



**PUBLIC HEALTH PRACTICE**

## One Health Outreach Efforts in Responding to Harmful Algal Blooms Issues in Hotspot Regions

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### ABSTRACT

**Background:** Globally, harmful algal blooms (HABs) in freshwater are both a historical and an ongoing issue for human, animal, and ecosystem health and have dramatic impacts on local communities. Multiple taxa of cyanobacteria, including *Microcystis*, *Planktothrix*, and *Anabaena* species can produce cyanotoxins. Exposure to these toxins may cause mild to severe adverse health effects.

**Methods:** An orchestrated effort was made by a team from multiple academic disciplines, public health agencies including the Centers for Disease Control and Prevention (CDC), and community stakeholders to engage the human and animal health communities to prepare for and respond to the emerging health threat of cyanotoxins from HABs.

**Results:** Our public health practice approaches reached multiple targeted stakeholders from public health, human, and animal health sectors. The team also helped promote the newly established nationwide One Health Harmful Algal Bloom (OHHABs) initiative in a HABs hotspot in Ohio.

**Conclusion:** Harmful algal blooms are a One Health issue demonstrating the interactions between animal, human, and ecological health. Environmental monitoring can provide early detection of environmental events, such as HABs, that pose both public health and ecological health threats. Public health surveillance can identify human and animal health events that may be linked to local environmental events

**Keywords:** One Health, Harmful algal blooms, Outreach and education, Early detection, Public health surveillance

### INTRODUCTION

Exposure to cyanotoxins can cause mild to severe adverse health outcomes. For example, ingestion of microcystins (MCs) or cylindrospermopsin can lead to liver and kidney damage. A microcystin has been identified as a liver tumor promotor in experiments with rats and as a possible human carcinogen according to the International Agency for Research on Cancer.<sup>1</sup> An ecological study showed that nonalcoholic liver disease mortality is significantly associated with the occurrence of cyanobacteria bloom-affected surface waters in counties in the United States (US).<sup>2</sup> In laboratory experiments, exposure to neurotoxins, including anatoxins produced by *Anabaena* species resulted in death due to respiratory system failure as rapidly as within 15 minutes of exposure.<sup>3</sup>

While researchers are trying to better understand this public health threat, state and local public health agencies are at the forefront of addressing environmental public health crises associated with the increasing intensity and frequency of harmful algal blooms (HABs) in freshwater.<sup>4</sup> Harmful algal blooms in marine (eg, red tides) and freshwater (eg, cyanobacterial HABs) are both a historical and an ongoing issue for human, animal, and ecosystem health and have dramatic impacts in all 50 states of the US and communities around the globe. There are multiple types of cyanobacteria, including *Microcystis*, *Planktothrix*, and *Anabaena* species that can produce cyanotoxins and exposure to these toxins may cause mild to severe adverse health effects.<sup>5</sup>

A growing body of evidence suggests that animals, particularly dogs and cattle, can be sentinel species for HAB poisonings.<sup>6</sup> Ani-



mals and humans may experience similar signs when exposed to HABs. Vomiting, diarrhea, rash, difficulty breathing, weakness, liver failure, seizures, and potentially death are all signs of HAB exposure.<sup>7,8,6</sup> However, not all veterinarians are likely to be familiar with or trained to consider cyanotoxin poisoning when their patients present with compatible signs. Thus, even when poisonings occur in these sentinel species, most cases are suspected to go undocumented because of misdiagnosis, failure to confirm the toxin in a biological specimen, or failure to report the case to a surveillance system.<sup>6</sup> A review of reports in the HAB-related Illness Surveillance System (HABISS), case files from a large veterinary teaching hospital in California, and publicly available documents revealed 231 HABs events and 368 toxicity cases in canines across the US from the late 1920s to 2012.<sup>7</sup> The researchers suggested that these cases of canine cyanotoxin poisonings represent a small fraction of overall cases in the US because of misdiagnoses and underreporting. Researchers also provided insights on using an animal diagnosis as an early warning for public health. Animals tend to have multiple routes of exposure (ie, direct contact, inhalation, and ingestion) and potentially higher levels of exposure than people because of their activities (eg, swimming in visibly contaminated water, ingesting scum, or licking algae from their fur).<sup>7,9</sup> Recognizing the need for animal health surveillance, public health agencies and researchers formed the HABISS program, led by the CDC between 2007 and 2011. The HABISS program set the groundwork for the One Health Harmful Algal Bloom System (OHHABS). Their efforts helped improve public health understanding and the importance of a One Health approach.

In August 2014, the Collins Park Water Treatment Plant in Lucas County, Ohio, detected MC levels above the Environmental Protection Agency (EPA) drinking water advisory threshold of 1.0 µg/L in finished drinking water, which had been sourced from western Lake Erie. The county issued a 2-day do not drink advisory. This was an unprecedented event that uncovered gaps in knowledge about how to respond to a HAB-related public health crisis that poses various threats to Toledo and the many adjacent jurisdictions that rely on Toledo's water treatment plant. We reached out to Toledo-Lucas County Health Department (TLCHD), an agency experienced with the 2014 HAB event that resulted in a 2-day do not drink advisory impacting over 500,000 people,<sup>10</sup> to learn more about lessons they learned and recommendations for researchers.

We partnered with TLCHD and the Ohio Department of Health (ODH) to learn about the gaps in awareness and education on HABs they had identified after the 2014 event. During this event, it was widely acknowledged that information about animal exposures to MC was an area where education and information needed to be more widely available and disseminated to the community. Over the course of 2 years, we took a comprehensive approach to increase HAB awareness among public health and medical practitioners for both human and animal health.

## METHODS

### Setting and Design

In autumn 2015, The Ohio State University (OSU), College of Public Health partnered with the TLCHD to develop a plan to address gaps in HAB-related medical needs in humans and animals. Ohio, particularly Toledo, was a HABs hotspot in 2014 when TLCHD responded to a HABs event.<sup>10</sup>

### Procedures

We conducted 3 HAB-related initiatives between 2016 and 2018: a workshop held in Toledo, Ohio, for the medical community (summer 2016) on the impacts of HABs on human, animal, and environmental health that included an introduction to the CDC's One Health Harmful Algal Bloom (OHHABS) surveillance system; a survey of veterinarians to assess their HAB knowledge and practices (fall 2016 through early 2017) in Ohio and Michigan, which was completed by veterinarians; and a statewide distribution of CDC's Veterinarian Reference Card to members of the Ohio Veterinary Medical Association (OVMA).

### Workshop

A 1-day workshop with 63 participants (including speakers and the organizing team) was conducted in Toledo, Ohio, in May 2016, preceding Ohio's peak HAB season of June through September. The workshop targeted local human and animal health officials and included speakers from academic institutions and public health institutions from local, state, and federal public health agencies to share their studies and practices. The workshop included presenters from ODH, CDC, University of Toledo, Bowling Green State University, and TLCHD. During the workshop, we addressed gaps in HABs education and practice in the animal health sector by providing reference cards and information about CDC's public health surveillance to veterinarians and other practitioners in publications such as this article (see Supplemental Materials).

### Survey

We conducted a survey on veterinary practices to assess the knowledge and practices of veterinarians from Michigan and Ohio, 2 states affected by the 2014 bloom in Lake Erie. We asked Ohio and Michigan Veterinary Medical Associations (OVMA and MVMA, respectively) to contact their approximately 3000 members, consisting mainly of veterinarians, with an introductory message and follow up with a link to the survey. The survey included 12 questions that consisted of both open-ended and closed formats. The survey was approved as exempt (ie, not human subjects research) by OSU's Institutional Review Board. A total of 83 members (including veterinary medicine students) responded to the survey. To fulfill our target group of veterinarians, we only reported here on the 23 responses that were completed by currently practicing licensed veterinarians (**Tables 1, 2, and 3**). The survey tool is available upon request.

**Table 1. Case Definition Sufficiency**

Level of agreement with:	Strongly Agree/ Agree	Neutral	Disagree/ Strongly Disagree	Total
Sufficiency of CDC case definitions for identifying suspect, probable, or confirmed cases	60.9% (n=14)	26.1% (n=6)	13.0% (n=3)	23*
Adequacy of criteria of CDC's case definition for determining whether a case is suspect, probable, or confirmed	47.8% (n=11)	39.1% (n=9)	13.0% (n=3)	23*

\*Currently practicing licensed veterinarians only.

**Table 2. Information to Detect and Treat Cases of HABs Toxicity**

Response	Frequency	Percent
Yes	5	21.7
No	12	52.2
Unsure	6	26.1
Total	23*	100

\*Currently practicing licensed veterinarians only.

**Table 3. Experience with Water Quality Monitoring Initiatives**

	Sufficient	Lacking	Don't Know	Total
<b>For recreation</b>	13.0% (n=3)	56.5% (n=13)	30.4% (n=7)	23*
<b>For consumption</b>	13.0% (n=3)	56.5% (n=13)	30.4% (n=7)	23*

\*Currently practicing licensed veterinarians only.

## Outreach

In response to our survey completed by veterinarians, the Ohio Veterinary Medical Association helped us deliver 2600 veterinarian reference cards to their members via direct mail. The veterinarian reference card is one of the health promotion materials<sup>11</sup> made available by the CDC through a multi-sector and local-state-federal partnership that was formed to increase awareness on HABs and One Health surveillance and to improve understanding of HABs and HAB-related effects.

## Analysis

For our survey completed by veterinarians, descriptive statistics were generated using statistical software (SAS, version 9.4; SAS Institute Inc). For categorical values, the number of responses and percentages were calculated. The survey results in **Table 2** show that more than 52% of respondent veterinarians were unsure if they have enough information to detect and treat HABs toxicity in animals, which indicates a follow-up intervention with educational and outreach material was needed.

## RESULTS

The workshop was at full capacity with 63 participants representing local medical and public health practitioners. To assess the

effectiveness and outcomes of the workshop, we provided participants with a postworkshop evaluation survey, which was completed by 23 of 51 participants (excluding speakers and organizing team, 45% of participants completed the survey). Between 17 and 23 (74% and 100%) of the participants rated either *agree* or *strongly agree* in the 4 areas across all 6 topics: Microcystin and Environmental Health, Impacts on Human Health and Public Health, Microcystin and Lake Erie, Sandusky Bay and *Planktothrix*, Impacts on Animal Health, and Surveillance and Monitoring. A comments section captured consistently positive feedback related to the presentations, information, and resources provided.

For the survey completed by veterinarians, results showed the need for more education to which we responded by distributing CDC's Veterinarian Reference Card on HABs. All 83 respondents reported that they were unfamiliar with public health surveillance, cyanotoxin exposure pathways, and the importance of mitigating exposures by posting warnings to identify contaminated waters. More than half of the veterinarians (n = 23) felt that the CDC case definition was sufficient to help identify if cases are suspect, probable, or confirmed. After reviewing the case definition, veterinarians were asked to recall any potentially missed canine cases they might have examined since 2014. From the survey responses, 14 suspected canine poisonings were reported for the years 2014



through 2016 from Washtenaw and Gladwin Counties in Michigan and Hamilton County in Ohio. Twelve veterinarians (52%,  $n = 23$ ) reported asking owners during their animal's health assessment about contact with any bodies of water for recreation or consumption. More than three-quarters of respondents (78%,  $n = 23$ ) reported not having or being unsure if they had sufficient information on how to diagnose and treat animals that may have been exposed to HAB-related toxins. The majority of veterinarians also believed that they did not know or lacked knowledge regarding public, animal, and wildlife initiatives for monitoring the quality of water for recreation (86.9%,  $n = 23$ ) and consumption (86.9%,  $n = 23$ ) (see **Tables 1, 2, and 3**).

## DISCUSSION

Through our workshop and follow-up survey, we identified an opportunity for public health professionals to partner with veterinary professionals to provide education and training on the diagnosis, treatment, and reporting of HAB-related poisonings. The aim of the workshop was to inform the public health and medical communities of the emerging public health threat from HABs. Throughout the session, engaging questions were asked of participants and partnerships were formed to strengthen the One Health approach to public health concerns. As the severity and frequency of HAB events in freshwater increase, it is important to bridge the gaps between public health and the human and veterinary medical communities.<sup>7,8</sup>

Data obtained through our survey can guide public health education efforts through a One Health approach. Because of the relatively low response rate, we are not able to generalize our results to the entire veterinary community. However, our survey revealed gaps in knowledge related to diagnosis and treatment of HAB-related animal poisonings. Respondents indicated that educational materials, such as fact sheets for the animal's owner and guidance on clinical practice would help them increase HAB-related knowledge. The aim of this survey was to identify gaps in knowledge among the veterinary community regarding CDC's HAB-related poisoning case definitions and how to diagnose, treat, and report cases of HAB-related animal poisonings.<sup>12</sup>

All too often the animal or One Health approach is missing in public health messaging.<sup>11</sup> On a local level, the uncertainty expressed in the veterinary community on probing about HAB exposures is important and suggests a focus area for veterinary training and for practicing veterinarian outreach and education. Increased communication and partnerships with the veterinary community are integral to public health surveillance and education. Based on the feedback and need for integration of veterinary medicine into public health, the TLCHD has increased engagement with veterinarians, offering education on HABs and other public health issues that cross species lines (eg, mosquito-borne diseases, tick-borne diseases, animal bites, and rabies) and has strengthened relationships with the local veterinary medical community.

There were limitations to our findings. First, we had a low survey response and some surveys were incomplete; thus, we excluded these from our analysis. Second, we were not able to limit our communication to currently practicing veterinarians as there were other categories of membership including students and retirees in the email lists.

## PUBLIC HEALTH IMPLICATIONS

Animal, human, and ecosystem health are interrelated; thus, actions to protect one system can serve to protect all. Harmful algal blooms are a One Health issue demonstrating the interactions between animal, human, and ecological health. For example, environmental monitoring can provide early detection of environmental events, such as HABs, that pose both public health and ecological health threats. Public health surveillance can identify human and animal health events that may be linked to local environmental events such as HABs, and rapid detection can help public health officials, decision makers, and regulators protect public health by minimizing exposures.<sup>13</sup> With reporting of animal HAB toxicity cases through OHHABS and collaboration with animal health and environmental health sectors, public health agencies can identify bodies of water with ongoing HABs, conduct responsive water quality monitoring, and post warnings about potential hazards. Thus, collaboration between public and environmental health professionals, researchers, and veterinarians establishes a comprehensive One Health approach for HAB-related health risk management. Harmful algal blooms are ecological issues that require ecological and comprehensive approaches. While research continues, public health institutions and practitioners are at the front line to prevent and address HABs and HAB-associated illnesses.

Our collaborative efforts demonstrated the benefits of public health practice, multi-sectoral, and One Health approaches. We promoted a newly established surveillance program, OHHABS, created by state and federal public health institutes to link ecological health with public health to better understand HABs and HAB-associated illnesses prevention (see Supplemental Material).

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