Don't Swim in the Soup: A Survey in Utah of Recreator Perceptions on Harmful Algae

Hannah Bonner, PhD
Utah Division of Water Quality

Karen Valcarce, MSPH
Utah Department of Health and Human Services

Carina Thiriot, MPH
Utah Division of Water Quality

Ellen Bailey, MS
Utah Division of Water Quality

Abstract **Recreator knowledge of and confidence in identifying harmful algal blooms (HABs) are essential for protecting public health and shaping risk perception of people who use water bodies for recreational purposes. Our research used a structured, closed-ended questionnaire to gather information on Utah recreator perceptions of HABs (*N* = 200). Our results indicate that the majority (86%) of Utah recreators are familiar with HABs and most (61%) are at least moderately concerned about HABs. Participants had a 62% accuracy in identifying harmful water conditions for themselves and a 63% accuracy in identifying harmful water conditions for their dog. Respondents learned about HABs from news reports (75%) and/or seeing signs at a body of water (54%). Recreators who are non-White reported being less familiar with HABs, indicating that this group might be at elevated risk of HAB exposure. Our work identifies baseline Utah recreator HAB literacy and provides recommendations for channels to use and audiences who might benefit from HAB educational campaigns.**

Keywords: cyanobacteria, harmful algal blooms, water quality, public awareness, public perception, risk awareness, recreation

Introduction

Cyanobacteria, which are photosynthesizing bacteria, naturally occur in bodies of water around the world. When conditions are right, cyanobacteria can multiply quickly to form a harmful algal bloom (HAB), and blooms can become a thick scum that often resembles pea soup. People who use bodies of water recreationally are encouraged not to swim in the "soup" because the water can contain dangerous toxins. Humans and animals who engage in recreational activities—including swimming, boating, water-skiing, jet-skiing, fishing, and hunting waterfowl—can be exposed to toxins through contact with, ingestion, or inhalation of affected water (Patočka, 2001). Low levels of toxin exposure can cause rash, gastrointestinal illness, or respiratory irritation (Lad et al., 2022; Roberts et al., 2020). High levels of toxin exposure can cause kidney or liver damage, neurological problems, or respiratory paralysis (Azevedo et al., 2002; Trevino-Garrison et al., 2015).

Education is crucial to protecting the health of recreators and shaping public risk perception (Benitez Gonzalez, 2023; Cahyanto & Liu-Lastres, 2020; O'Leary et al., 2024). The limited research that exists on the topic, however, indicates variability in HAB literacy among the recreating public. For example, in Louisiana, most (60%) freshwater fishers were not familiar with the term harmful algal bloom (Smith et al., 2014). In contrast, the majority (60%) of Iowans surveyed in a statewide effort reported having seen an algal bloom in person at least once (Shr & Zhang, 2021). A 2020 nationally representative survey, which was the first of its kind in the U.S., found that more than one half (59%) of adult respondents were aware that HABs can pose a health threat (Jacobi et al., 2024). Among the respondents expressing the least concern about HABs were individuals who live in the Mountain Region, in which Utah is at the center.

In Utah, as in many locations around the U.S. and world, dozens of popular recreational bodies of water develop HABs each summer and fall (O'Neil et al., 2012). Previous evaluation of recreator knowledge has occurred at Utah Lake, which is a lake that has had recurring, highly publicized HABs. Smith et al. (2023) conducted surveys to characterize types of recreation, factors influencing recreation, and recreator ability to identify HABs. The majority of on-site respondents (85%) and nearly three fourths of mail respondents (71%) indicated that they had heard of HABs at Utah Lake. Even respondents who had heard of HABs, however, performed poorly at identifying images of them. A series of photo-based questions revealed no significant relationship between respondent desire for recreation and the bloom severity in the images.

In contrast, a study at Utah Lake by Do et al. (2021) examined recreator literacy at HAB identification; this work found that negative social media posts about Utah Lake were significantly and positively associated with poor measured water quality parameters, including HAB cell density. Beyond these studies, though, no direct research has been conducted to establish a baseline of typical Utah recreator or mountain state-specific knowledge of HABs. Yet these data are key in shaping future education strategy and pro-

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viding more context on public perception in this region of the U.S.

To address this gap, our primary study objectives were to quantify Utah recreator awareness of HABs, skill at identifying HABs, knowledge and concern about the risks of HABs, and usage of existing state HAB educational resources. The resulting knowledge can help state agencies, managers of bodies of water, and other public health officials refine messaging and prevent illness among their constituents.

Methods

We used a structured, closed-ended questionnaire to gather information on our objectives. The study design followed a computer-assisted self-interview (CASI) survey format in which researchers approached participants with a tablet-administered questionnaire (Fairweather et al., 2012; Leon et al., 2003). The survey was created in Qualtrics and administered through its offline application. Sampling was conducted at five outdoor locations in four Utah counties: Morgan County, Salt Lake County, Utah County, and Wasatch County.

Locations were chosen with the goal of collecting a sample representative of an average Utah recreator versus the general public in Utah. A majority (72%) of responses were collected at locations in Utah and Salt Lake counties: at two recreational ponds commonly used for swimming and water play (Highland Glen Pond and Blackridge Reservoir) and a popular outdoor concert venue (Red Butte Garden Amphitheatre). Priority was placed on Utah and Salt Lake counties because these regions have much higher population density and diversity than do other counties in the state and contain more than one half (57%) of Utah's total population (Utah Population Committee, 2026). Respondents from two large reservoirs (East Canyon Reservoir in Morgan County and Deer Creek Reservoir in Wasatch County) were also included to expand the reach of the survey to open-water recreators.

We selected survey participants using convenience sampling methods by approaching groups of people at the sampling locations. Two or three surveyors started at the entrance of each venue (usually a parking lot) and systematically approached as many groups as the time allotted (approximately 1–2 hours). The same script was used when approaching participants: Surveyors identified themselves as working with the Utah Division of Water Quality and asked each group if any adults would volunteer to take an anonymous 3- to 4-min electronic survey about recreational water quality in Utah. Researchers used identical tablets set to uniform outdoor brightness settings. To avoid interference due to glare, researchers provided shading with an umbrella when the participant was not already shaded. Potential participants were excluded if they were <18 years or unable to take the survey in English. There was no limit to how many people could take the survey from a single group.

Data were collected using multiple-choice and "select all" questions. Survey questions fell within five categories: 1) awareness of HABs and HAB risks, 2) level of concern about HABs, 3) level of contact with Utah waters, 4) HAB identification skills and confidence, and 5) utilization of HAB information sources. For questions regarding HAB identification, five images were shown to respondents. The control photo (showing clear water with no growth) was modified using Adobe Photoshop to create four additional photorealistic iterations. These iterations showed two types of HABs and two nonharmful HAB lookalikes (i.e., non-HABs): filamentous green algae and duckweed (Figure 1).

A respondent could answer a maximum of 14 HAB-related questions. The number of questions presented was based on branching logic, where subsequent questions were asked based on a participant's answer to questions about recreation frequency, dog ownership, and previous familiarity with HABs and HAB resources. The questionnaire also collected data on age, race and ethnicity, and education level. The survey did not collect any identifying information and thus, the Utah Department of Health and Human Services institutional review board determined the survey to be exempt from review per federal guidelines 46.111(a)(2)(i).

Statistical analyses were conducted using RStudio (version 2024.12.1.563) and MATLAB (version R2024b). Descriptive statistics were used to summarize the data collected for each survey question. Bivariate analyses between survey questions were conducted by calculating Cramér's V for all possible associations due to its suitability for categorical data. For any associations with effect size (ES) > 0.2, we used chi-square tests (or Fisher's exact tests when there were <5 expected observations) to assess the statistical significance of associations.

A significance level of $\alpha = .05$ was used and the results were considered statistically significant at $p < .05$. Post hoc tests were performed for any significant associations to determine the contributing factors. Post hoc testing used either the chisq.posthoc.test() R function based on the work by Sharpe (2015) for conducting post hoc testing for significant chi-square associations or the fisher.multcomp() R function for pairwise comparisons when Fisher's exact test was used. The Bonferroni correction was applied in both cases to account for the multiple comparisons. Additionally, logistic regression was used to evaluate the variables associated with past familiarity with HABs and HAB resource utilization. Responses to questions asking respondents to identify photos as harmful were coded and analyzed with a confusion matrix.

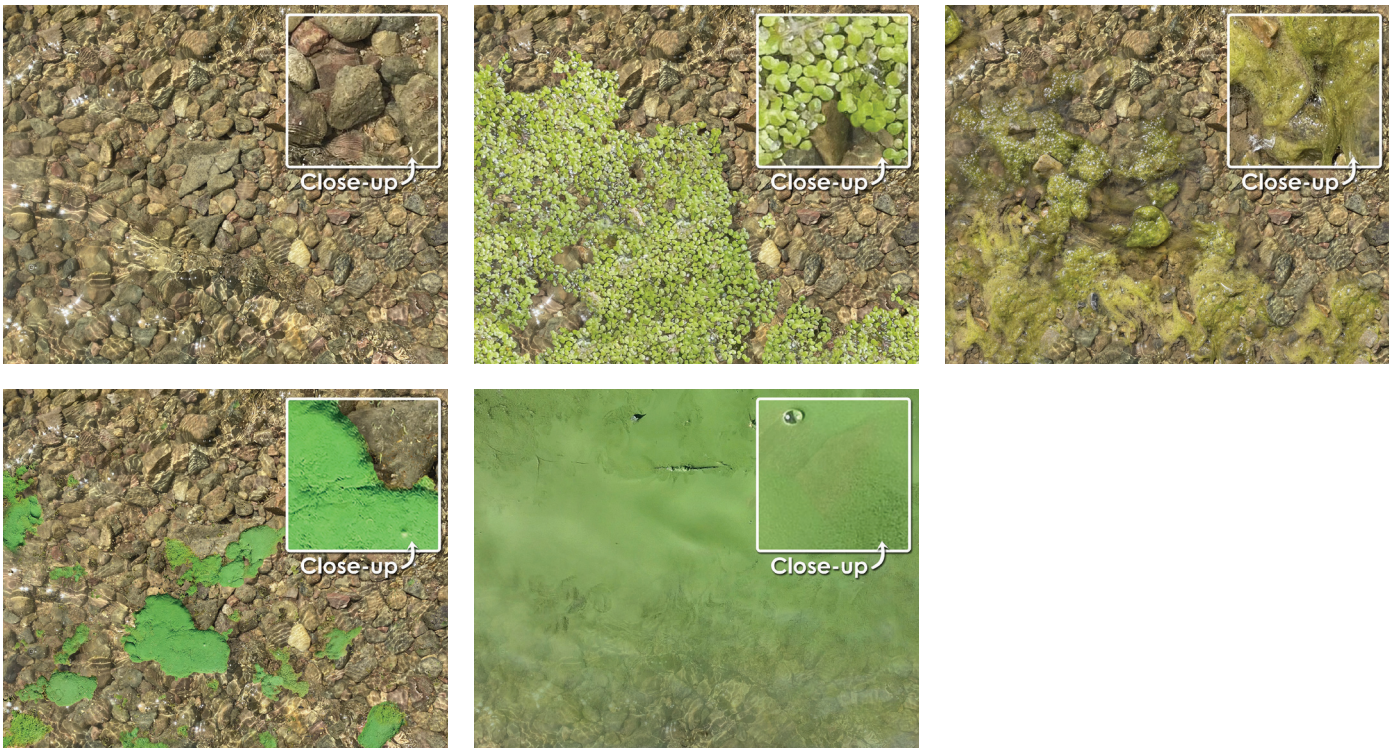
Results

In total, 200 participants completed the survey (77% response rate). We tracked the response rate by the number of groups approached, not the number of individuals in each group. Reasons for not participating in the survey included disinterest, lack of time, preoccupation with other activities, or inability to take the survey in English. Demographic information was collected on age, race and ethnicity, and highest level of education (Table 1). The majority of participants across all survey locations self-identified as White (169, 88%). At swimming ponds and large reservoirs, the majority of participants were 25–44 years (60, 68%). Approximately one half of the participants at Red Butte Garden were adults 45–64 years (55, 49%). Among participants at all locations, the largest majority (74, 37%) reported a bachelor's degree as their highest level of education.

Survey results identified common characteristics of Utah recreators. Recreating 6–10 days per year and 3–5 days per year at a body of water in Utah were reported by 62 (31%) and 58 (29%) participants, respectively. These groups account for more than one half of respondents. While at a body of water, 121 recreators (64%) reported getting most or all of their body wet and, similarly, 115 recreators (61%) reported wading in the water. Only 20 respondents (11%) said they had

FIGURE **1**

Images Used to Test Harmful Algal Bloom (HAB) Identification Skills



Top row: control image (left) and non-harmful HAB look-alikes (e.g., duckweed, middle; filamentous green algae, right). Bottom row: HAB images.

no contact with the water. The majority of respondents (171, 86%) said they had heard of HABs before taking the survey. Cramér's V associations indicated a moderate association (ES = 0.36) between race and having previously heard of HABs that was statistically significant ($p < .001$; Figure 2, Table 2). Further logistic regression analysis showed that, compared with other races, individuals who self-identified as White had 7.9-times increased odds of having heard of HABs ($p < .001$, 95% confidence interval [CI: 2.9, 21.8]) when keeping age and education constant (Table 2). Respondents who had heard of HABs had most frequently gotten their information from news reports (128, 75%), signs at a body of water (91, 54%), a friend or family member (60, 35%), and/or a state webpage (50, 29%).

Of the recreators who had heard of HABs, only 10 respondents (6%) said they were not concerned about HABs in bodies of water in Utah, whereas the majority of respondents (105, 61%) said they were moderately or extremely concerned. Recreation frequency was moderately and positively associated with concern about HABs (ES = 0.23), and Fisher's exact test was statistically significant ($p = .0011$). The recreators we surveyed did not report high confidence in identifying HABs or symptoms of a HAB-related illness. Most respondents (102, 60%) said that they were not at all confident in identifying a HAB, and a majority of respondents (120, 71%) said they were not at all confident in identifying symptoms of HAB illness in a human. A few respondents reported being very confident in identifying either category: 8 (5%) for a HAB and 5 (3%) for symptoms of HAB illness. Confidence in identifying HABs and confidence in identifying symptoms of HAB illness were statistically significantly associated (ES = 0.39, $p < .001$; Figure 2, Table 2). Specifically, there was a statistically significant difference between recreators who reported being somewhat confident and being not at all confident for both variables ($p < .001$; Table 2). A statistically significant difference was identified among recreators who reported not at all confident for both variables, very confident in identifying HABs, and somewhat confident in identifying symptoms of a HAB illness ($p < .001$; Table 2). Among the not at all confident and very confident levels for both variables, there was also a statistically significant difference ($p = .04$; Table 2).

Dog ownership was moderately positively associated with confidence in identifying HABs (ES = 0.29, $p < .001$) and symptoms of HAB illness in humans (ES = 0.31, $p < .001$; Figure 2, Table 2). Specifically, when comparing dog owners with people who do not own dogs, pairwise post hoc testing revealed a statistically significant difference in recreators who said they were not at all confident and those who said they were somewhat confident in their ability to identify a HAB ($p = .003$) and their ability to identify a HAB illness in humans ($p < .001$). There was no

TABLE **1**

Survey Respondent Demographics and Recreation Frequency at Different Intercept Locations

	Local Swimming Ponds (*n* = 31) # (%)	Large Reservoirs (*n* = 57) # (%)	Red Butte Garden (*n* = 112) # (%)
Race			
White	27 (87)	39 (68)	103 (92)
Hispanic/Latino	1 (3)	7 (12)	3 (3)
Asian/Asian American	1 (3)	2 (4)	0
Black/African American	0	3 (5)	0
Other	1 (3)	5 (9)	2 (2)
Age (years)			
18–24	2 (6)	5 (9)	4 (4)
25–44	21 (68)	39 (68)	37 (33)
45–64	4 (13)	11 (19)	55 (49)
≥65	4 (13)	2 (4)	16 (14)
Education			
No schooling	0	0	1 (1)
High school or GED	7 (23)	13 (23)	19 (17)
Associate degree	8 (26)	12 (21)	9 (8)
Bachelor's degree	11 (35)	18 (32)	45 (40)
Master's degree	4 (13)	11 (19)	27 (24)
Professional degree or doctorate	1 (3)	2 (4)	11 (10)
Recreation frequency at a Utah body of water per year (in days)			
0	0	1 (2)	10 (9)
1–2	5 (16)	13 (23)	16 (14)
3–5	11 (35)	19 (33)	28 (25)
6–10	9 (29)	17 (30)	36 (32)
≥11	5 (16)	7 (12)	22 (20)

difference in other confidence levels between the two groups for either scenario.

The survey also yielded data on recreators' ability to evaluate the potential health risks depicted in images showing HABs, non-HABs, and clear water (Figure 1). Overall, participants had a 62% accuracy at identifying harmful water conditions for themselves and a 63% accuracy at identifying harmful water conditions for their dog. The majority of respondents correctly identified a HAB resembling spilled paint (153, 78%) and in globule form (144, 74%) (Figure 3). When evaluating non-HABs, 106 respondents (51%) misevaluated filamentous green algae and 86 respondents (44%) misevaluated duckweed as harmful (Figure 3). In contrast, only 16 dog owners (11%) misevaluated non-HABs as harmful, while 60 dog owners (39%) correctly identified non-HABs as low risk for their pets. Fewer dog owners (35, 25%) identified actual HABs as dangerous for their dog. Nearly one third of dog owners (41, 27%) misevaluated HAB images as nonharmful for their dog.

Overall, there was a positive, moderate association between age and identifying non-HABs (ES = 0.27, $p < .001$; Figure 2, Table 2). Post hoc analysis revealed a statistically significant difference in correctly identifying non-HABs among adults ages 25–44 years and adults >65 years, with adults 25–44 years more likely to correctly identify one non-HAB image (p = .029; Table 2). This finding did not hold true when comparing other age and image identification categories. No other statistically significant associations were observed between other demographic variables and performance with photo identification.

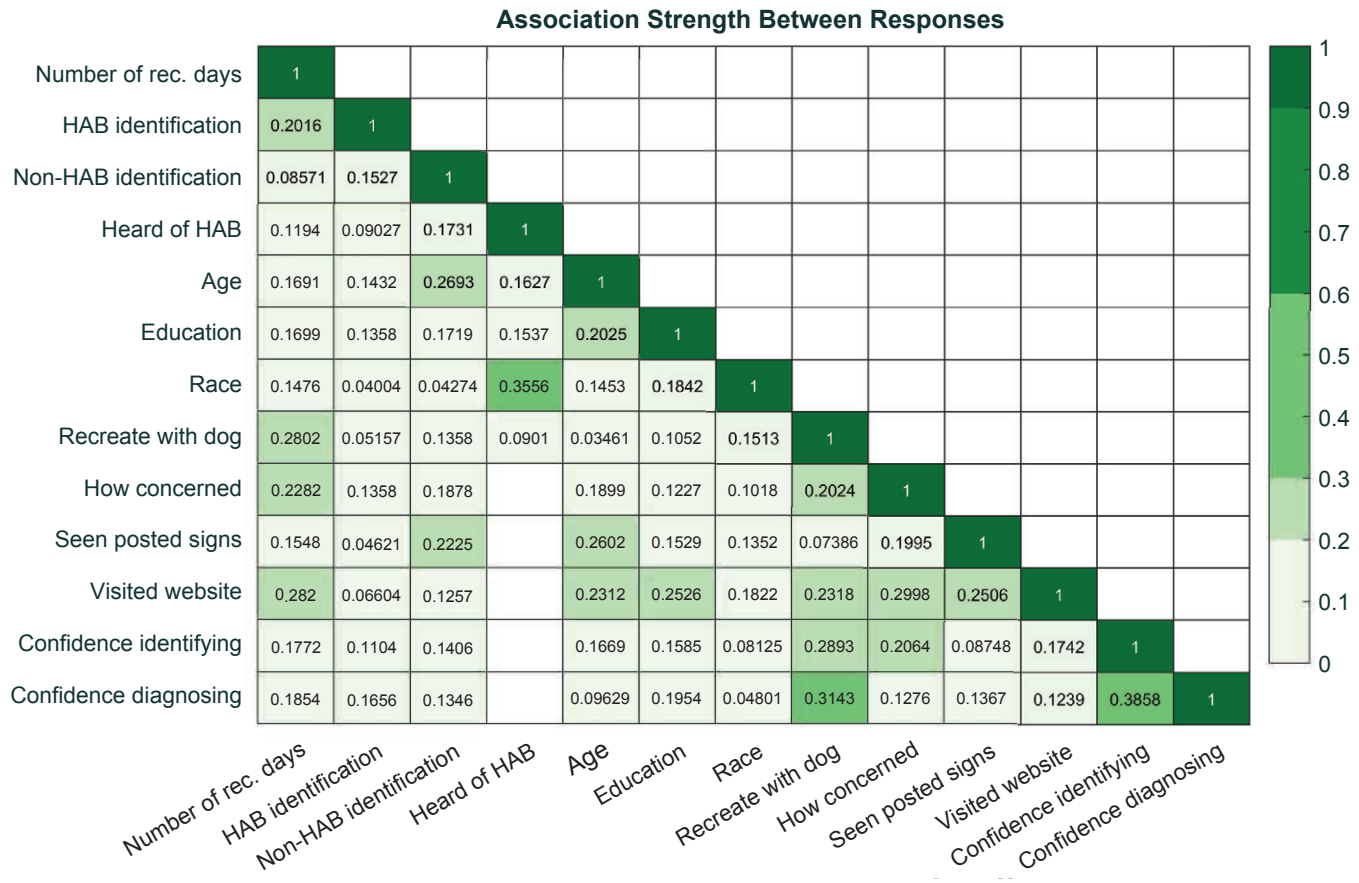
The survey asked several questions to evaluate the efficacy of preexisting communication efforts. These questions, directed to recreators who reported having heard of HABs before taking the survey, indicated that more than one half of respondents (99, 58%) had seen a posted HAB sign at a Utah body of water but few respondents (25, 15%) had visited the state of Utah website about HABs (https://HABs.utah.gov).

Seeing a HAB sign was moderately and statistically significantly associated with identifying non-HABs (ES = 0.22, p = .02; Figure 2, Table 2). Specifically, respondents who had seen a HAB sign at a body of water were more likely to correctly evaluate one non-HAB image (p = .041; Table 2). This difference was statistically significant but did not hold true when correctly evaluating both images. Seeing a HAB sign was also moderately and statistically significantly associated with visiting the HAB website (ES = 0.25, p = .001; Figure 2, Table 2) and age (ES = 0.26, p = .007; Figure 2, Table 2). Recreators who had seen a HAB sign had 6.2-times increased odds of visiting the website compared with those who had not seen a sign (p = .006, 95% CI [1.9, 28.0]). When comparing the number of recreators who had seen a sign between age groups, there was a statistically significant increase among adults 25–44 years compared with adults >65 years (p = .007; Table 2). No other significant differences were observed when comparing other age categories.

Visiting the HAB website was positively and statistically significantly associated with dog ownership (ES = 0.23, p = .003; Figure 2, Table 2) and level of concern about HABs (ES = 0.3, p = .005; Figure 2, Table 2). Owning a dog increased the odds of having visited the website by 2.9 times compared with those who did not report owning a dog (p = .035, 95% CI [1.1, 8.1]). Respondents who reported being slightly concerned about HABs in Utah were statistically significantly less likely to have visited the HAB website compared with respondents who reported extreme concern (p = .004; Table 2) or moderate concern (p = .005; Table 2).

FIGURE **2**

Cramér's V Heatmap of Categorical Association



Note. Effect size (ES) is shown on the right-hand bar. An ES > 0.2 is considered a moderate association. An ES > 0.6 is considered a strong association. HAB = harmful algal bloom; rec. = recreational.

Discussion

Compared with residential demographics for Utah and Salt Lake counties (U.S. Census Bureau, 2024), survey respondents were similar in age distribution, but there was a greater proportion of participants who self-identified as White and reported higher education levels. This finding is likely representative of U.S.-wide trends of lower racial diversity and higher education levels in outdoor recreation (Outdoor Industry Association, 2023).

Research in other U.S. states has shown high HAB familiarity among water-based recreators (Cahyanto & Liu-Lastres, 2020; Shr & Zhang, 2021; Sohngen et al., 2015). In the general adult population, only 59% of respondents in a nationwide study reported familiarity with HABs (Jacobi et al., 2024). This pattern appears consistent in Utah, where 86% of recreator respondents reported familiarity with HABs. Furthermore, in our survey, recreators who were previously familiar with HABs and who reported freshwater recreating more frequently were more likely to be concerned about HABs. These results also align with previous work that found higher levels of concern about water quality are associated with recreational engagement among Utahns (Barnett et al., 2018).

Respondent familiarity could also be attributed to highly publicized HAB events at bodies of water in and near Utah and Salt Lake counties, where most of the participants were surveyed. This explanation is consistent with the majority of recreators (75%) most commonly citing news reports as the source of their information; more frequent exposure to news stories about HABs has been linked with increased HAB risk perception (Cahyanto & Liu-Lastres, 2020; Kuhar et al., 2009; Li et al., 2015).

Utah's most publicized HAB events have occurred on Utah Lake. In 2022, Smith et al. (2023) conducted on-site perception surveys at Utah Lake. An almost identical proportion of respondents (85%) indicated they had heard of HABs at Utah Lake, as compared with the respondents (86%) in our survey. Likewise, hearing about HABs through local news reports was the most commonly cited source of information in both surveys. This finding emphasizes the importance of local and state entities collaborating with the news media to present accurate information and provide time-sensitive alerts.

TABLE **2**

Statistically Significant Relationships Identified via Chi-Square or Fisher's Exact Testing With Associated Post Hoc Testing and Odds Ratio

Comparison Variables *	Significant Relationships Identified From Post Hoc Tests (*p*-Value)	*OR* [95% CI]	*OR p*-Value
Age versus non-HAB identification score ($p < .001$)	25–44 years old:≥65 years old versus scores 0:1 ($p = .029$)	NA	NA
Age versus education level ($p = .01$)	No significant relationships identified	NA	NA
Race versus previous HAB awareness ($p < .001$)	White:Hispanic/Latino ($p = .005$)	7.9 [2.9, 21.8] (White:Other reported races)	<.001
	White:Other races ($p = .005$)		
Dog ownership versus recreation frequency ($p = .004$)	3–5 days/year:≥1 day/month ($p = .03$)	NA	NA
Level of HAB concern versus recreation frequency ($p = .01$)	No significant relationships identified	NA	NA
Saw a HAB sign versus non-HAB identification score ($p = .02$)	Score of 1:Scores of 0 and 2 ($p = .04$)	NA	NA
Saw a HAB sign versus age ($p = .007$)	25–44 years old:≥65 years old ($p = .03$)	NA	NA
Used the website versus recreation frequency ($p = .02$)	No significant relationships identified	NA	NA
Used the website versus age ($p = .02$)	No significant relationships identified	NA	NA
Dog ownership versus used the website ($p = .003$)	NA	2.9 [1.1, 8.1]	.03
Level of HAB concern versus used the website	Extremely concerned:Slightly concerned ($p = .004$)	NA	NA
	Moderately concerned:Slightly concerned ($p = .005$)		
Saw a HAB sign versus used the website ($p = .001$)	NA	6.2 [1.9, 28.0]	.006
Confidence level in identifying HABs versus dog ownership ($p < .001$)	Somewhat confident:Not at all confident ($p = .003$)	NA	NA
Confidence level in identifying HABs versus level of HAB concern ($p = .01$)	No significant relatio nships identified	NA	NA
Confidence level in identifying human HAB illness versus dog ownership ($p < .001$)	Somewhat confident:Not at all confident ($p < .001$)	NA	NA
Confidence level in identifying human HAB illness versus confidence level in identifying HABs ($p < .001$)	Not at all:Somewhat confident in identifying HABs versus Not at all:Somewhat confident in identifying HAB illness ($p < .001$)	NA	NA
	Not at all:Very confident in identifying HABs versus Not at all:Somewhat confident in identifying HAB illness ($p < .001$)		
	Not at all:Very confident in identifying HABs versus Not at all:Very confident in identifying HAB illness ($p = .04$)		

* Chi-square or Fisher's exact *p*-value.

Note. A significance level of $\alpha = .05$ was used, and results were considered statistically significant at $p < .05$. CI = confidence interval; HAB = harmful algal bloom; NA = not applicable.

Most participants (60%) in our survey reported low confidence in identifying HABs. These respondents, however, performed well at identifying photos of harmful HABs the majority (>70%) of the time. These results suggest that Utah recreators are better equipped to make safe recreational decisions than they give themselves credit for. That said, our respondents were less successful in differentiating between HABs and non-HABs. Participants who indicated they had seen a posted HAB sign were more likely to correctly identify a non-HAB image. Utah recreators might avoid water due to mistaking nonharmful green growth as a HAB, so more awareness of educational HAB signs and other resources could help reduce missed recreational opportunities.

Other confounding factors, such as turbidity or subsurface blooms, could also inhibit the ability of recreators to identify HABs (Flood, 2021; Smith et al., 2023). More education on how to differentiate HABs from filamentous green algae and duckweed is needed to build recreator confidence and accuracy. Additionally, most respondents (71%) reported low confidence in identifying the symptoms that are associated with a HAB illness. Respondents who had higher levels of confidence in identifying HABs were more likely to have higher levels of confidence in identifying the symptoms associated with a HAB illness. This finding illustrates the importance of recreator confidence in identifying HABs, as recreator confidence likely leads to an increased understanding of the health effects and consequences of recreating in water with HABs.

Dogs are at increased risk for acute cyanotoxin poisoning due to their smaller size and increased likelihood of ingesting affected water (Backer et al., 2013). Our survey yielded some insights into how dog owners differ from other Utah recreators. Most concerning, dog owners were more likely to incorrectly state that a HAB pictured in a photo did not pose health risks to their pet. Dog owners were, however, more likely to correctly evaluate non-HAB images as nonharmful for their dogs. Together, these results could indicate fewer missed recreational opportunities for dog owners but an increased risk for their dogs from recreating in potentially harmful water. Dog ownership might result in more education about HABs than a typical Utah recreator gets. Dog owners were more likely to be informed by visiting the state HABs website and have more confidence in their ability to recognize a HAB and the symptoms of an illness caused by a HAB.

Since 2014, the Utah Division of Water Quality, local health departments, state parks, the Utah Department of Health and Human Services, and other agencies have partnered to communicate known HABs and safe recreational behaviors. These communication efforts have evolved over time but consistently have emphasized the state website and involved the installation of both temporary and permanent HAB signage.

Our survey results indicate that these efforts have been successful. A majority of recreators (58%) had seen a posted HAB sign, and more than one half of recreators (53%) credited signs as one of their sources for learning about HABs. These results suggest that HAB signs are effectively reaching many recreators. When signage is the main source recreators rely on for risk evaluation, however, they might miss posted signs or feel dissatisfied with the limited information available (Brouwer et al., 2020; Towner, 2019).

The most up-to-date and comprehensive resource on HABs in Utah is the state website. A small percentage of respondents (15%) reported visiting https://HABs.utah.gov. Nearly one third of respondents (29%), however, cited visiting "a state webpage" when asked where they had heard about HABs. It is likely that these recreators reached https://HABs.utah.gov through an online search engine instead of via a direct URL.

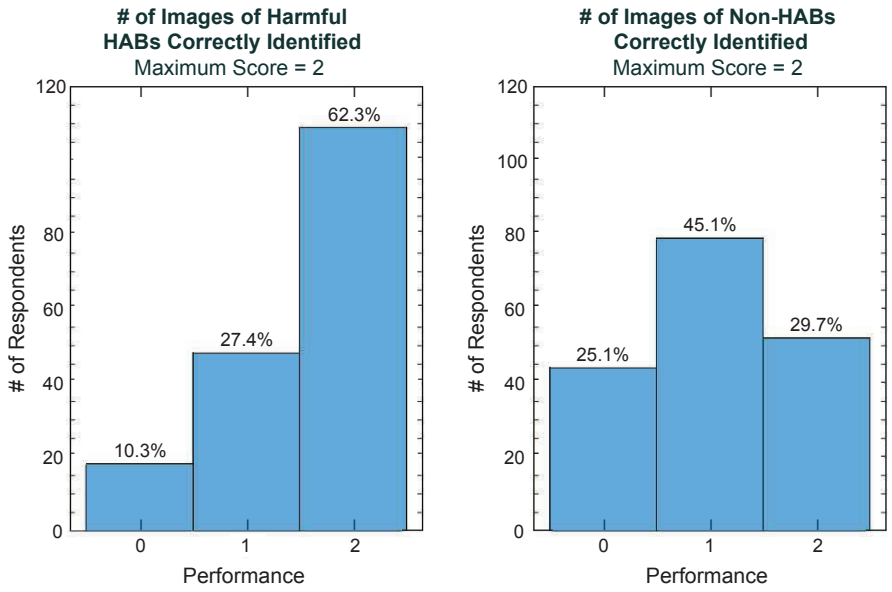
Signs alerting recreators about HABs in recent years have included QR codes. Given that participants who had seen a HAB sign were much more likely to have visited the HABs website, it is likely that the signs with the QR codes drove additional individuals to the state website. Increased awareness of signage and the use of search engines to find additional information likely is triggered initially by news media exposure (Altay et al., 2023; Geiß et al., 2015).

Consequently, optimizing passive communication venues (e.g., news stories, social media, school curricula, veterinarians) to help Utahns learn about HABs and point recreators toward state resources will help increase the use of these efforts. Our survey showed that increased concern led to increased use of the state website, so communication efforts should also focus on instilling feelings of thoughtfulness that lead recreators to care and want to learn more. Exploration of other communication venues is also warranted to target recreators who are less likely to have familiarity with HABs and state resources, including recreators who are older adults and identify as non-White.

Our study's findings have some limitations. As described in the Methods section, participants were surveyed via convenience sampling and our sample size was relatively small (N = 200). Thus, results might not represent Utahns around the entire state. Likewise, respondents represent recreators specifically and not the general population. Recreational sites used (i.e., community ponds, large reservoirs, and an outdoor venue) had their own population biases and differed from each other. These selected sites cannot fully represent all outdoor recreational sites in this region of Utah. Participation was voluntary, which could introduce nonresponse bias, as participants who took the survey could inherently be more interested in or educated about water quality in Utah. Participation was also limited to recreators who could take the survey in English, which likely reduced demographic diversity. Lastly, data was self-reported and respondent knowledge cannot be verified for accuracy.

FIGURE **3**

Performance Distribution of Survey Respondents at Identifying Images of Harmful Algae and Non-Harmful Algal Bloom (HAB) Look-Alikes



Conclusion

Our results indicate that the majority of Utah freshwater recreators are familiar with the concept of HABs and concerned about them. That familiarity, however, does not equip the average recreator with the ability

to discern between HABs and non-HABs nor with confidence in recognizing symptoms of HAB illness. Recreators who are ≥65 years old and identify as non-White are at elevated risk for unintentional HAB exposure. This finding is particularly concerning when paired with the data that most recreational freshwater use involves full-body contact and thus heightened risk of exposure to cyanotoxins in the water.

The good news is that communication efforts in Utah seem to be working—most recreators report having seen HAB signage, and nearly one third of recreators who knew about HABs had turned to the state website for information. Our results also highlight the power of the news media to raise awareness of HABs and point the public toward reliable sources of information. These results have implications both for Utahns and for freshwater recreators throughout the U.S., particularly in the Mountain Region.

We recommend more targeted communication to vulnerable groups (e.g., educational materials in multiple languages, tailored social media campaigns, messages channeled through trusted community leaders), confidence-building education on HAB identification, and prioritization of clear communication about HABs and HAB resources—especially on the state HABs website—in news media and signage near bodies of water.

Corresponding Author: Karen Valcarce, MSPH, One Health Epidemiologist, Utah Department of Health and Human Services, 288 North 1460 West, Salt Lake City, UT 84116. Email: kvalcarce@utah.gov

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