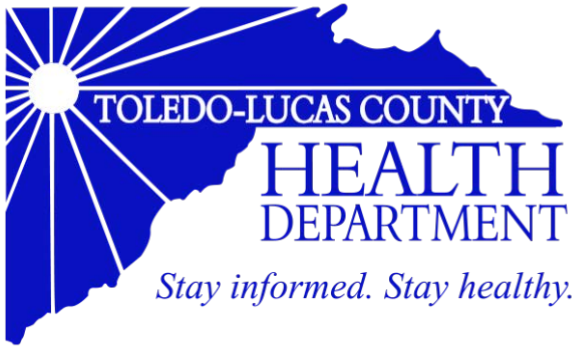
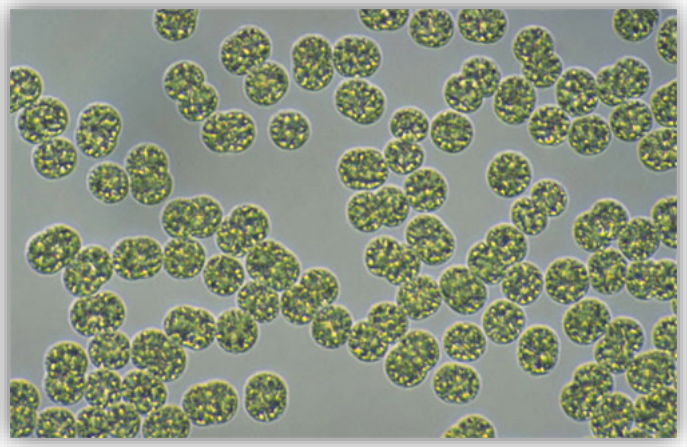
Impacts of Microcystin in a Municipal Water Supply



What is HAB?

- A Harmful Algal Bloom (HAB) is a large growth of cyanobacteria (blue-green algae) that can produce toxins
- These bacteria are naturally found in Ohio lakes, ponds, and slow-moving streams
- Microcystin is a class of toxin produced by certain freshwater cyanobacteria



Aerial View of Western Lake Erie from August 4, 2014

Why does a HAB occur?

- Under the right water conditions (typically warmer months), the number of the blue-green algae dramatically increase, or “bloom”

- Some blooms can be visible as thick mats or scum on the surface of the water, while others can be present without visible surface scum

Why does a HAB occur?

- Blue-green algae need warm temperatures, sunlight, phosphorous, and nitrogen to reproduce

- Phosphorus and nitrogen are commonly found in animal and human waste and in fertilizers
  - Some common ways for phosphorous and nitrogen to enter lakes and streams are from:
    - Agricultural and residential lawn runoff
    - Improperly functioning septic systems
    - Erosion of nutrient-rich soil

Exposure Guidelines

- Vary greatly from state-to-state
- United States EPA follows World Health Organization
- Prior to August 2014, Ohio had no firm guidelines about microcystin
- World Health Organization advises a concentration of:
  - No greater than 1.0 ppb for consumption
  - No greater than 6.0 ppb for recreational water exposure

Drinking Water Exposure

State Only 3/50 states	Drinking Water Guidance/Action Level
Minnesota	Microcystin-LR: 0.04 ppb
Ohio	Microcystin: 1.0 ppb
Oregon	Microcystin-LR: 1.0 ppb

http://www2.epa.gov/nutrient-policy-data/policies-and-guidelines

Recreational Water Exposures

State Only 20/50 states	Recreational Water Guidance/Action Level	Recommended Action
California	Microcystin: 0.8 ppb	Advisory
Illinois	Microcystin-LR concentration results approach or exceed 10 ppb	Reporter of HAB event and the local lake management entity will be informed immediately
Indiana	Level 1: very low/no risk < 4 ppb Level 2: low to moderate risk 4-20 ppb Level 3: serious risk > 20 ppb	Level 1: use common sense practices Level 2: reduce recreational contact with water Level 3: consider avoiding contact with water until levels of toxin decrease
Ohio	Microcystin: 6 ppb (Public Health Advisory- PHA) and 20 ppb (No Contact Advisory-NCA)	PHA- swimming and wading not recommended, water should not be swallowed and surface scum should be avoided. NCA- recommend the public avoid all contact with the water

http://www2.epa.gov/nutrient-policy-data/policies-and-guidelines

What are the Health Effects of HAB?

- Contact with the skin may cause rashes, hives, or skin blisters (especially on the lips and under swimsuits)

- Breathing aerosolized water droplets from lake water-related recreational activities and/or lawn irrigation can cause runny eyes and noses, a sore throat, asthma-like symptoms, or allergic reactions

What are the Health Effects of HAB?

- Swallowing HAB-contaminated water can cause:
  - Acute (immediate) severe diarrhea and vomiting
  - Liver toxicity (abnormal liver functioning, abdominal pain, diarrhea and vomiting)
  - Kidney toxicity
  - Neurotoxicity (weakness, salivation, tingly fingers, numbness, dizziness)
  - Difficulty breathing
  - Death

Not Just a Lake Erie Problem…

- Harmful Algal Blooms have also appeared in:
  - Grand Lake St. Mary's
  - Village of Cadiz
  - City of Clyde
  - Buckeye Lake
  - Bowling Green Reservoir
  - And others…

Volume 92 Issue 32 | p. 9 | News of The Week
Issue Date: August 11, 2014 | Web Date: August 8, 2014

Danger From Microcystins In Toledo Water Unclear

Safety: Algal contaminants have varying toxicities

By Elizabeth K. Wilson

Department: Science & Technology
News Channels: Environmental SCENE
Keywords: Toledo, microcystin, blue-green, algae, water supply, drinking water

[+]Enlarge

A bloom in Lake Erie of blue-green algae, which can produce liver toxins, made the water unfit to drink.
Credit: AP

An academic lab on Aug. 7 released test results of water from Lake Erie that paint a more complicated, and possibly less toxic, picture of the potential health hazards from the presence of algal toxins in the tap water of Toledo, Ohio. Residents were ordered not to drink from their taps for several days.

On Aug. 1, the **Collins Park Water Treatment Plant**, which treats Toledo's Lake Erie-based water supply, found elevated levels of microcystins, a class of more than 90 related compounds that are produced by blue-green algae, or cyanobacteria, and which are highly toxic to the livers of humans and other animals.

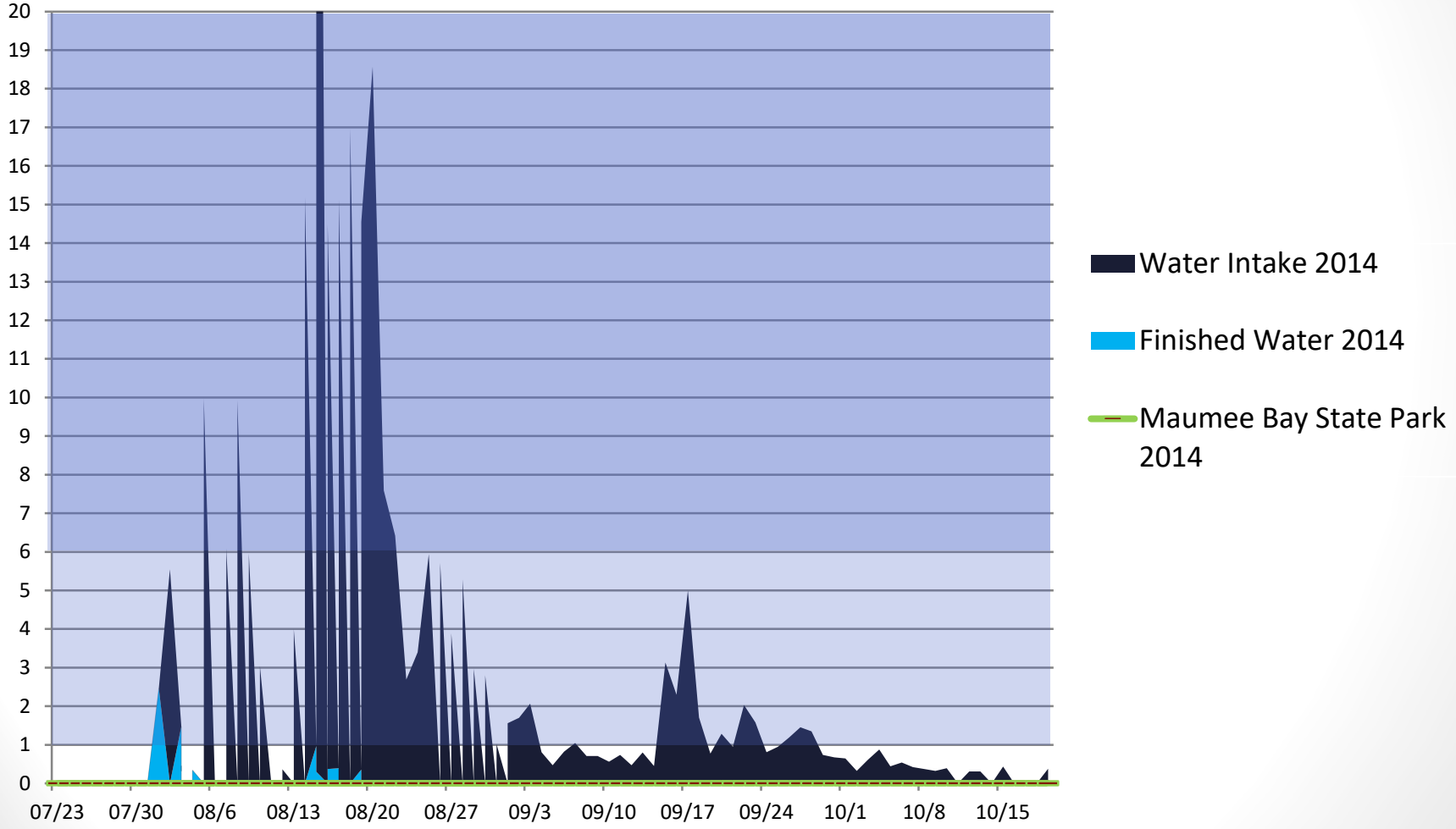
The situation prompted the **Ohio Environmental Protection Agency** to order the temporary tap water ban, which was lifted on Aug. 4.

But the true danger posed by the microcystin contamination remained unclear because scientists didn't know exactly which microcystins were present, says **Gregory L. Boyer**, acting director of the Great Lakes Research Consortium. He notes that algae found in Lake Erie produce

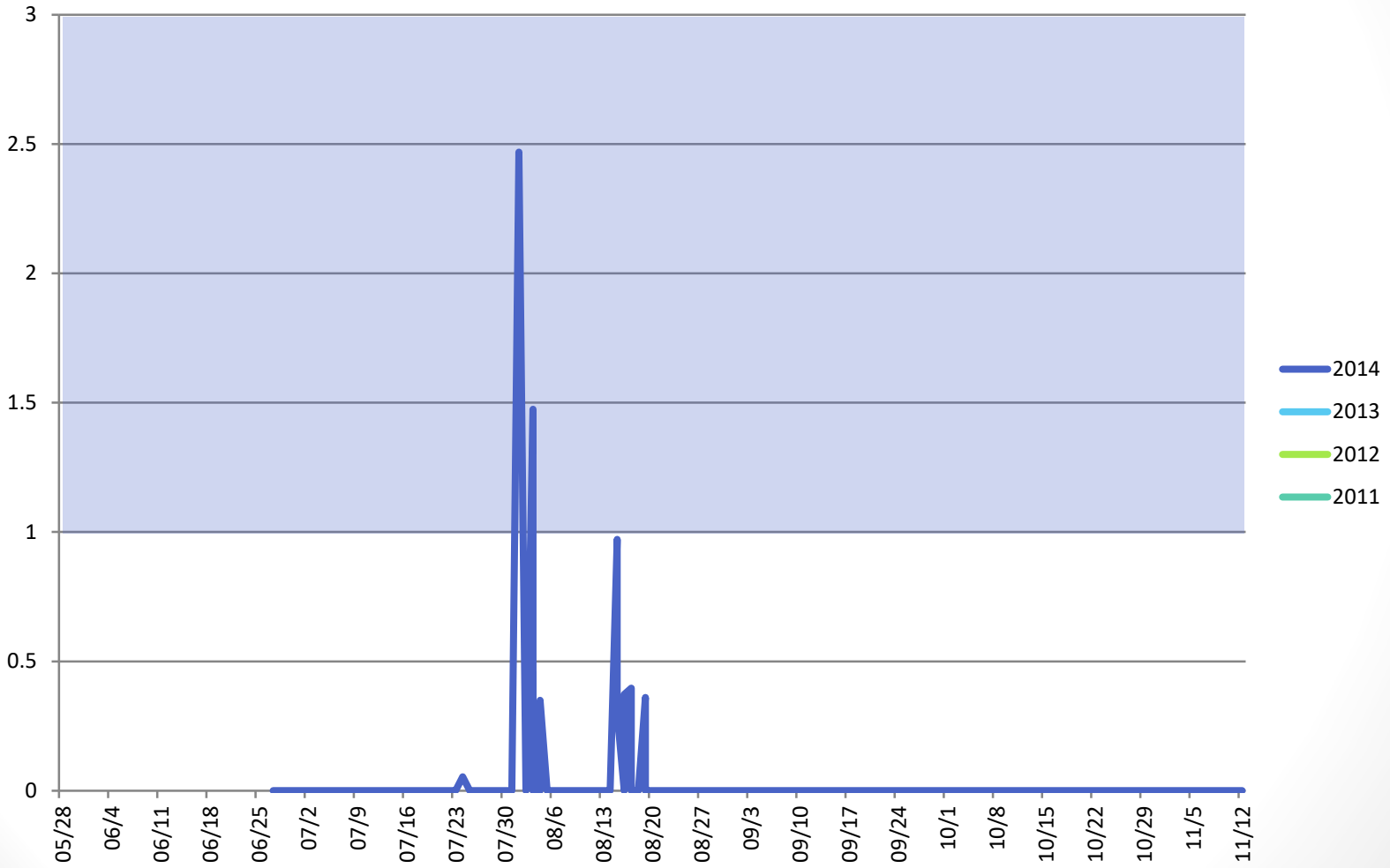
The Collins Park Water Treatment Plant used an enhanced treatment plan to remove microcystins in Toledo water, according to the *Chemical and Engineering News* report. First, extra powdered activated carbon helped bind or "adsorb" microcystin to the surface of powdered carbon. Additional alum was added as well;

The public safety warnings w
treatment plants showed readings for the toxin, although it isn't clear how high the

2014 Microcystin Levels

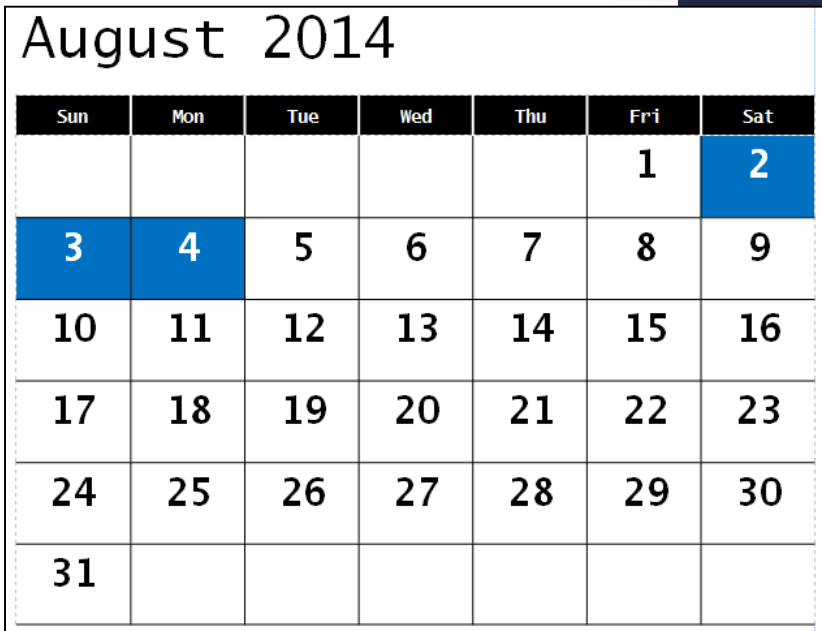


Microcystin Sampling for City of Toledo, Finished Water



Brief Timeline of Events

- EPA (prior to August 2014) did not require municipal water suppliers to test for Microcystin
- Municipal water supplied by Collins Water Treatment Plant regularly tested for Microcystin during period when Algal Blooms occur on Lake Erie (typically July-October)
  - Population Served by Collins Water Treatment Plant:
    - Lucas County: 370,314
    - Wood County: 39,700
    - Fulton County: 2,250
    - Monroe County: 28,288
- August 1, 2014 – reported elevated result (2.469 ppb)

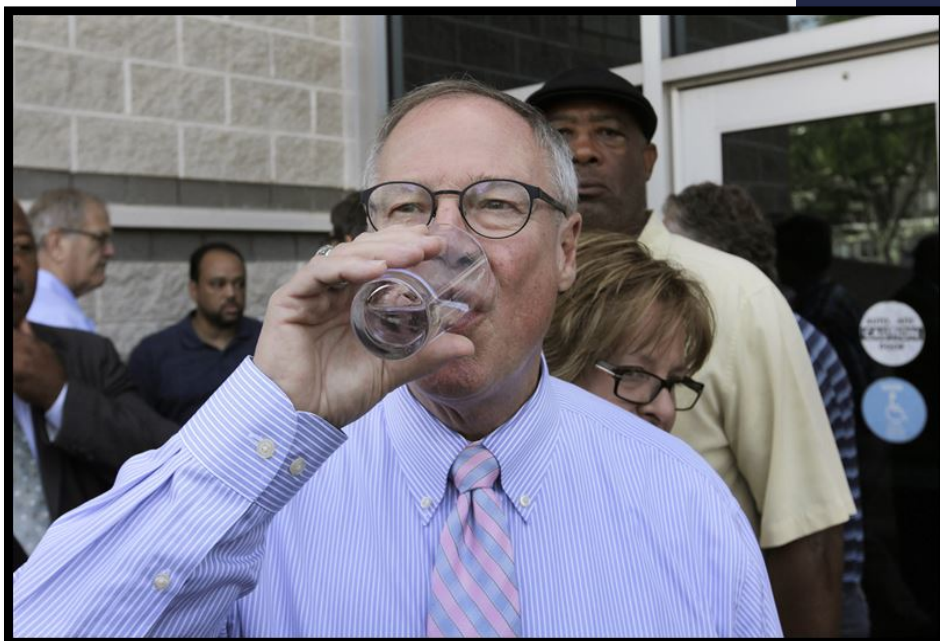


August 2014

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Brief Timeline of Events

- Early AM August 2, 2014 – >1.0 ppb result
  - World Health Organization recommends drinking water concentration 1.0 ppb or less (no national standard)
- Early AM: “DO NOT DRINK” and “DO NOT TOUCH” advisory sent out to media outlets/stakeholders
- Advisory revised later in the day to a “DO NOT DRINK” advisory (safe for bathing/other non-consumption usage)
- Repeat testing occurred multiple times over the entire weekend
- Advisory lifted at 10:00 AM on Monday, August 3, 2014



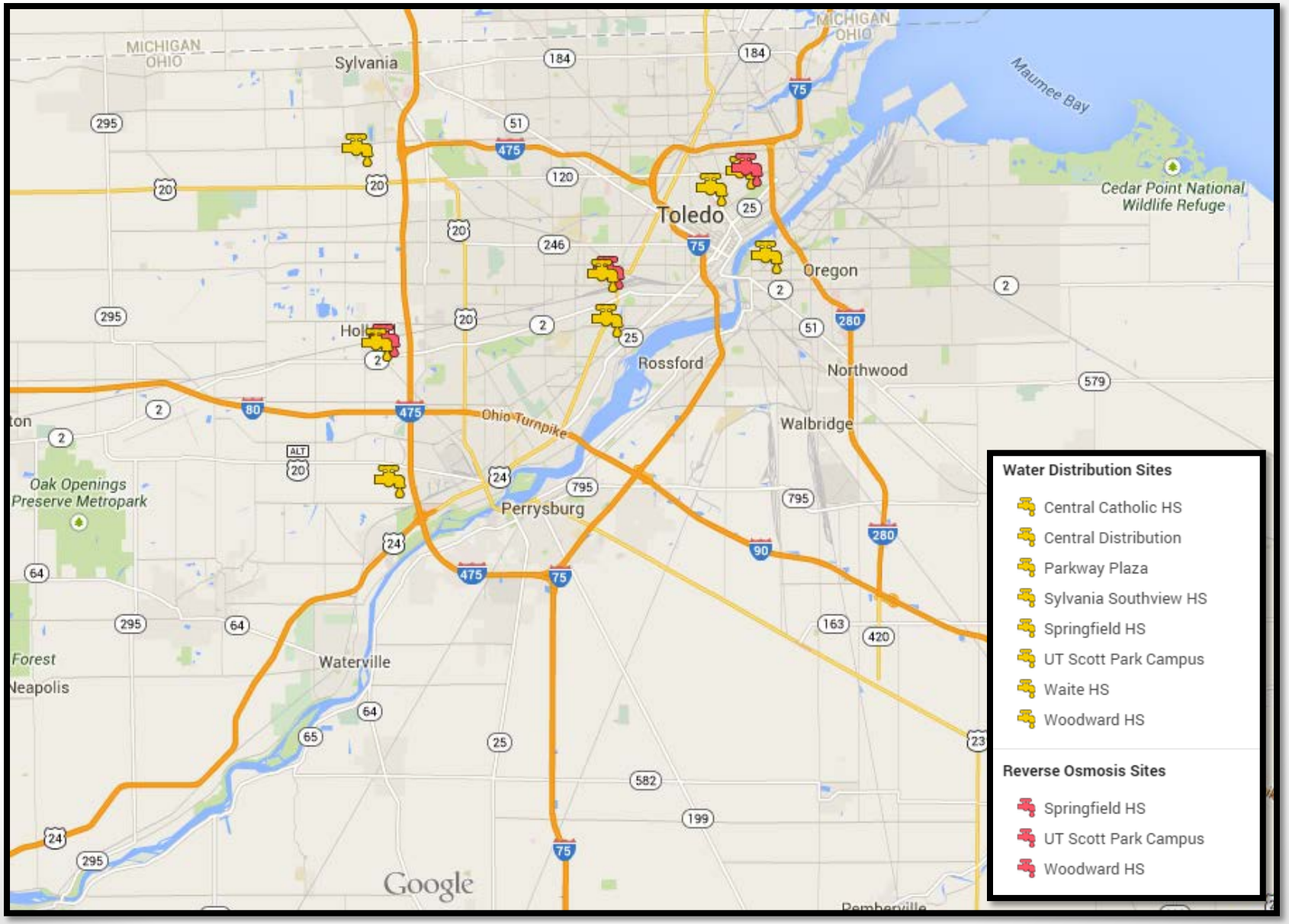
Not *Quite* What Happened

Highlights of the Response

What Nearly Every Store Looked Like in Northwest Ohio
at Approximately 10:00am on August 2, 2014

Donations and Resources Poured in From Numerous Sources

Water Distribution Sites




ingwood Water
419-241-6715

Highlights of the Response

- Enforced water restrictions at restaurant locations that were using unapproved containers for water distribution as well as those that were continuing to operate using tap water, amidst the ban.

- TLCHD's sanitarians staffed a restaurant question hotline for 9 hours on August 3, receiving and responding to public questions at the rate of approximately 100 calls/hour.

- Conducted health surveillance of hospital emergency departments on impact of the event to residents.

Highlights of the Response

- Coordinated the distribution of ready-to-feed formula to participants of the Women, Infants and Children (WIC) supplemental nutrition program and ensured sufficient metabolic formula was available to infants with special dietary needs.

- American Red Cross provided home delivery to shut-ins and other individuals with functional needs unable to visit distribution sites.

- Facilitated outreach to impacted long-term care, adult care, and rehabilitative care, other congregate care facilities, and dialysis centers to ensure their operations were provided with necessary water and proper education.

Highlights of the Response

- Provided guidance on restaurant openings, doctors and dentists offices, and how to flush plumbing when the incident was officially over and water was once again safe.

- TLCHD's public information officer and back-ups monitored and responded to social media.

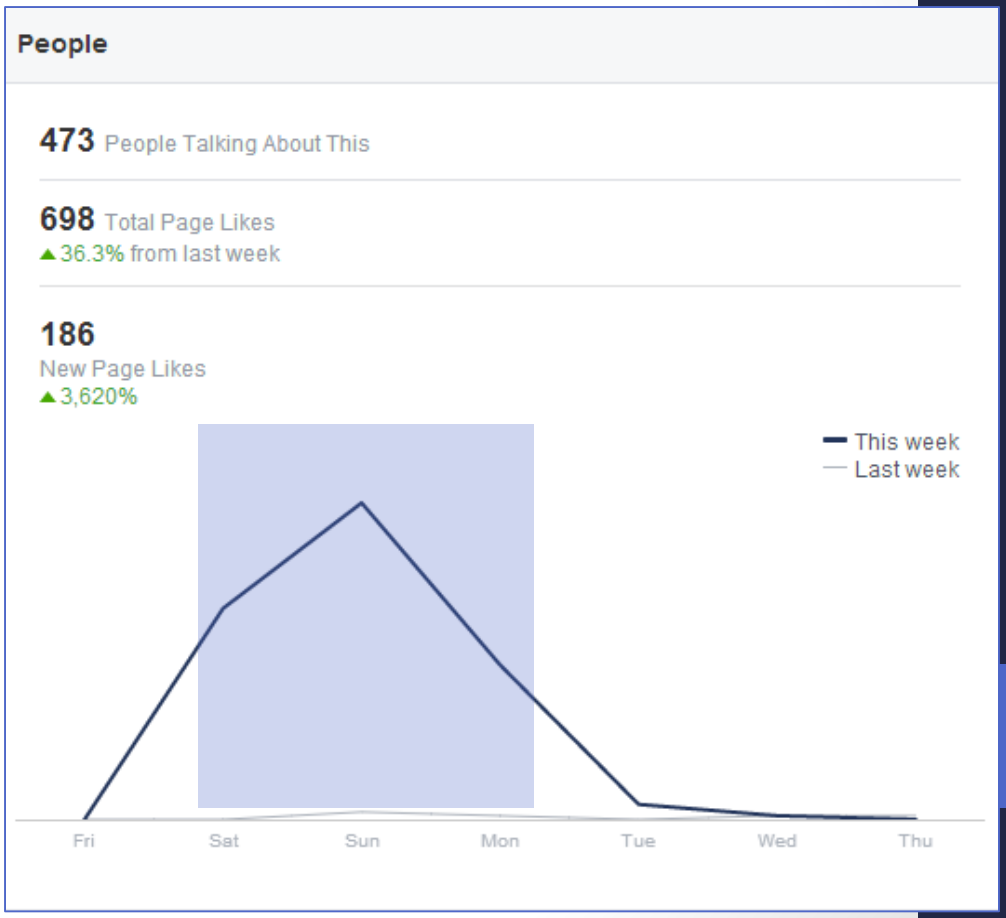
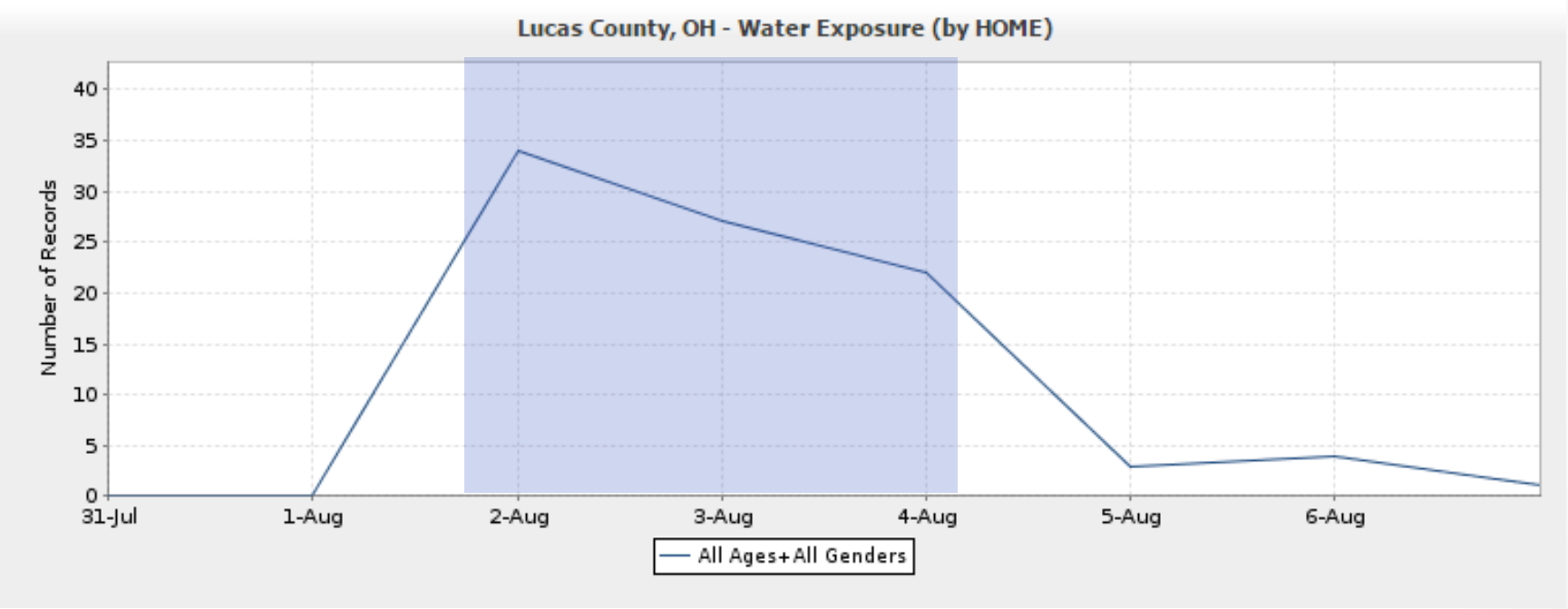


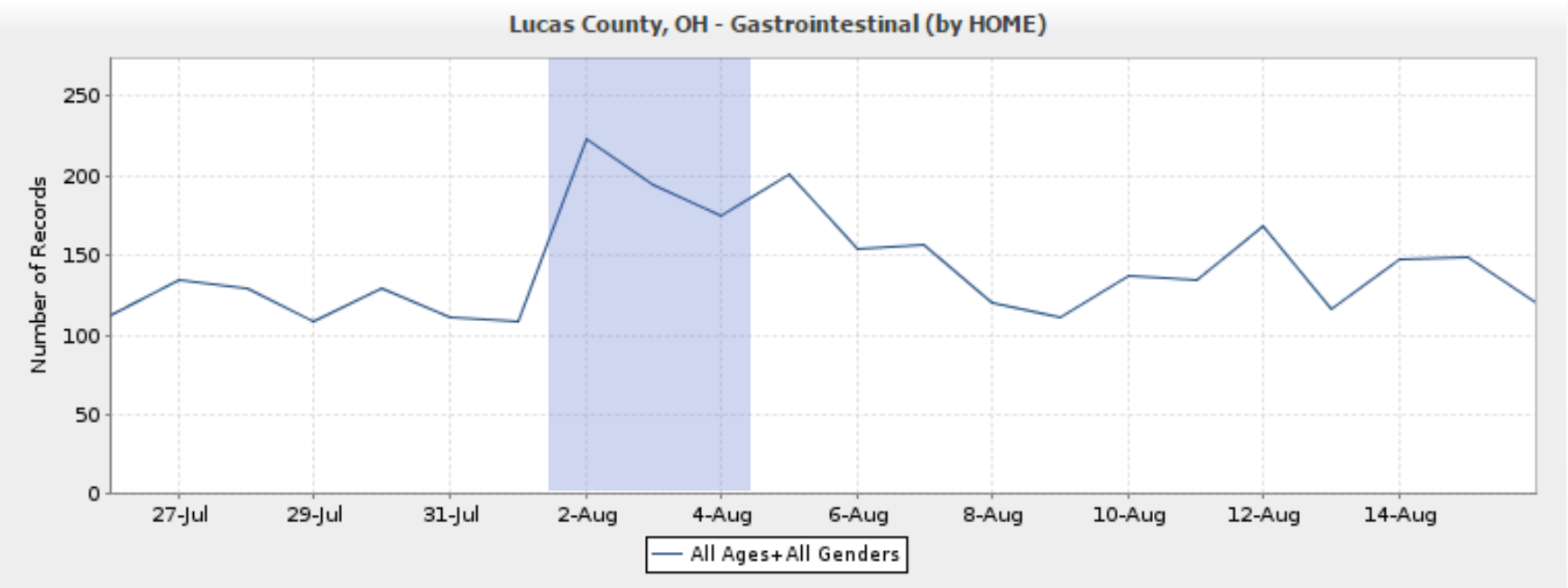
Figure 1 Statistics from TLCHD Facebook Page taken 8/7/14

EpiCenter Data

- Custom Classifier: Water Exposure

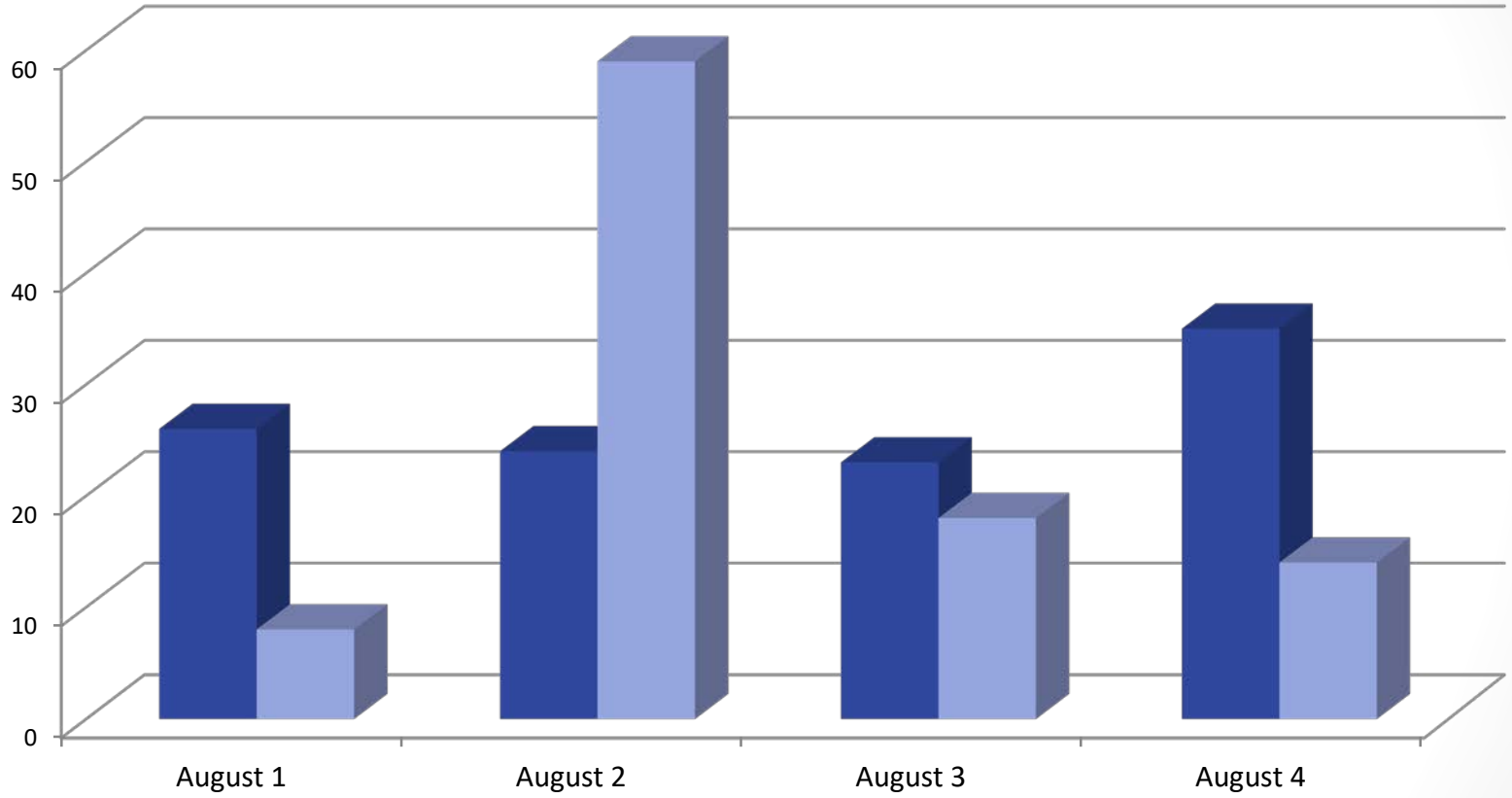


EpiCenter Data



Comparison of Poison Control Calls from Lucas County

1st weekend in August (Water Event)
2013-2014



	August 1	August 2	August 3	August 4
2013	26	24	23	35
2014	8	59	18	14

Investigation

- Difficult to classify illness
  - No “rapid” diagnostics
  - Generalized symptoms
  - Difficult to assess exposures
- Outbreak Definition: Individuals having ED visits from August 1 through August 3, 2014 in Lucas County, Ohio who voiced a concern for illness as a result of the microcystin levels in the municipal water supply

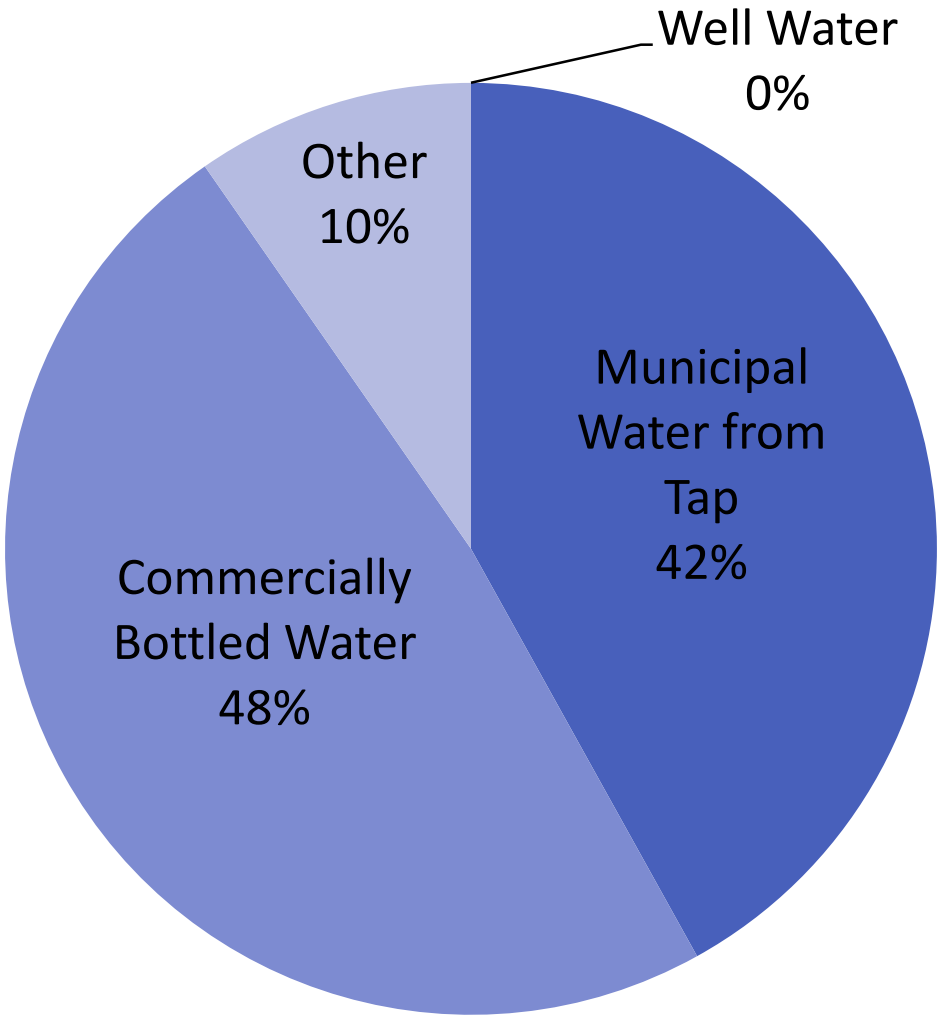
Investigation

- Emergency Department visits were used as a starting point to determine if and how many persons may have been affected, symptoms and the extent of illness
- Line listing was requested from eight hospitals in Lucas County
- Conducted a phone survey of those reporting illness from water (n=110)
  - 28 individuals completed the survey
  - 25% response rate

Data

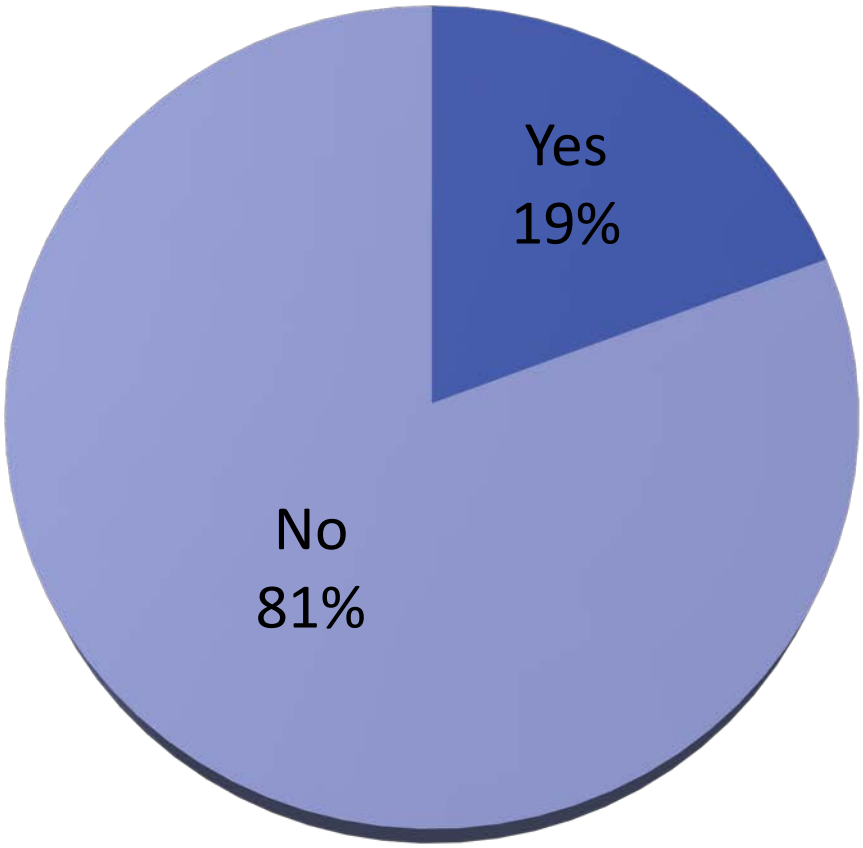
- Demographics of Respondents:
  - Age range (n=27): 1-90 years of age (median 30)
  - Sex (n=27): 19 Female/8 Male
  - Race (n=23):
    - American Indian: 0
    - African American: 8
    - Caucasian: 13
    - Asian/Pacific Islander: 0
    - Unknown: 1
    - Other: 1

Between 8/2/14 and 8/4/14, What Was Your Primary Source of Drinking Water?



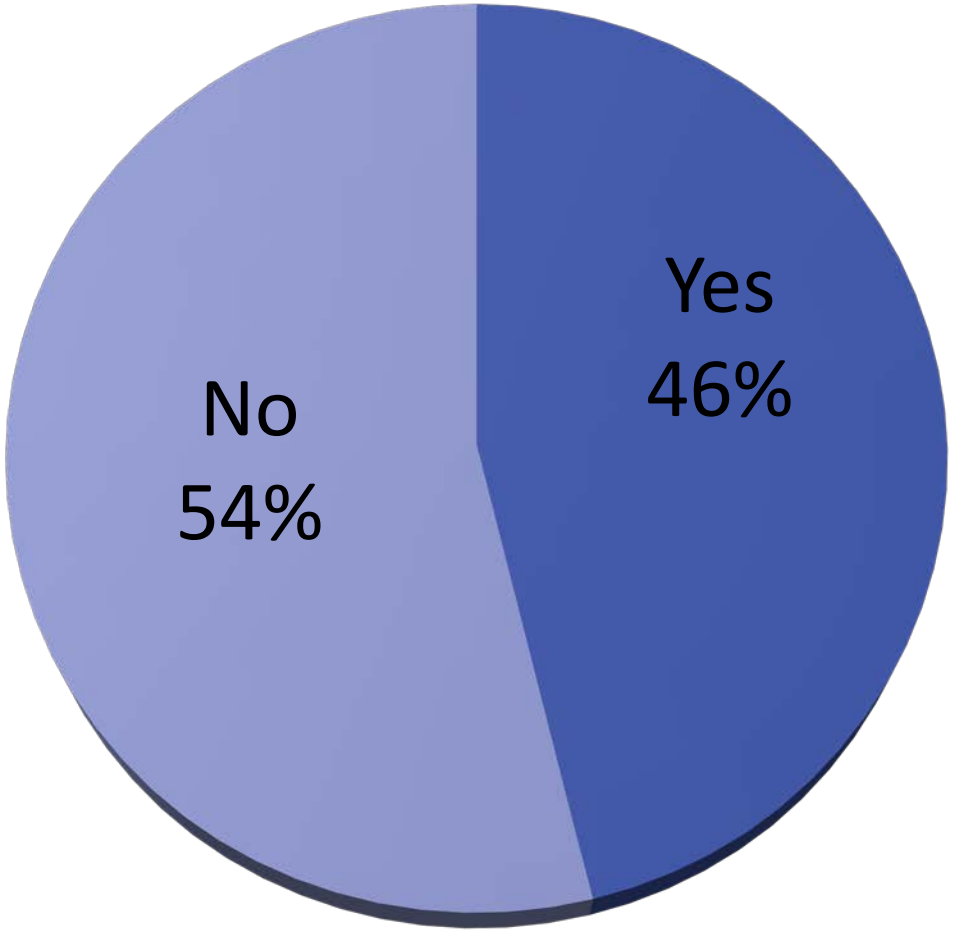
N=28

Between 8/2/14 and 8/4/14, did you use tap water in cooking or preparing food?



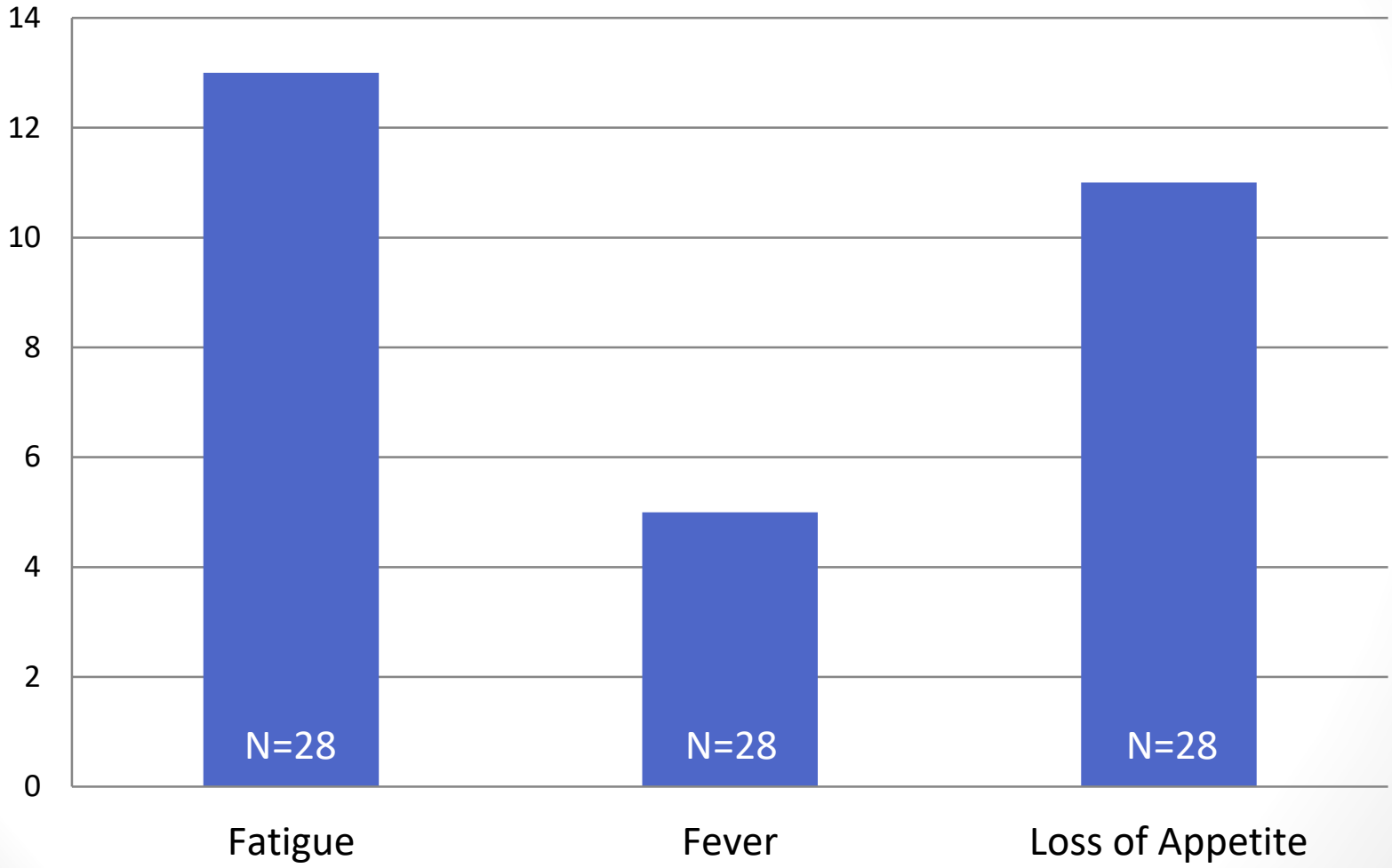
N=26

Between 8/2/14 and 8/4/14, did you use tap water to brush your teeth or clean dentures?

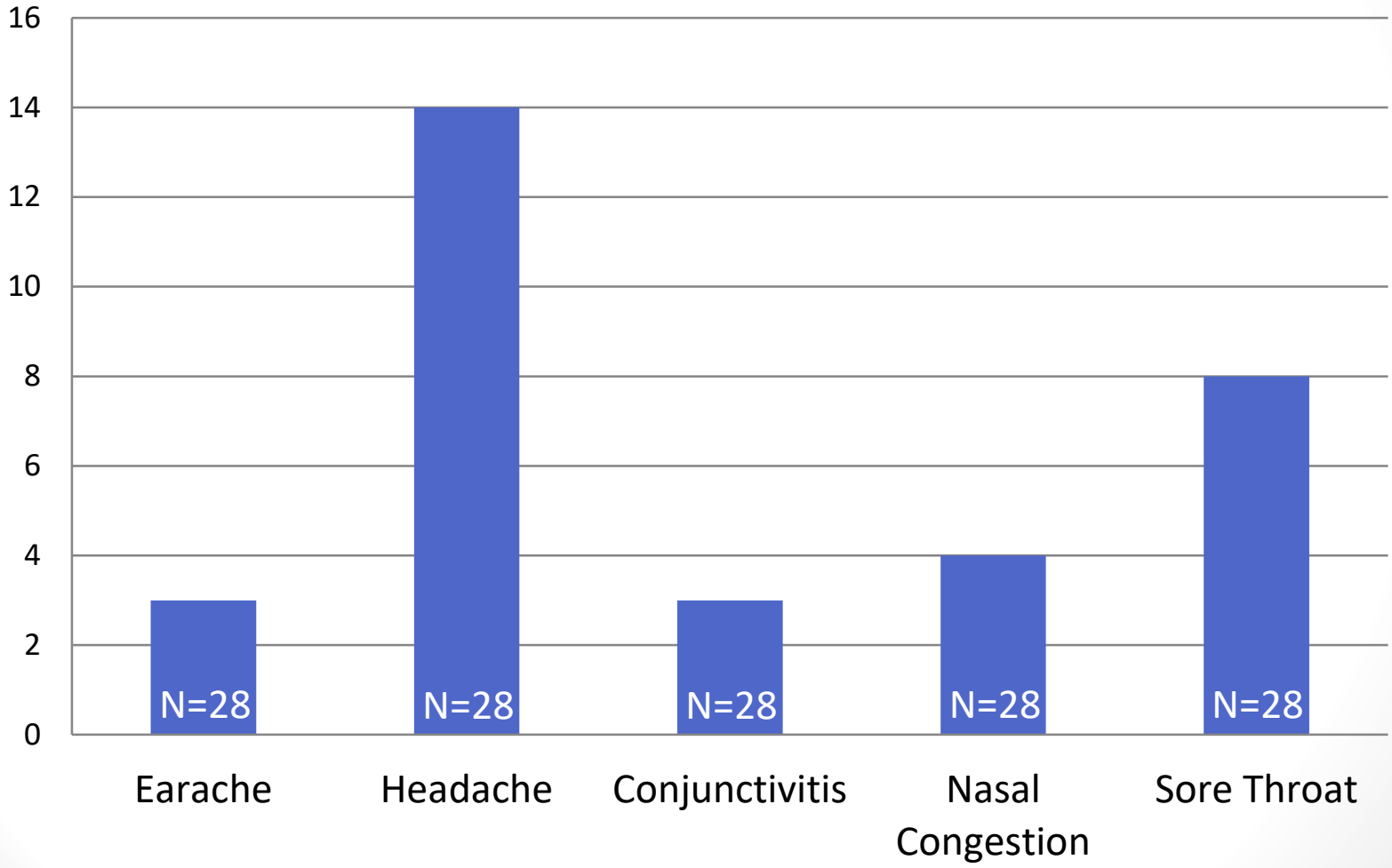


N=26

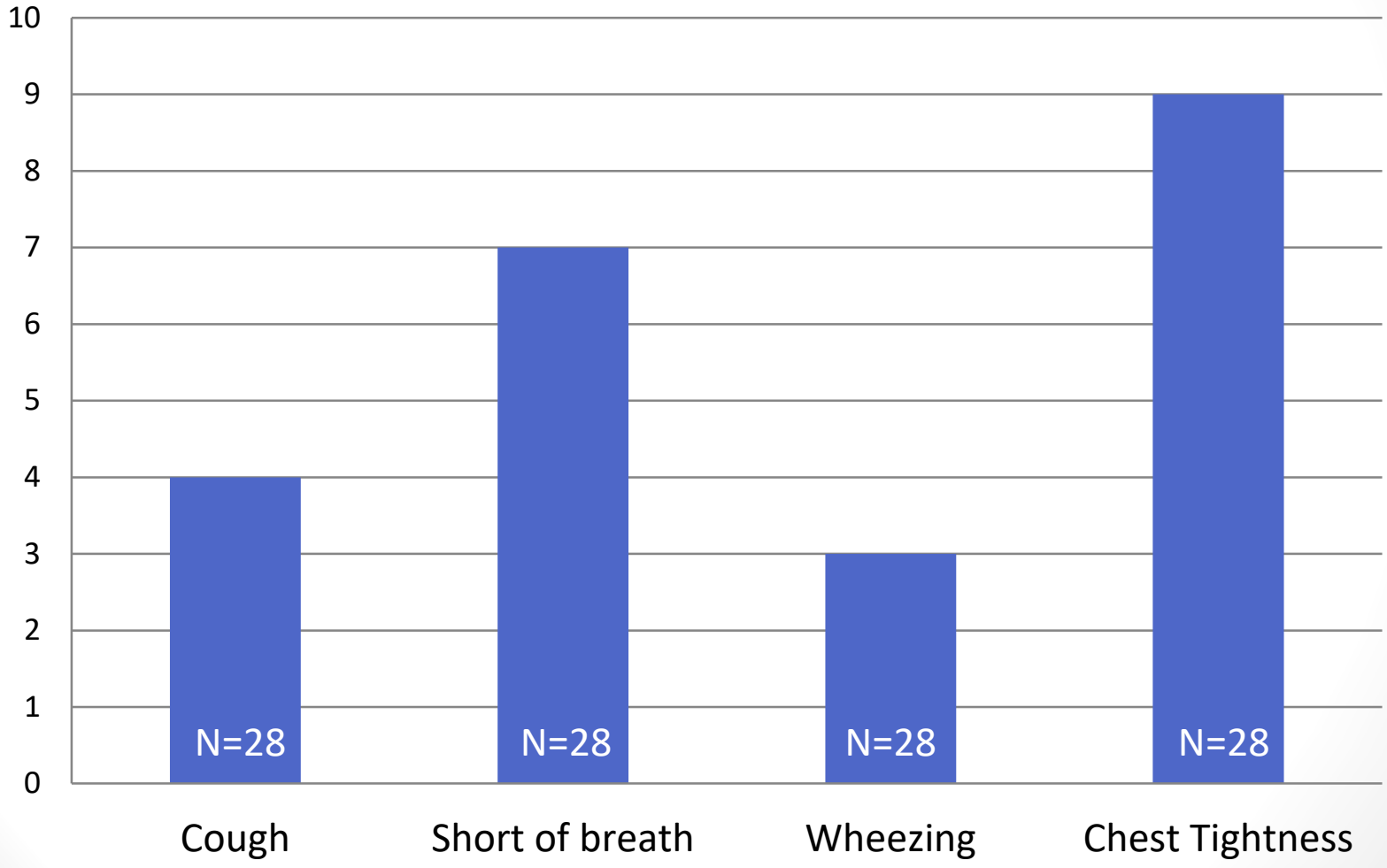
Generalized Symptoms



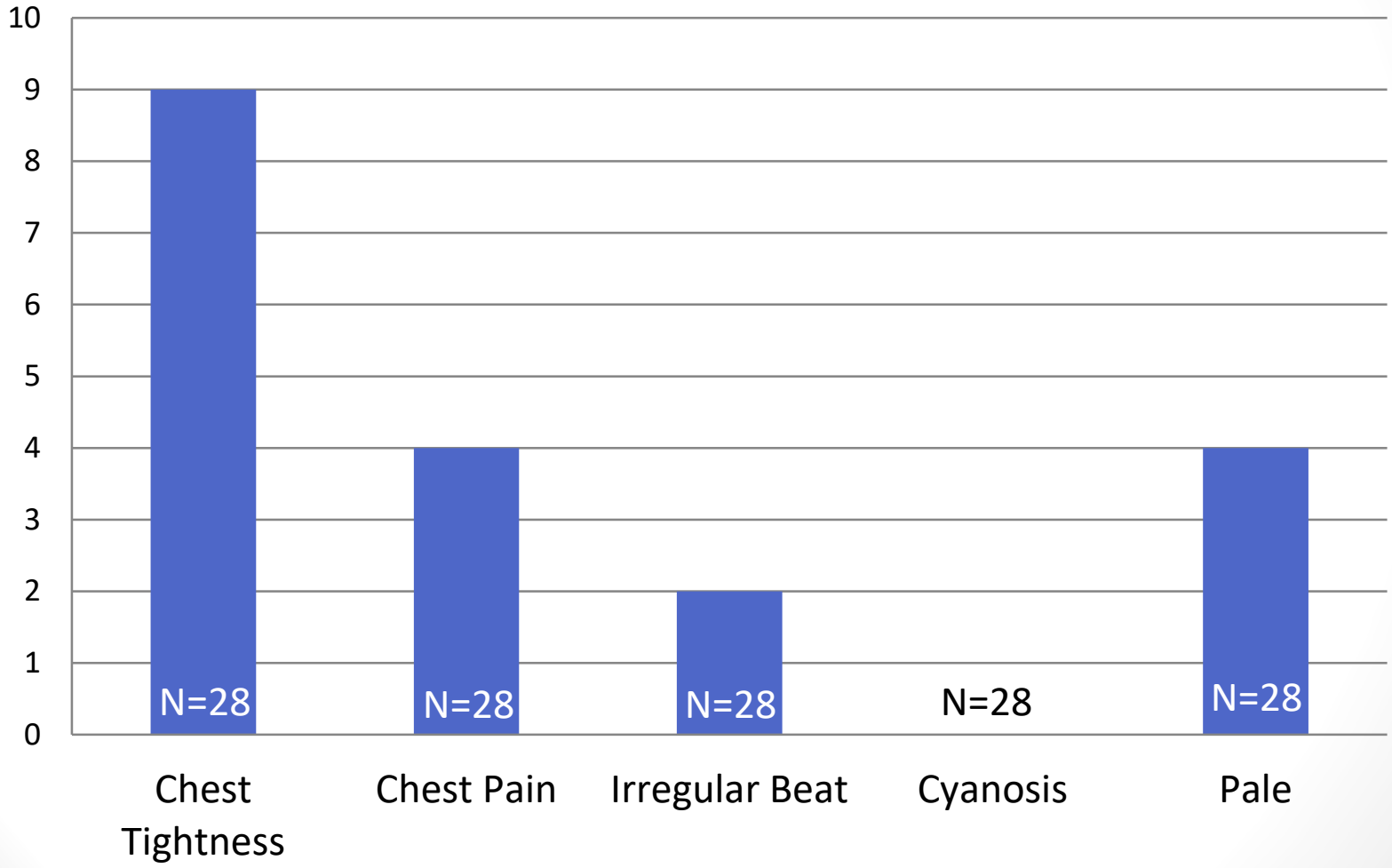
EENT Symptoms



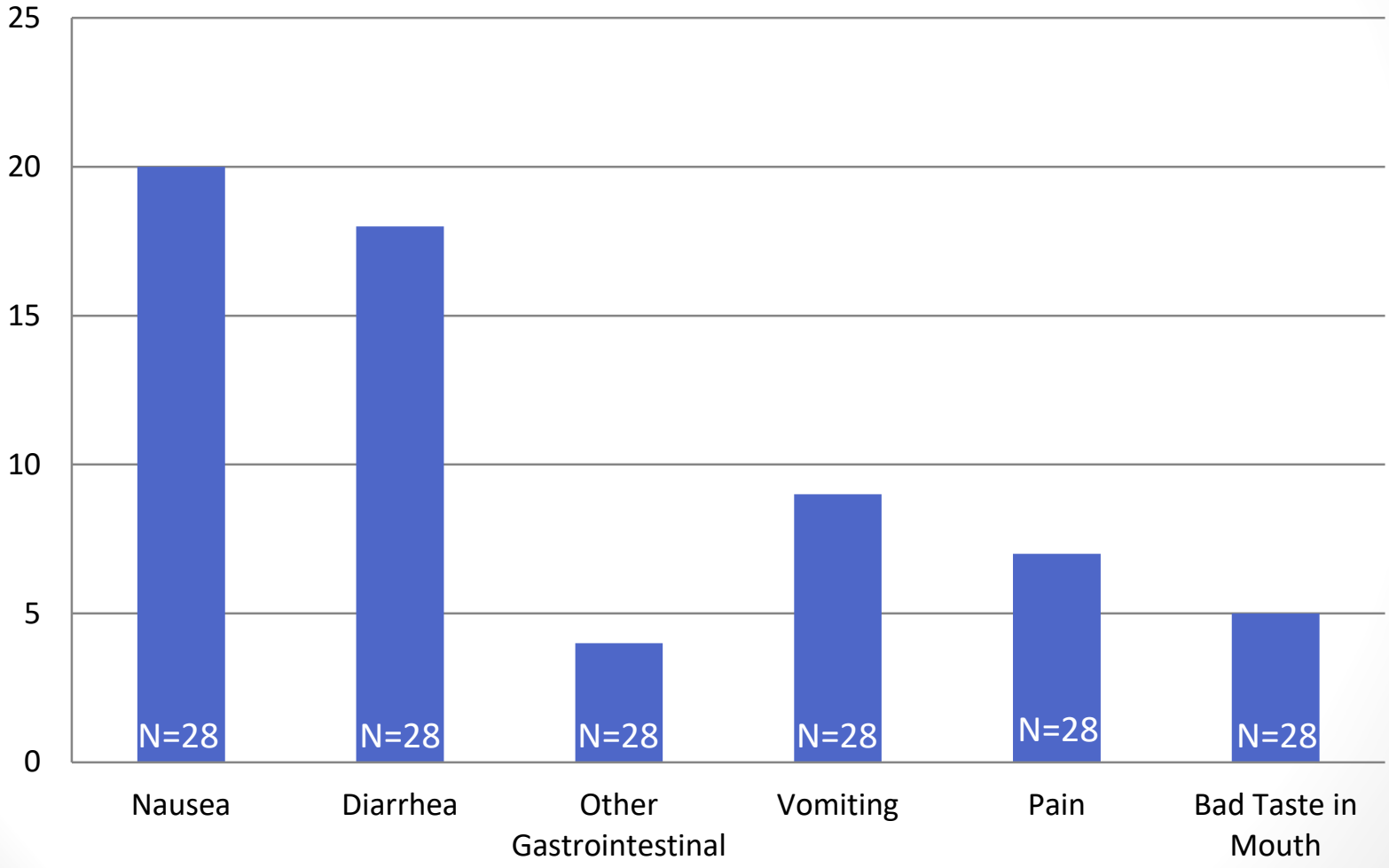
Respiratory Symptoms



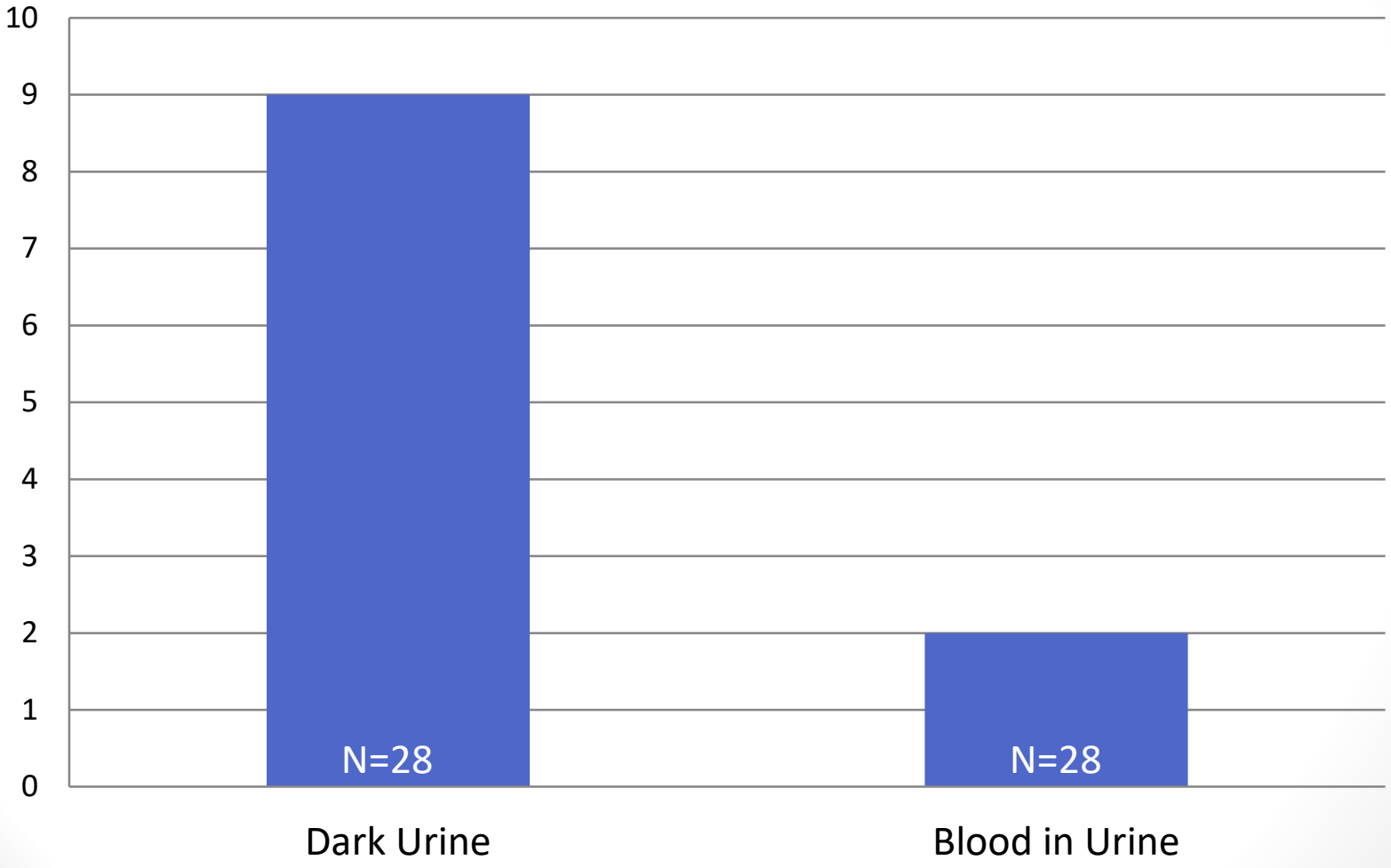
Cardiovascular Symptoms



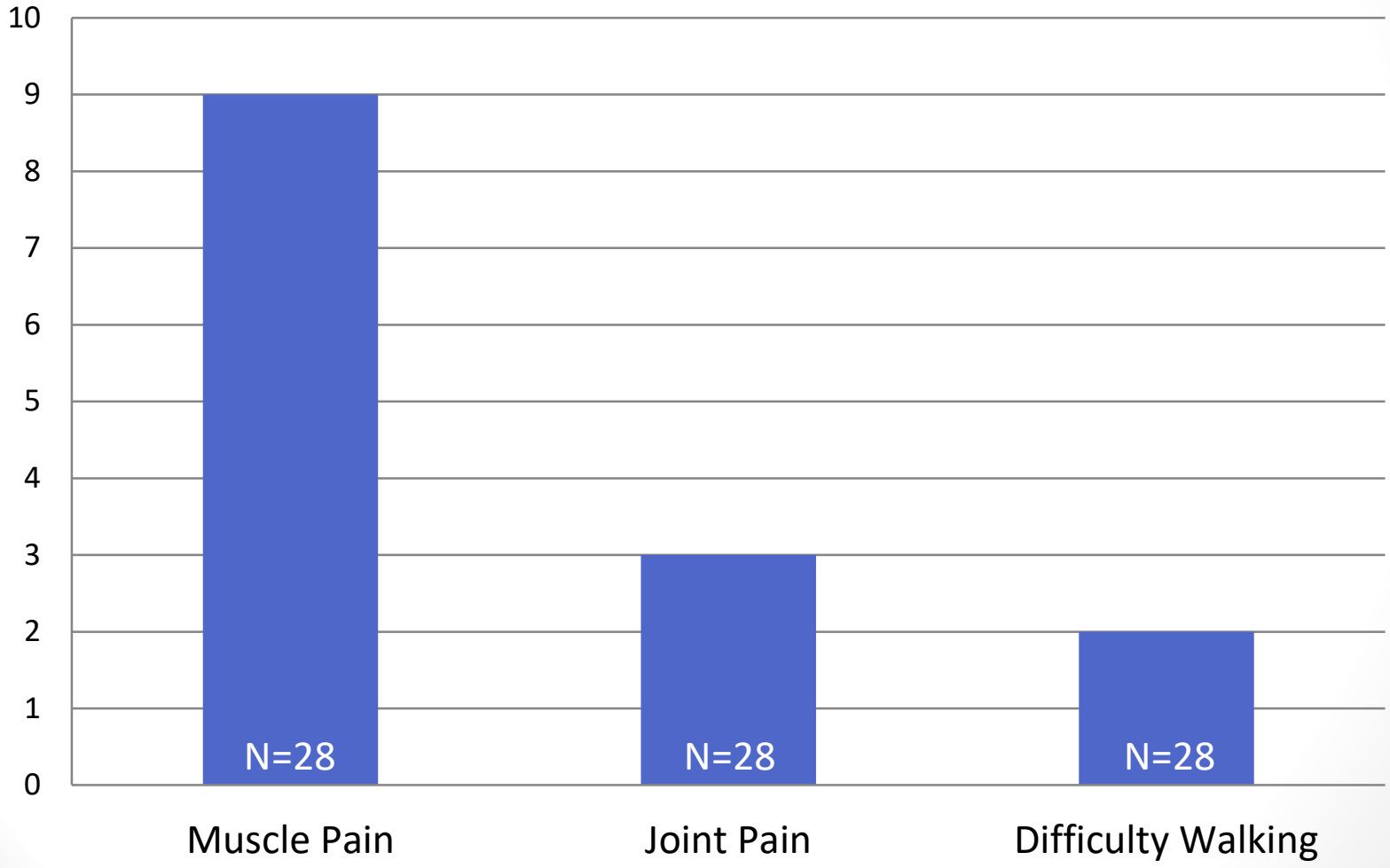
Gastrointestinal Symptoms



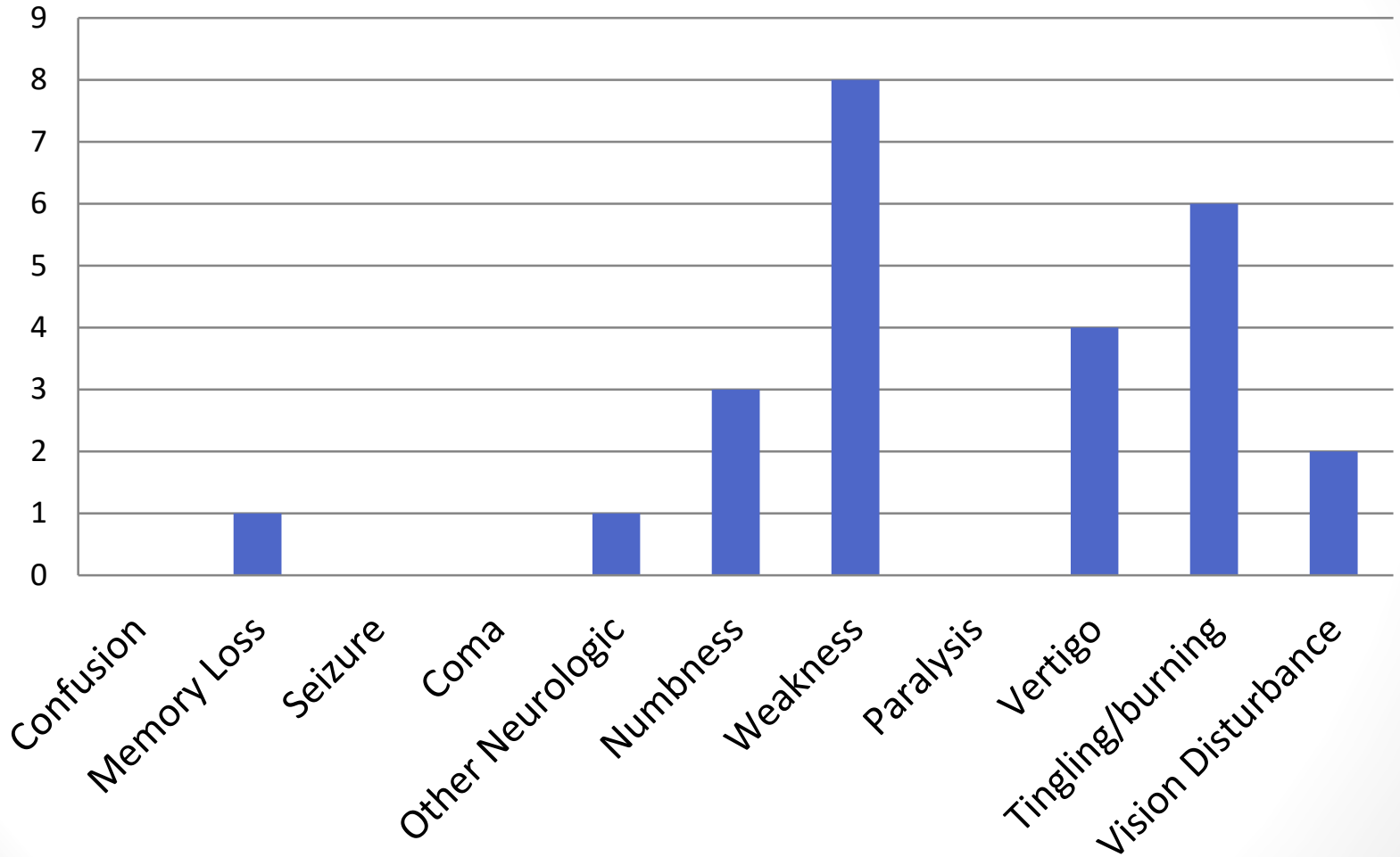
Genitourinary Symptoms



Musculoskeletal Symptoms

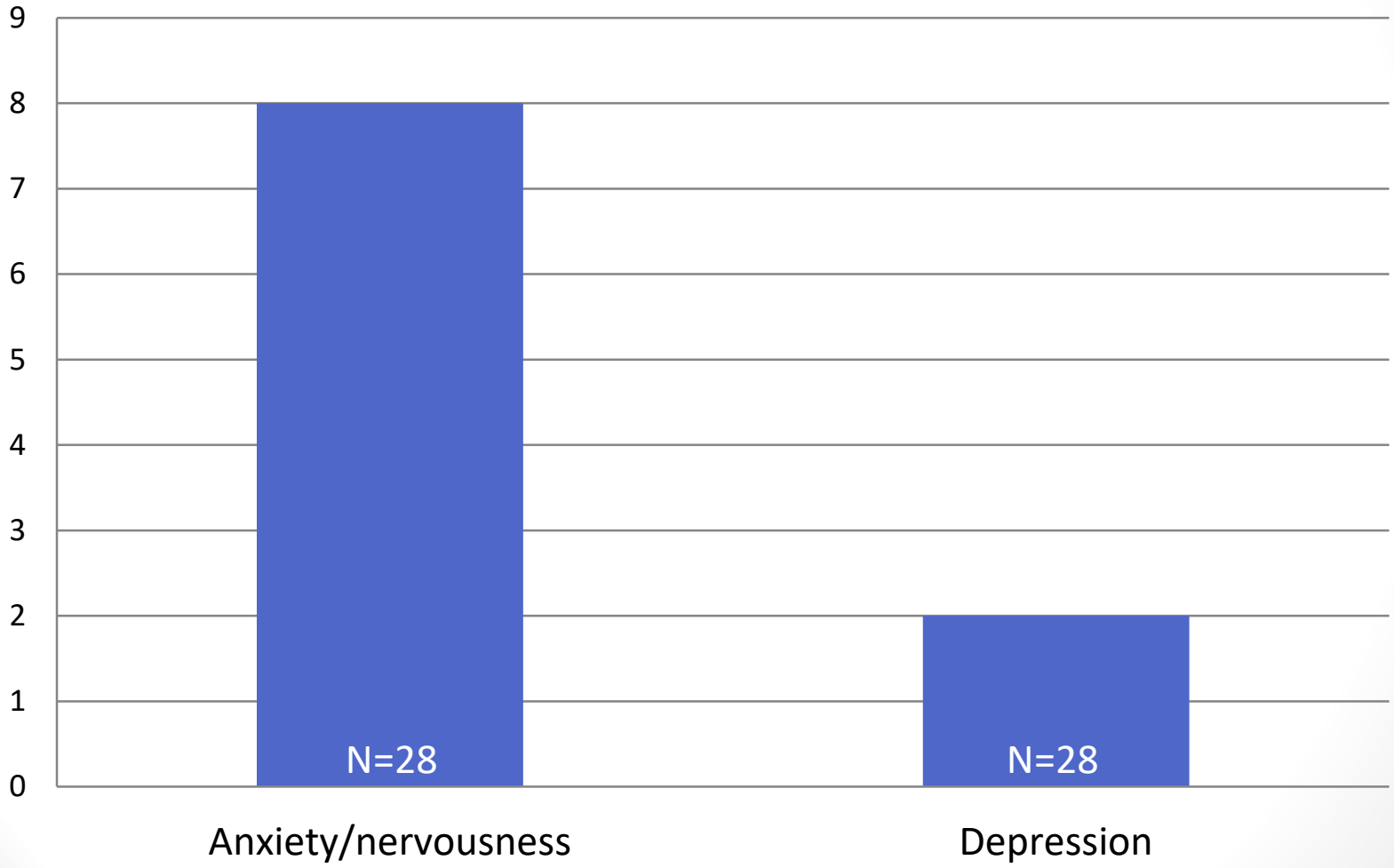


Neurologic Symptoms

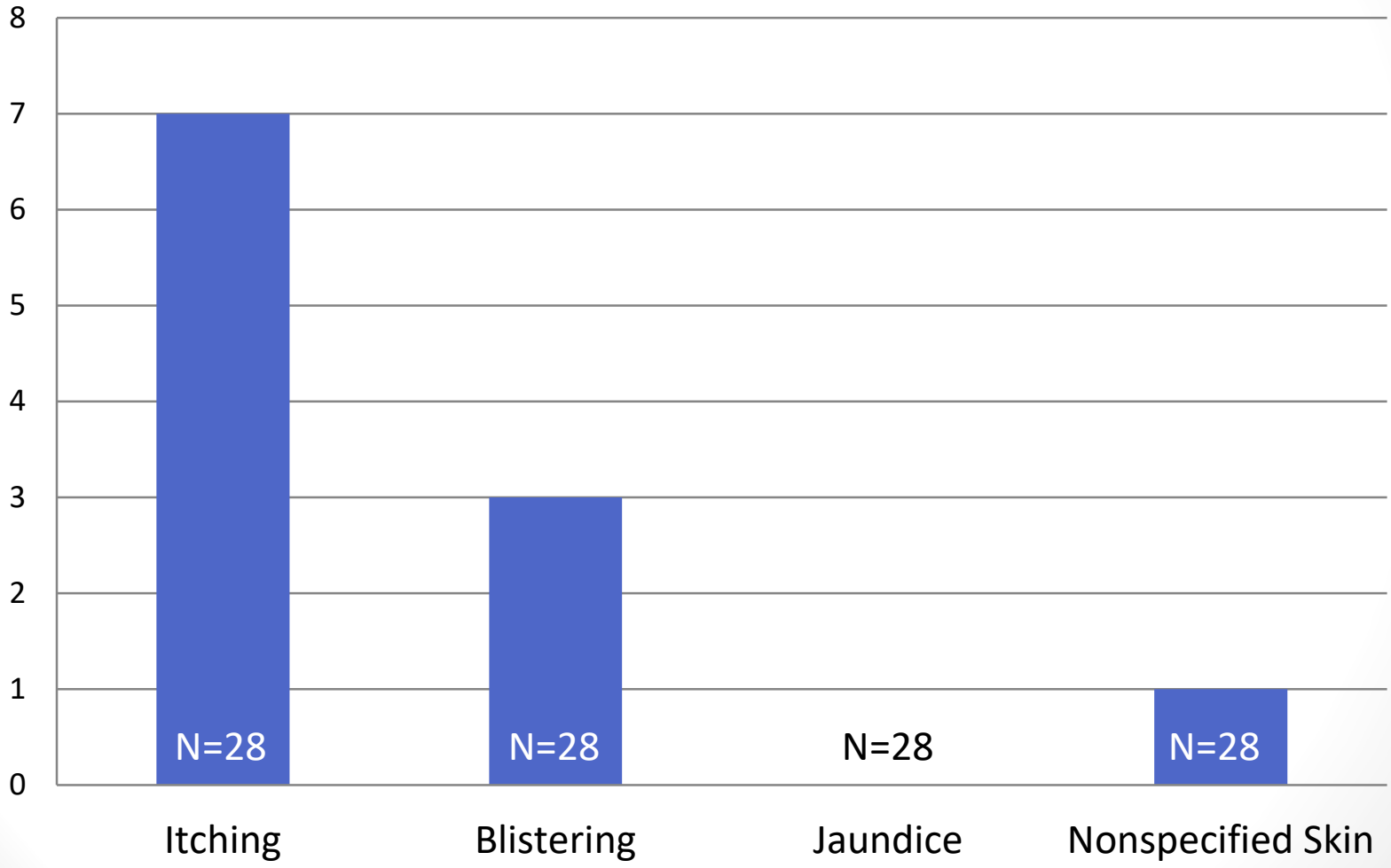


N=28

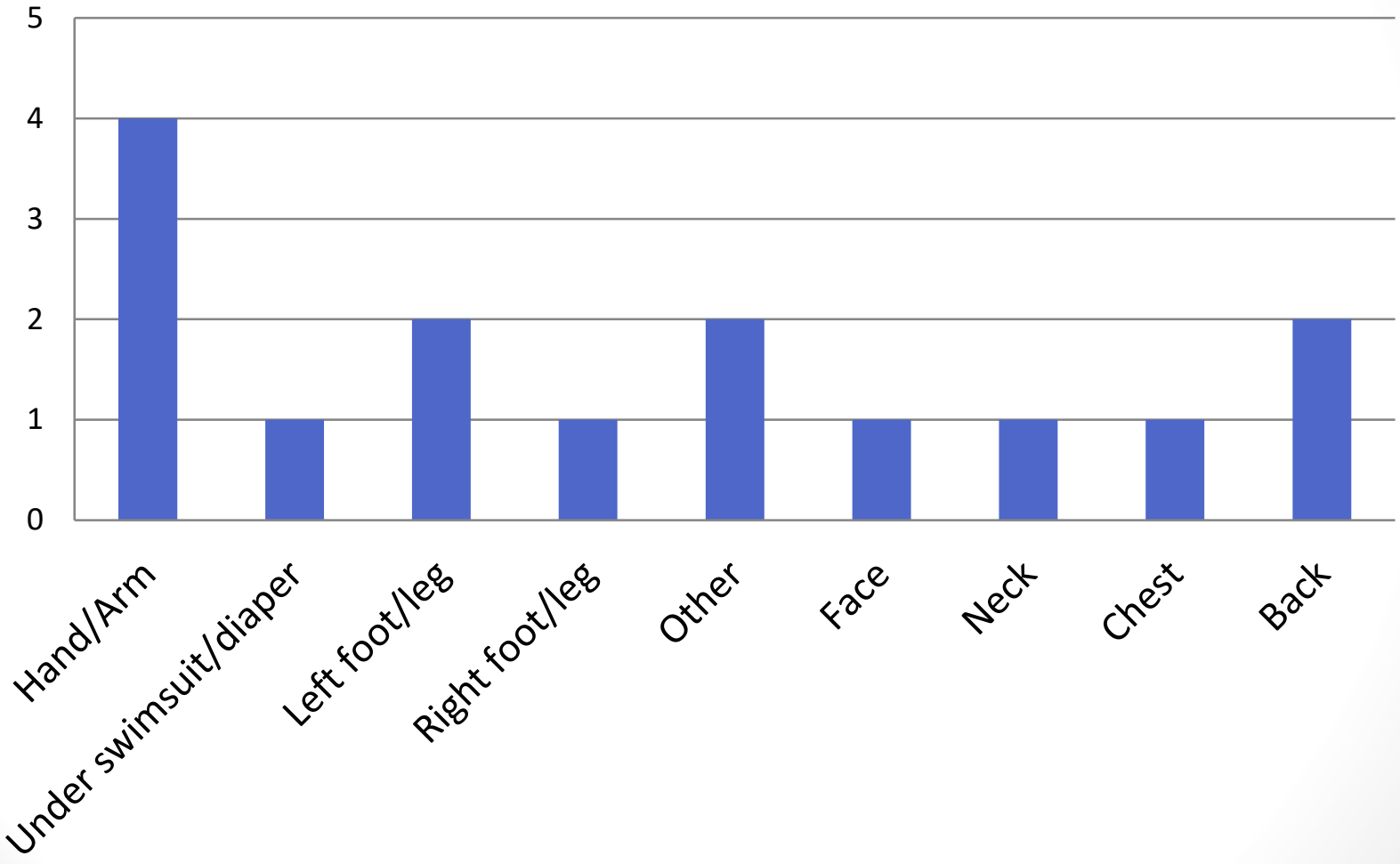
Mental Health Symptoms



Dermatologic Symptoms

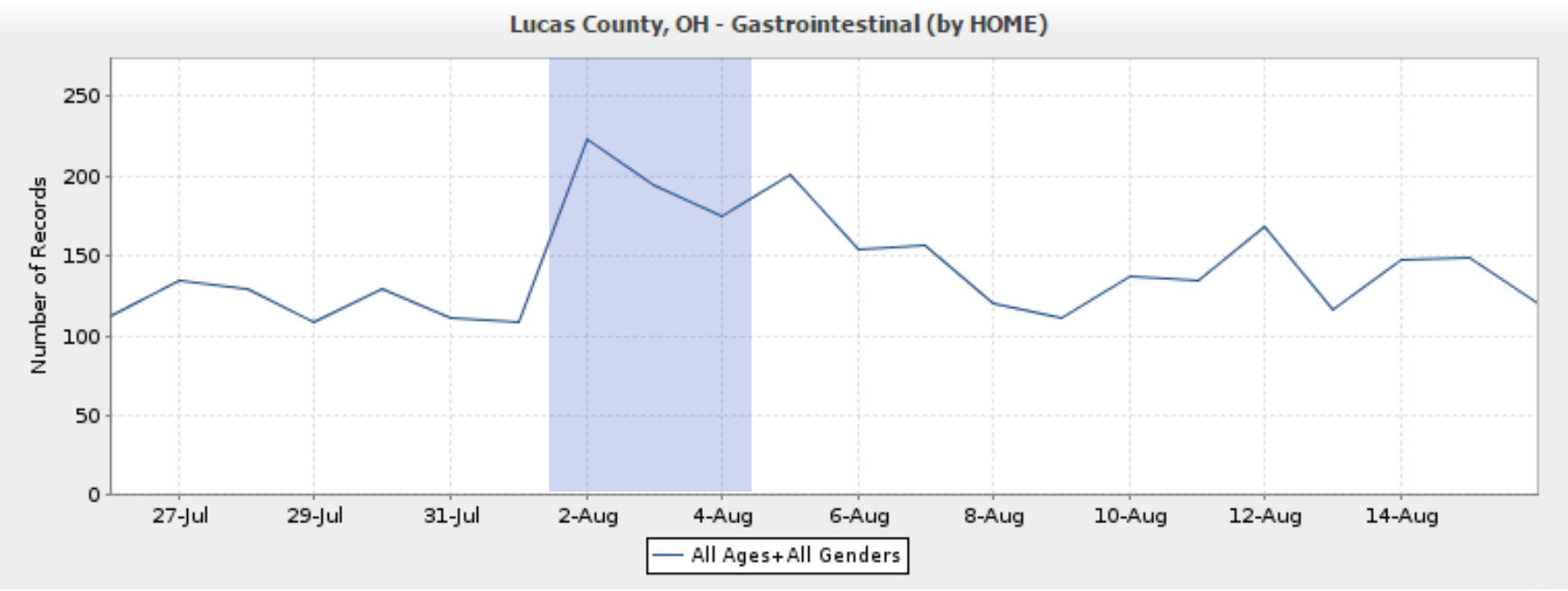


Location of Rash



N=28

Additional Follow-Up



- Chart Review for patients seen in Hospitals/Urgent Cares in Lucas County

Issues with Data

- No testing for microcystin
- **Dose-response relationship not widely studied/known**
- Truly water exposure?
  - Physician response varied heavily
    - One respondent: “Doctor took liver tests and was normal and not from water”
- Existing Non-Water Related Medical Issues
  - One respondent “felt like the tap water had little to do with her hospital visit”
  - Another indicated that he/she was NOT exposed to the water
- Anomalies
  - One respondent: water cooler at carryout had been opened in her presence and she instantly collapsed and became ill

Over Reaction?

CURRENT WEATHER

Clouds and sun 32°

Complete Forecast→

THE BLADE

One of America's Great Newspapers

NEWS | SPORTS | A & E | BUSINESS | OPINION | OUR TOWNS | HELP | BUSINESS DIRECTORY

HOME → OPINION

Print Story Search: GO →

Published: Sunday, 3/8/2015 - Updated: 4 days ago

Related stories

- Fighting human trafficking: stronger law enforcement, victim protection
- No turning back from Ohio's Medicaid expansion
- Rosa Parks: Much more than a civil-rights icon
- Time for Governor Kasich to act on

COMMENTARY

Toledo's don't-drink-the-water alarm went too far

Officials can make protective decisions such as the no-drink advisory, but they mu

BY JOSEPH A. COTRUVO

OhioWatchdog.org

HOME | STATES | NATIONAL | NEWS | OPINION | WATCHDOG ARENA | RADIO | SUBSCRIBE | DONATE

EDUCATION | ENERGY | FIRST AMENDMENT | HEALTH CARE | PENSIONS | STATE BUDGETS | TECHNOLOGY | LABOR

Search Site

The Toledo water crisis that wasn't

By Maggie Thurber / August 15, 2014 / No Comments

LATEST STORIES

Over Reaction?

The NEW ENGLAND JOURNAL of MEDICINE

HOME | ARTICLES & MULTIMEDIA | ISSUES | SPECIALTIES & TOPICS | FOR AUTHORS | CME

ORIGINAL ARTICLE

A Correction Has Been Published

Liver Failure and Death after Exposure to Microcystins at a Hemodialysis Center in Brazil

Elise M. Jochimsen, M.D., Wayne W. Carmichael, Ph.D., JiSi An, M.Sc., Denise M. Cardo, M.D., Ph.D., Susan T. Cookson, M.D., Christianne E.M. Holmes, M.D., M. Bernade Antunes, M.D., Djalma A. de Melo Filho, M.D., Tereza M. Lyra, M.D., Victorino Spinelli T. Barreto, M.D., Sandra M.F.O. Azevedo, Ph.D., and William R. Jarvis, M.D.

N Engl J Med 1998; 338:873-878 | March 26, 1998 | DOI: 10.1056/NEJM199803263381304

Share:

Abstract | Article | References | Citing Articles (399)

BACKGROUND

Hemodialysis is a common but potentially hazardous procedure. From February 17 to 20, 1996, 116 of 130 patients (89 percent) at a dialysis center (dialysis center A) in Caruaru, Brazil, had visual disturbances, nausea, and vomiting associated with hemodialysis. By March 24, 26 of the patients had died of acute liver failure.

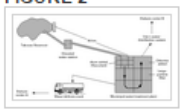
Full Text of Background...

METHODS

A case patient was defined as any patient undergoing dialysis at dialysis center A or Caruaru's other dialysis center (dialysis center B) during February 1996 who had acute liver failure. To determine the risk factors for and the source of the outbreak, we conducted a

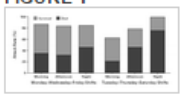
MEDIA IN THIS ARTICLE

FIGURE 2



System of Water Treatment and Distribution in Caruaru, Brazil.

FIGURE 1



Attack Rate According to Dialysis Shift, Caruaru, Brazil, February 20 to

"Our investigation had several limitations. Medical records at the dialysis center and water-treatment records at the city's water plant were poor. **Water samples from the time of probable exposure were unavailable**, **so we could not quantitate exposure.** We were unable to obtain serum from patients who received dialysis in Caruaru and were exposed to treated water only."

Kinetics and Metabolism

- Research has shown that approximately 70% of ingested toxin is rapidly localized in the liver
  - Kidney and intestine also accumulate significant amounts
  - Microcystin-LR is excreted rapidly, with 75% of the total excretion occurring within 12 hours
    - Remaining 24% excreted after 6 days; 9% via urinary route and 15% slowly (~1%/day) via fecal route
  - Microcystin-LR does not readily cross cell membranes
    - Crosses the ileum through multispecific organic ion transport system and mainly enters hepatocytes where it is covalently bonded to a protein in the cytosol

Acute Exposure

- LD_{50} via the intraperitoneal route is approximately 25-150 µg/kg of body weight in mice; LD_{50} by **oral route is 5000** µg/kg of body weight in mice
- What does that mean?
  - "Average" mouse weight= 0.02 kg
  - Therefore the LD_{50} would be around 100 µg/kg
  - "Average" human weight= 62 kg
  - Therefore the LD_{50} would be around 310,000 µg/kg
- In swine, a no-adverse-effect level (NAEL) for microcystins of 280 µg/kg of body weight was reported
  - What does that mean?
    - "Average" pig weight= 70 kg
    - Therefore the LD_{50} would be around 19,600 µg/kg
    - "Average" human weight= 62 kg
    - Therefore the LD_{50} would be around 17,360 µg/kg

So What Does *That* Mean?

- Harmful doses of Microcystin, in animal models, are quite high
  - Human data is under-studied and widely unknown
- Institute of Medicine's Adequate Daily Water Intake for:
  - Men: 3 Liters
  - Women: 2.2 Liters
- For 1.0 µg/dL (the WHO threshold) that equates to consuming
  - 30 µg of microcystin for men
  - 22 µg of microcystin for women

So….If you're not supposed to swim in 6.0 µg/dL…. (?)

An Ounce of Prevention…

JOHN R. KASICH
GOVERNOR • STATE OF OHIO
Communication Department

August 14, 2014
Rob Nichols, (330) 760-7582, Rob.Nichols@governor.ohio.gov

KASICH ADMINISTRATION ANNOUNCES FURTHER EFFORTS TO HELP PROTECT LAKE ERIE WATER QUALITY

More than $150 Million in targeted resources for local water systems and farmers

COLUMBUS – Today Gov. John R. Kasich and members of his Cabinet announced major new multi-agency initiatives that make available significant resources to local communities and the agriculture community to help further strengthen protections for Lake Erie water quality and local drinking water supplies.

The initiatives were unveiled by the directors of the Ohio Environmental Protection Agency, Department of Agriculture and Department of Natural Resources at the Kris Swartz Farm in Perrysburg. Highlights include:

- $150 million in zero-interest loans for local water plants: $150 million in no-interest loans for improvements to local drinking water and wastewater treatment facilities, reconfirming a single statewide testing protocol for microcystin approved by the Ohio EPA and US EPA, $1 million for local water systems for testing equipment and training, and testing support from Ohio EPA's lab for any system that requests it;
- Support for agriculture: $1.25 million for farmers to plant cover crops or install controlled drainage devices that protect against nutrient runoff and help support water quality, and;
- $2 million for research: $2 million to Ohio universities for further research on algal blooms.

"Lake Erie is one of Ohio's most precious resources and each day millions turn to it for drinking as well as their livelihoods. Ohio has been increasingly aggressive in protecting it and we're building on those efforts with new resources for those on the front lines of this battle. There's more work to be one and we're going to keep pushing forward," said Kasich.

Over the past four years, Ohio has made significant progress in protecting the lake, including:

- Restricting water amounts that can be pumped out of the Lake Erie watershed;
- Enacting new regulations on fertilizer application to reduce the nutrient runoff that contributes to algal blooms;
- Reducing open-water dumping of Maumee River dredge material and prohibiting open-water dumping of Cuyahoga River dredge material;
- Banning oil and gas production under Lake Erie; and
- Helping combat invasive species via mutual aid agreements with nine other Great Lakes states and Canadian provinces.

Details on today's announcements can be found in this fact sheet.

http://www.governor.ohio.gov/Portals/0/08.14.14%20Kasich%20Announces%20Further%20Efforts%20to%20Help%20Protect%20Lake%20Erie%20Water%20Quality.pdf

- $150M in zero-interest loans for water plants
- $1.25M for farmers to plant cover crops or install drainage devices
- $2M for research

Additional Measures

- $521 million toward expansion project intended to phase out sewage spills– expected to be finished 2020

CASPER

- Community Assessment for Public Health Response
- Prior to water event, CASPER was scheduled to occur August 4-5 and was to focus on recreational water usage and exposure to HABs
- Plan changed during the weekend of August 2 and CASPER was re-scheduled for early September and re-worked to focus on municipal water exposure to HABs

Preparing for 2015

- City of Toledo Water Department, Lucas County EMA, Toledo-Lucas County Health Department, and Hospital Council of Northwest Ohio Planning Meetings
  - Increasing Availability of ICS Courses for Public Officials
  - Water Customer Education
  - Forums to Collect Feedback
  - Improvement of Communication Pathways

Thanks

- **City of Toledo**
  - Elected Officials
  - Water Treatment
  - Department of Public Utilities
  - Forestry
  - Toledo Public Schools
  - Central Catholic High School
- **Lucas County**
  - Lucas County Emergency Management Agency
  - Toledo-Lucas County Health Department
  - Lucas County Sheriff Office
  - Lucas County Elected Officials
- **State of Ohio**
  - Ohio Department of Transportation
  - Ohio Emergency Management Agency
  - Ohio Fire Chiefs Emergency Response Plan
  - Ohio Environmental Protection Agency
  - University of Toledo Police Department
  - Army National Guard
  - Ohio State Highway Patrol
  - Governor's Office
- **Federal**
  - Federal EPA
  - FEMA
  - United States Coast Guard

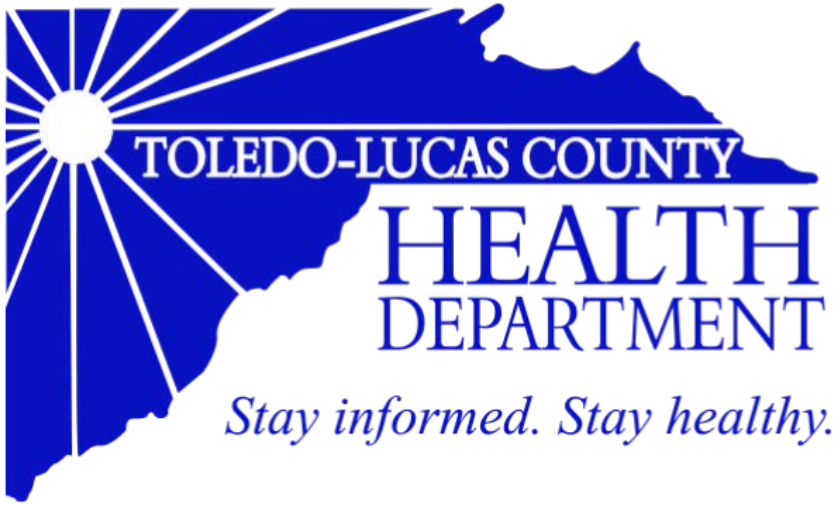
Thanks

- **Fire Departments – 28**
  - Toledo Fire and Rescue Department (Command and Control)
  - Springfield Twp. Fire Department (Command and Control)
  - Monclova Twp. Fire Department (Command and Control)
  - Whitehouse Fire Department (Command and Control)
  - Sylvania Twp. Fire Department
  - Oregon Fire Department
  - Jerusalem Twp. Fire Department
  - Waterville Fire Department
  - Maumee Fire Department
  - Napoleon Fire Department
  - Wauseon Fire Department
  - Liberty Twp. Fire Department
  - Harrison-Elmore Fire Department
  - Sandusky Twp. Fire Department
  - Allen-Clay Twp. Fire Department
  - German Twp. Fire Department
  - Deshler Fire Department
  - Ridgeville Fire Department
  - Carroll Twp. Fire Department
  - Ballville Twp. Fire Department
  - McClure Fire Department
  - Napoleon Fire Department
  - Hamler Fire Department
  - Delta Fire Department
  - Erie Twp. Fire Department
  - Portage Fire Department
  - Catawba Fire Department
  - Union Twp. Fire Department
  - Lyons/Royalton Fire Department
  - Damascus Fire Department
- **Law Enforcement Agencies**
  - Toledo Police Department
  - Oregon Police Department
  - Holland Police Department
  - Maumee Police Department
  - Sylvania Police Department

Thanks

- **Non-Governmental Organizations**
  - American Red Cross
  - Salvation Army
  - Kroger
  - Walmart
  - Walgreens
  - Fastenal
  - Volunteers
  - Toledo Catholic Diocese
  - Area Churches
  - United Way
- **Universities**
  - University of Toledo
  - University of Cincinnati
  - Lake Superior State University
- **Other**
  - Hospital Council of Northwest Ohio

Questions?



Samantha Eitniear, MPH-VPH, CPH
Bioinformatics Analyst
eitnieas@co.lucas.oh.us
419-213-4073

References

- http://www.cdc.gov/nceh/hsb/hab/
- http://www2.epa.gov/nutrientpollution/harmful-algal-blooms
- http://oceanservice.noaa.gov/hazards/hab/
- http://www2.epa.gov/nutrient-policy-data/policies-and-guidelines
- http://www.who.int/water_sanitation_health/dwq/chemicals/cyanobactoxins.pdf?ua=1