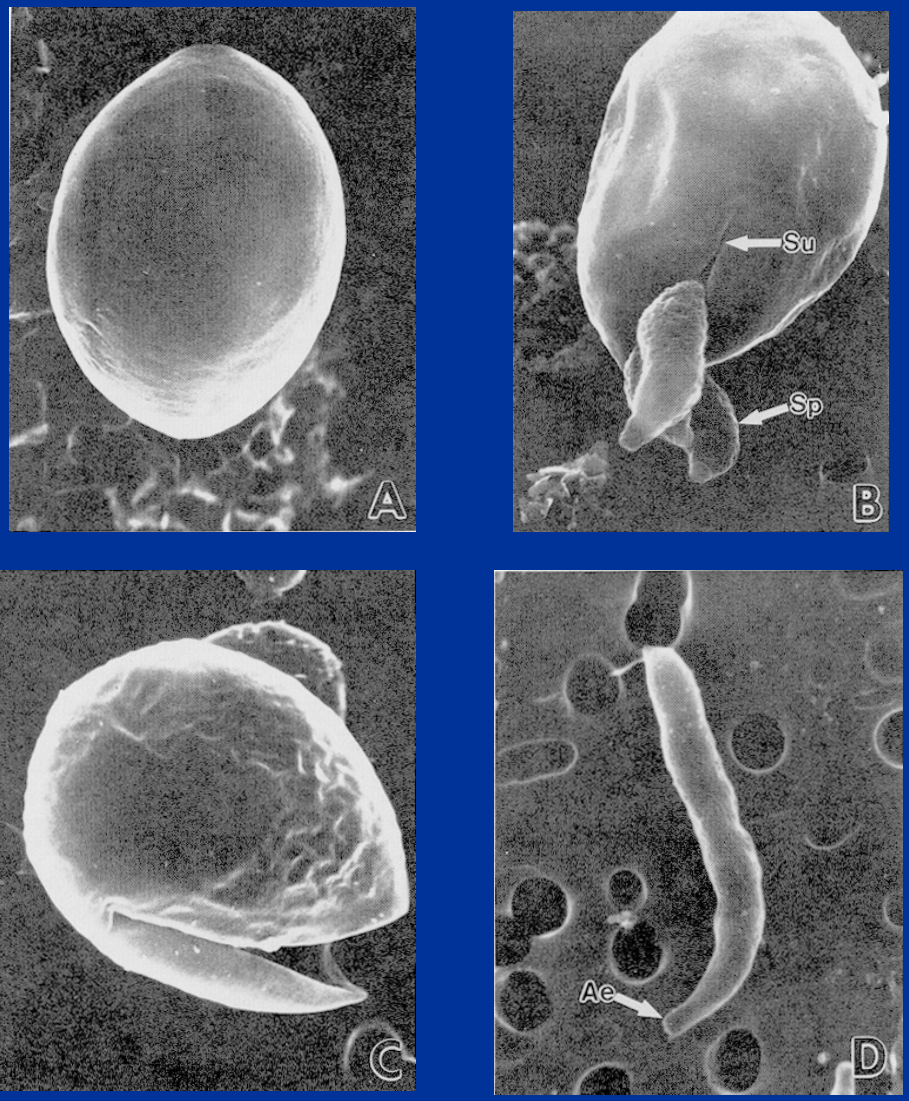



* Treated venues: Pools, water parks, interactive fountains

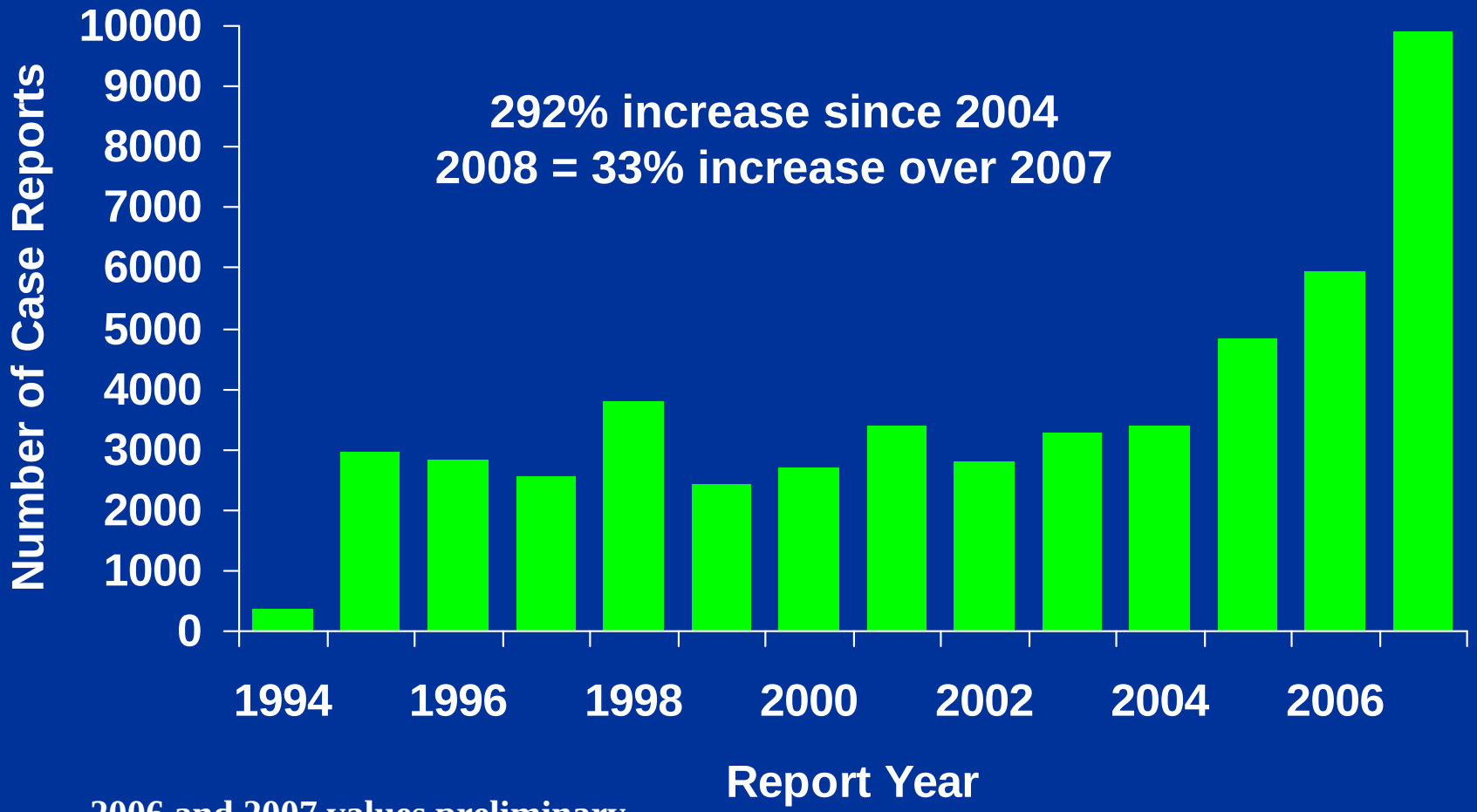
** N=104, Yoder JS et al. 2008. MMWR 57(SS-9):1–38.

# What is Happening with Cryptosporidiosis Reporting?

**Chlorine resistant**



# Cryptosporidiosis Non-Outbreak Case Reports: United States, 1994-2007

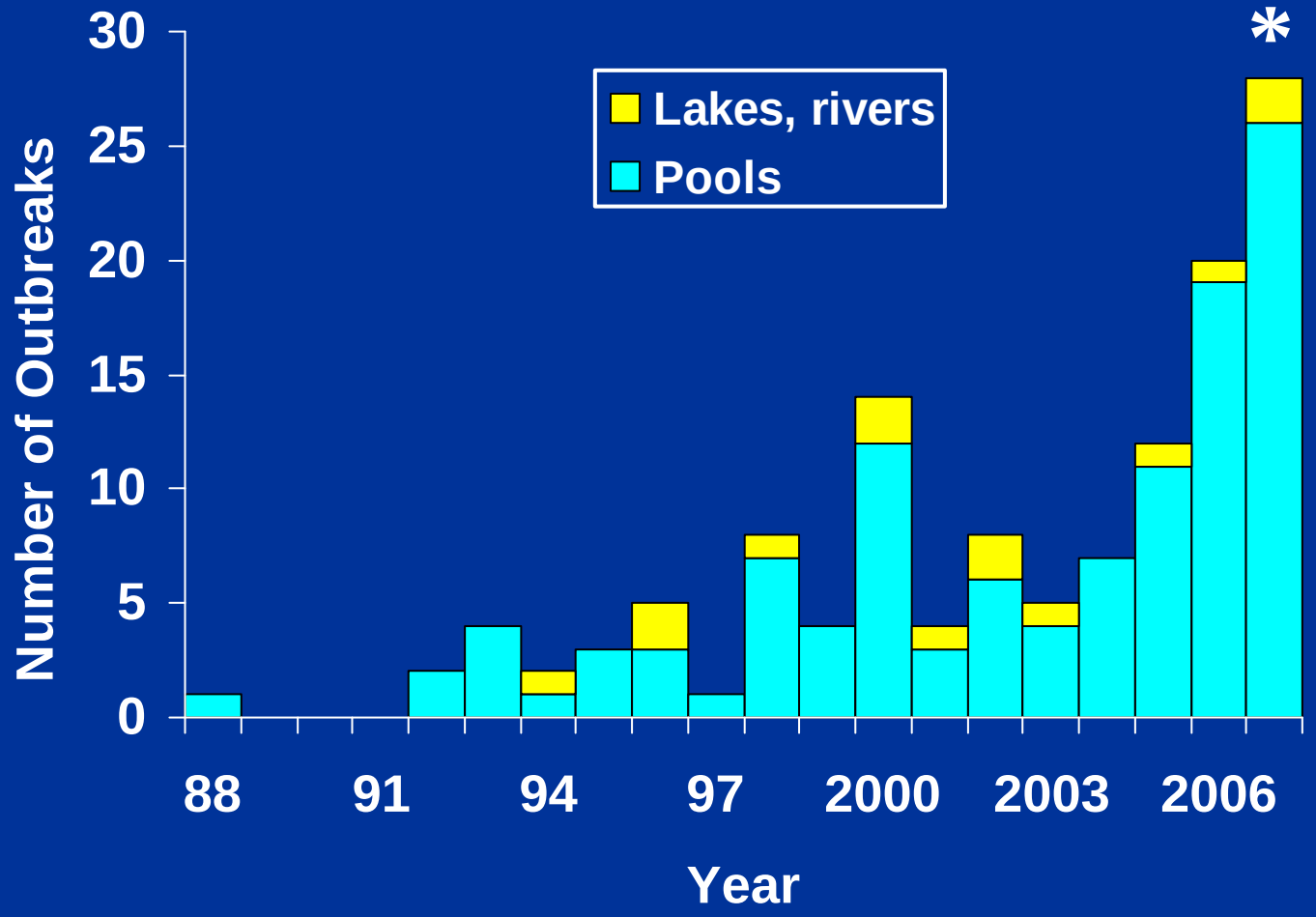



2006 and 2007 values preliminary

17-58% of case reports do not include outbreak status.

These" unknown outbreak status" reports are included in this graph

# Recreational Water–Associated Outbreaks of Cryptosporidiosis by Recreational Water Type: United States, 1988-2007




* N=128, Yoder JS et al. 2008. MMWR 57(SS-9):1–38.
2007 numbers are preliminary based on state interactions

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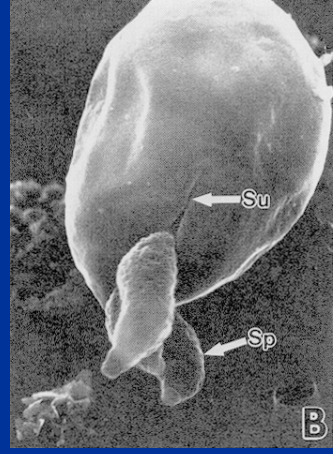
# Increases in Cryptosporidiosis Reporting: Hypotheses




- Real increase in transmission
- Changing testing practices resulting from new drug approval
  - New drug approved for adult use in 2005 (only drug ever approved)
    - Children's formulation in 2002
  - More requests for crypto testing because of treatment availability
- Combination of above
- More case reports means more DOH follow-up and outbreak detection

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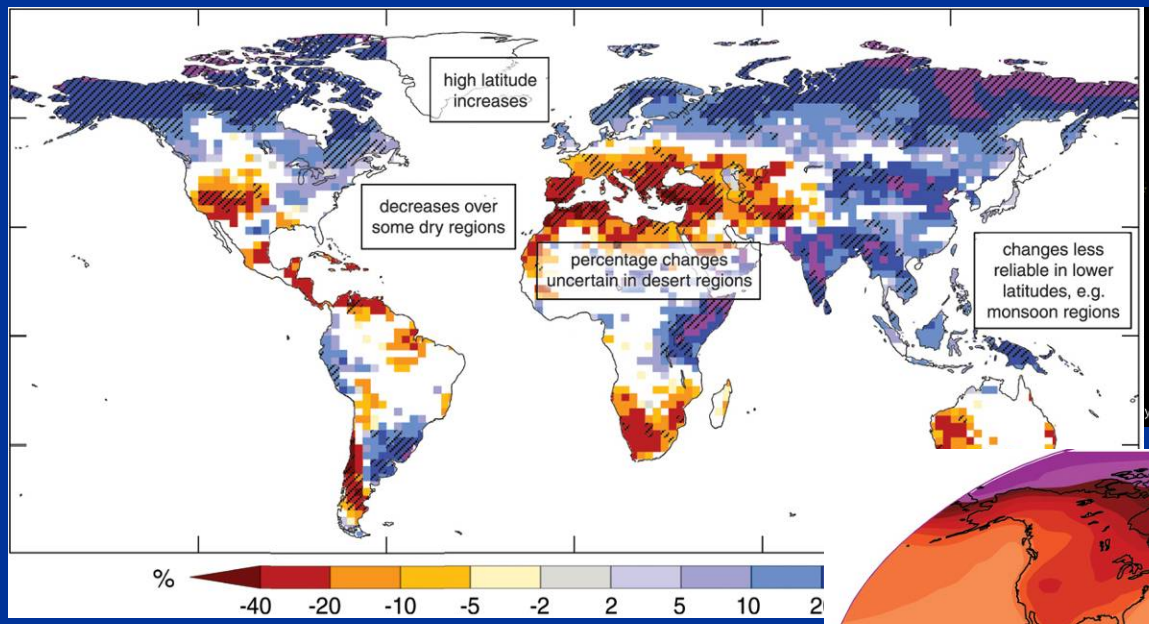
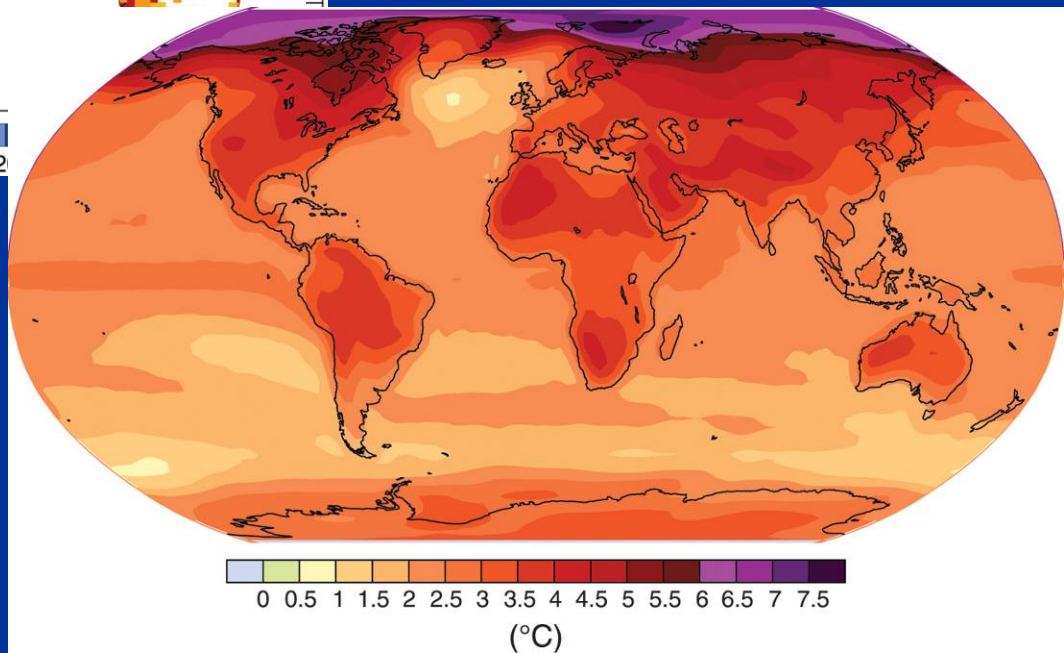
# Severe Weather Events, Climate Change, and Water Availability/Quality








**Source: IPCC Climate Change 2007 Synthesis Report**

# Climate Change
# Water Impacts

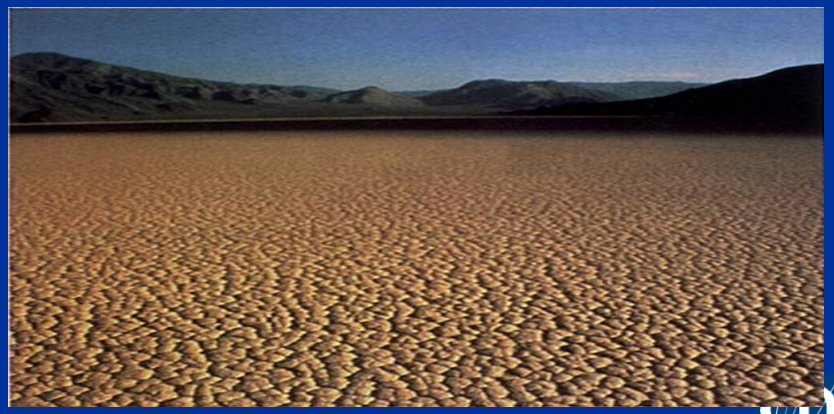

- Increased water availability in moist tropics and high latitudes
- Decreased water availability and increasing drought in mid-latitudes and semi-arid low latitudes
- Water stress for hundreds of millions
- Extreme weather events
  - Droughts
  - Floods
  - Increased temperatures

Source: IPCC

# Water and Climate Change: Challenges


## Water quality

**Cholera, cryptosporidiosis, campylobacter, shigellosis, giardiasis, *Naegleria*, leptospirosis, vibriosis, HABs, chemicals**



## Water quantity

# Drought

- Current problems
  - Colorado basin
  - Tucson, AZ
  - Atlanta, GA
- Drinking and recreational water quality and quantity decreasing
- Surface water
  - Concentration of contaminants
  - Decreased dilution factor in outflows, run-off

# Drought

- Groundwater
  - Increasing need for groundwater recharge
  - Changing soil/geology may increase potential for contamination
  - Surface water sources used to recharge
  - Saltwater intrusion into groundwater as levels drop
- Collateral damage
  - Air quality, mental health, poor hygiene, fires, crop loss

# Water Reuse

- Indirect Potable Reuse
  aka “Toilet-to-Tap”---indirect potable water re-use
  - Orange County, CA: 70 mgd
    - Salt water intrusion
  - Gwinnett County, GA: 60 mgd
    - Drought affecting reservoir


- Grey Water
  - Tucson, AZ
  - Australia

- Aquifer depletion
  - Land subsidence (San Joaquin Valley, CA)
  - Direct pumping of water back into aquifers (Tucson, AZ)

# Floods

- Midwest 2007/8, post-hurricane, tsunami
  - extreme precipitation
- Collateral damage
  - Injuries, mental health, crop loss
- Mold growth
- Potential infrastructure failures for drinking/ wastewater treatment
- Drinking and recreational water quality issues

# Floods

- Sewer overflows (combined and sanitary)
  - >1 trillion gal of sewage & storm water discharged annually during CSO's
- Agricultural and livestock areas rinsed into surface water---"first flush"
- Water quality
  - Surface & ground water contamination w/ pathogens, chemicals

# Extreme Precipitation and Waterborne Disease Outbreaks in the United States, 1948 -1994

- 67% of WBDO preceded by precipitation above the 80th percentile, $p < 0.001$
- 51% of WBDO's preceded by precipitation above the 90th percentile, $p < 0.002$
  - Surface water-related outbreaks 1 month after extreme precipitation
  - Groundwater-related outbreaks 2 months after extreme precipitation.

Curriero et al AJPH 2001:91;1194-1199.

# Extreme Weather Events

- Hurricanes Gustav and Ike, 2008
- Millions without electricity
- Pumping stations and lift stations with no power
  - Drinking water and wastewater treatment impacted
- Flooded wells
- Boil water advisories
- 1993 Midwest flood well data
  - 9 states, widespread contamination, long-term water quality issues with wells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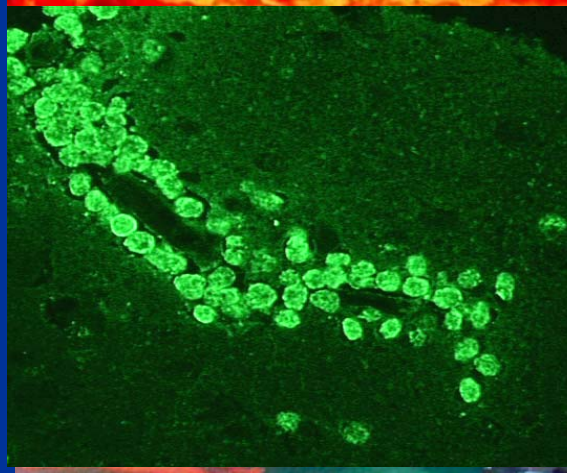
# Higher Temperatures

- Increasing water temperatures and/or nutrients
  - Movement of pathogens to more northern regions
    - *Vibrio paraheamolyticus* in Alaska
  - Enhanced growth of pathogens
    - *Naegleria*, *Vibrio*, harmful algal blooms, *Pseudomonas*
    - Recreational water climate change indicators
    - Increased water use resulting in increased infections, health effects



# Solutions

- How can we address these apparently disparate topics?
  - Transition to developed world paradigm
    - Get on same page
  - Form network of like-minded state/local HD's for collecting data, testing interventions, developing communication materials, planning prevention programs, etc.
  - Collaborative, team-based
  - Multidisciplinary
    - Lab, epidemiology, engineering, environmental heath, behavioral science, economics, etc
  - Consistent funding

# Goals of Waterborne Disease Prevention Network

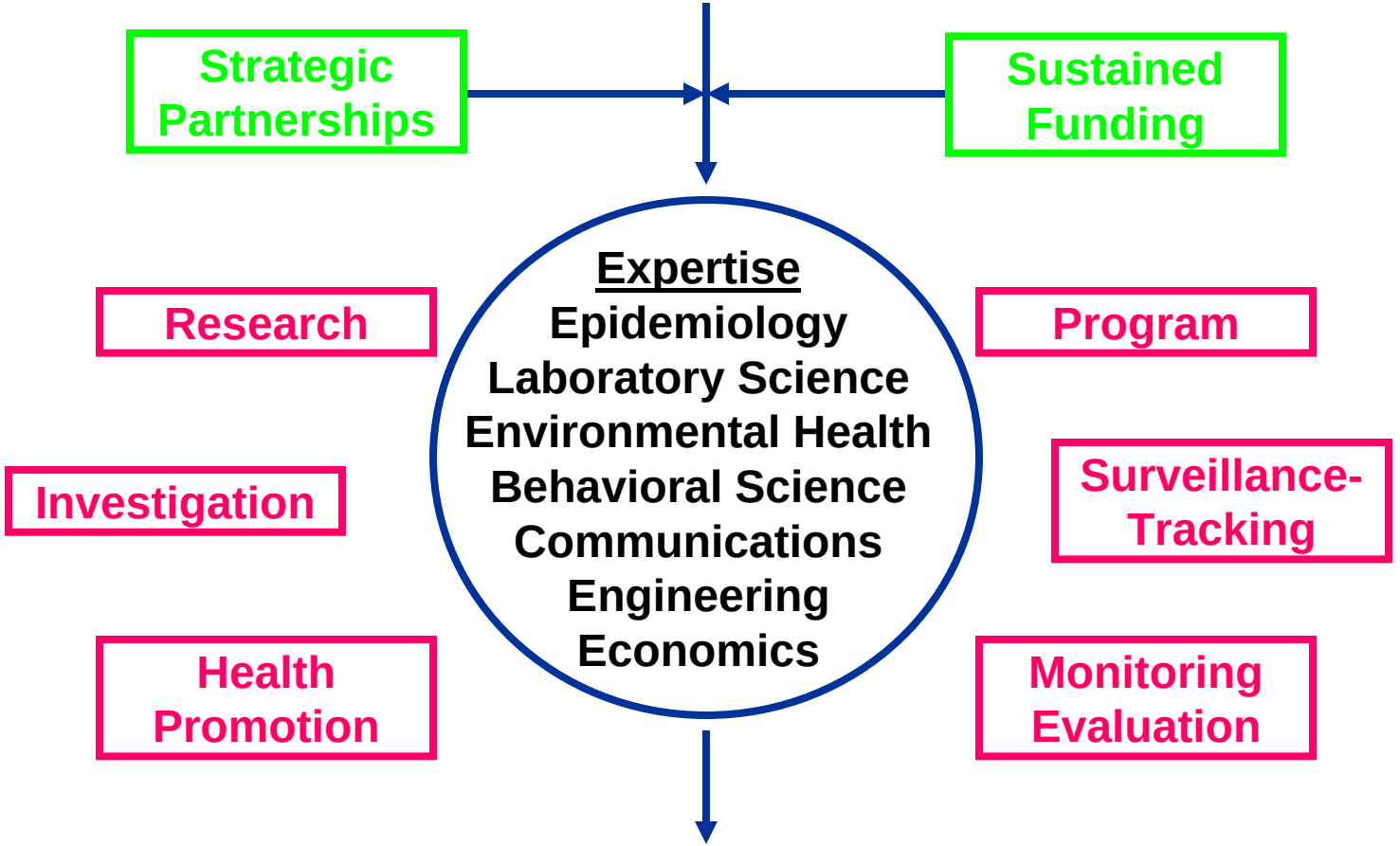
- Strengthen national waterborne disease detection, investigation, diagnostic, and reporting capacity
- Promote education and training through improved access to water-related public health information
- Develop and evaluate public health interventions to provide safe water and prevent waterborne disease

# Goals of Waterborne Disease Network

- Develop environmental testing and diagnostic methods to characterize waterborne pathogens
- Test disinfection and filtration methods for waterborne pathogen inactivation or removal
- Provide public health expertise and technical assistance to help develop improved policy and regulations

# WaterNET

**Prevention network for public health issues arising from drinking, recreational, and other water uses**




**Identify emerging public health issues**
**Answer water-specific health research questions**
**Develop recommendations for decreasing waterborne illness**

# Summary

- Changing paradigm of waterborne disease
  - Increasing importance of outbreaks associated with groundwater and private systems
  - Increasing importance of premise plumbing (e.g., *Legionella*)
  - Increases in recreational water assoc. outbreaks
- New Challenges
  - Aging drinking water infrastructure
  - Increasing complexity of chemical contamination
  - New pathogens, some more chlorine resistant
  - Severe weather effects
  - Water re-use
  - Food production

# Future Needs

- Improved detection/investigation/reporting
- Accurate burden estimate for all waterborne disease
- Investment in drinking water infrastructure
- Health effects studies and intervention testing
- Guidance on adaptive strategies for water scarcity
- Prevention network to address future needs

# Newly Required Disclaimer From the Department of Health and Human Services (Please Interpret as You See Fit)


- "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“

# Acknowledgements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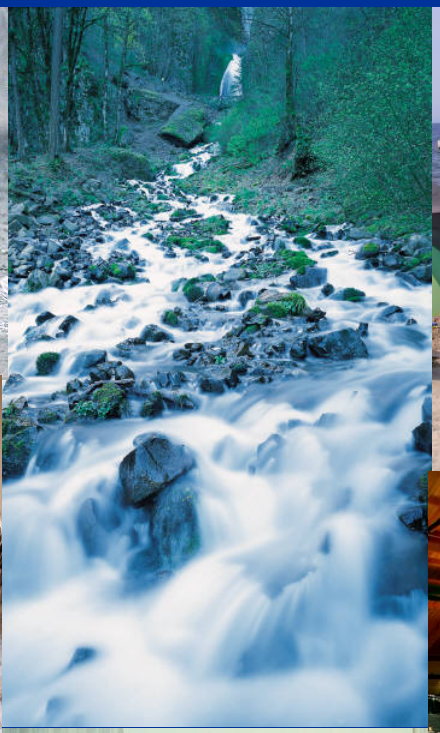
# Questions?
# www.cdc.gov/healthywater &
# www.cdc.gov/healthyswimming

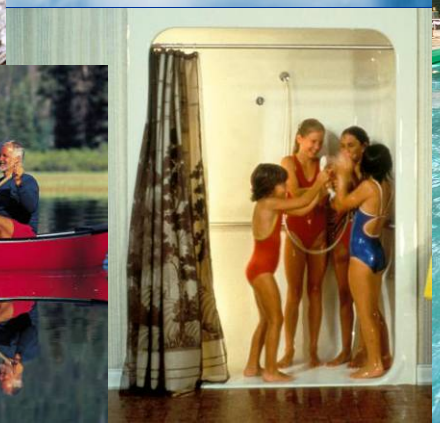












# Think Healthy. Be Healthy. Swim Healthy!

**Remember, you share the pool water with everyone.**

If someone with diarrhea contaminates the water, swallowing that water can make you sick.

*Pool water is not drinking water.*

So, you think chlorine kills germs. Yes, it does. But it doesn't work right away. It takes time to kill germs.

Without your help, even the best-maintained pools can spread germs.

**Many people have become sick from germs found in contaminated recreational water.**

**What are Recreational Water Illnesses?**
Recreational Water Illnesses (RWIs) are the various illnesses caused by germs that can contaminate water in pools, lakes, and the ocean. The most common RWI is diarrheal illness caused by germs like "Crypto" and *E. coli* O157:H7.

**How is diarrheal illness spread?**
You share the pool water with everyone. A person with diarrhea can easily contaminate the pool with fecal matter. Germs that cause diarrheal illness can be spread when swimmers swallow contaminated water.

*Pool water is not drinking water.*

**Does chlorine protect against RWIs?**
Yes, RWI germs are killed by chlorine, but it doesn't work right away. Some germs, like "Crypto," can live in pools for days. Without your help, even the best-maintained pools can spread germs.

**FOR MORE INFORMATION, VISIT**
**www.cdc.gov/healthyswimming**

## Three Steps for Water Safety

**PLEASE** keep an eye on your child at all times. Remember, kids can drown in seconds and in silence.

**PLEASE** use appropriately fitted life jackets* instead of air-filled or foam toys (such as "water-wings" or "noodles"). These toys are not designed to keep children safe.
*www.uscgboating.org/waypoints/archived/may07/art1_care.htm

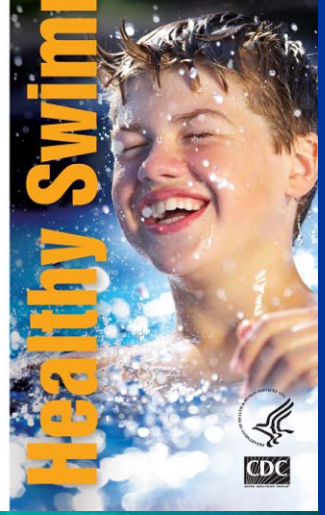
**PLEASE** use sunscreen with at least SPF 15 and both UVA and UVB protection, and be sure to reapply it after swimming. Just a few serious sunburns can increase the risk of getting skin cancer.

**FOR MORE INFORMATION, VISIT**
**www.cdc.gov/healthyswimming**

**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES**
**Centers for Disease Control and Prevention**

# Healthy Swimming

**Protect Yourself and Your Family Against Recreational Water Illnesses**



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# Practice These Six Steps to Protect Yourself and Others

**Without Your Help, Even the Best-Maintained Pools Can Spread Germs**

## All Swimmers

**Keep germs from causing recreational water illnesses (RWIs)**

**PLEASE** don't swim when you have diarrhea. You can spread germs in the water and make other people sick.

**PLEASE** don't swallow pool water. Avoid getting water in your mouth.

**PLEASE** practice good hygiene. Shower with soap before swimming and wash your hands after using the toilet or changing diapers. Germs on your body end up in the water.

## Parents

**Keep germs out of the pool**

**PLEASE** take your kids on bathroom breaks or check diapers often. Waiting to hear "I have to go" may mean that it's too late.

**PLEASE** change diapers in a bathroom or a diaper-changing area and not at poolside. Germs can be spread in and around the pool.

**PLEASE** wash your children thoroughly (especially the rear end) with soap and water before they go swimming. Invisible amounts of fecal matter can end up in the pool.

# Also available in Spanish

# POOL CHEMICAL SAFETY

## EDUCATE YOURSELF ABOUT POOL CHEMICAL SAFETY

- **ALWAYS** read entire product label or Material Safety Data Sheet (MSDS)
- **ALWAYS** complete appropriate training or education

## STORE POOL CHEMICALS SAFELY

- **ALWAYS** secure chemicals: Keep children and animals away
- **ALWAYS** store chemicals as recommended by the manufacturer
- **ALWAYS** safeguard stored chemicals from mixing or getting wet
- **ALWAYS** respond to pool chemical spills immediately

## USE POOL CHEMICALS SAFELY

- **ALWAYS** read product label and manufacturer's directions before each use
- **ALWAYS** use chemicals in original manufacturer's labeled container
- **ALWAYS** use appropriate protective gear, such as safety glasses and gloves
- **NEVER** pre-dissolve solid chemicals or add water to liquid chemicals
- **NEVER** mix chlorine products with each other, with acid, or with any other substance

For more information about the safe use of pool chemicals, check your pool safety plan or visit
**www.cdc.gov/healthyswimming**

DEPARTMENT OF HEALTH & HUMAN SERVICES, USA
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

Please display this poster in your pool's pump room ■ Para español, vea el reverso

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SAFER·HEALTHIER·PEOPLE

# New CDC Healthy Water Website
# www.cdc.gov/healthywater