Beach communications: a need for evaluation of current approaches

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ABSTRACT

Aims: Programs to notify the public about water quality at beaches are developed at the state and local levels. We sought to characterize the messages and message delivery options in use, and information about the effectiveness of these beach notification programs. *Methods*: A telephone survey of 37 US state, tribal and territorial and 18 county, city or local beach programs was conducted to characterize current public notification practices and any evaluations of those practices. *Results*: Beach notification practices vary substantially at the state and local levels. Color-coded signs or flags are commonly used, but not universally, and the color schemes and their meanings vary. New communication approaches utilizing text messaging and the internet are in use or under development for local use. Few communication methods had undergone systematic evaluations of their content, delivery methods or effectiveness in promoting behavior change. *Conclusion*: The prevention of waterborne illness requires communications that effectively promote the avoidance of swimming when water quality is impaired. Current communication practices are variable and generally have not undergone formal evaluations for their effectiveness. It is not known whether or how they impact health risk.

Key words | beach programs, communication methods, evaluation, public notification, water quality

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INTRODUCTION

Across the US, local and state agencies collect water samples at beaches and test the waters for fecal indicator bacteria (FIB). The Beaches Environmental Assessment and Coastal Health Act of 2000 (US EPA 2000) provides funding for states, territories and tribes to develop and implement beach monitoring and notification programs to advise the public about water quality at Great Lakes and marine coastal beaches. There are currently 30 eligible states, 5 territories and 2 tribes that receive BEACH Act grants. Since 2001, the US Environmental Protection Agency (EPA) has awarded close to $90 million to eligible states, territories and tribes for their beach water protection programs; about $10 million of this was awarded in 2009 (US EPA 2010) . The program has been successful in increasing the number of monitored beaches (from 1857 in 2003 to 3740 in 2008), and the development of a national database of coastal beaches and beach water quality (US EPA 2009). These monitoring programs have identified many beaches of concern. According to an environmental advocacy agency report, BEACH Act monitoring resulted in 20 341 days of closures or advisories issued for recreational beaches in 2008 (NRDC 2009). However, to date little is known about the impact of beach notification programs on public health or even public knowledge about beach water quality.

The BEACH Act of 2000 amended sections of the Clean Water Act, including the addition of Section 406, 'Coastal Recreation Water Quality Monitoring and Notification'. States, territories and tribes that receive BEACH Act grants are required to provide 'prompt notification to the public' about exceedances of, or likely exceedances of, applicable water quality standards. States must specify 'measures for prompt communication' of water pollutant exceedances. Additionally, states must identify 'measures for the posting of signs at beaches or similar points of access, or

doi: 10.2166/wh.2011.171

functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable water quality standards' (US EPA 2000) . Furthermore, states must identify 'measures that inform the public of the potential risks associated with water contact activities in the coastal recreation waters that do not meet applicable water quality standards' (US EPA 2000). An important database has been established under the BEACH Act, EPA's Beach Advisory and Closing Online Notification system (BEACON), which makes state beach advisory and closing data available to the public (http://iaspub.epa.gov/waters10/beacon_national_page.main).

The BEACH Act mandates public notification although it does not mandate the message content or message delivery methods for beach notification. Consequently, a variety of water quality communications approaches have been developed and implemented at the state and local level. Limited annual summaries about the communications content and delivery methods have been published by an environmental advocacy agency (NRDC 2008, 2009, 2010), but it is not known to what degree beach water quality communications have been evaluated at the state or local level for effectiveness in promoting behavior change. The goals of this study were to (1) characterize recreational communication strategies used as part of USEPA BEACH Act Programs, (2) identify elements of beach programs that have undergone evaluation, such as public notification message content, communication methods and program effectiveness, (3) characterize programs identified as 'model programs' by beach program staff for their best practices and (4) identify risk communication programs used for inland waters and non-BEACH Act Programs in the United States.

METHODS

In developing our study methodology we communicated with officials who work at many levels of the USEPA BEACH program. The BEACH program is implemented at the national level by the USEPA headquarters in Washington, DC. BEACH Act grants for each state are administered by Regional EPA Beach Program Coordinators housed in the 10 regional offices of the EPA and the Gulf of Mexico. The activities for each state beach program are in turn overseen by a state beach program coordinator. Finally, all local or county beach programs in each state are implemented by the local beach program managers who are in charge of monitoring and notification. These local beach program managers report back to their respective state beach program coordinator. Prior to the survey we solicited input from national and regional coordinators of the EPA BEACH Program regarding the content and purpose of the survey. All EPA regional beach program coordinators were contacted via e-mail to inform them about the upcoming survey and provided a copy of the survey. The regional beach program coordinators were asked to inform the state beach program coordinators in their jurisdiction about the upcoming survey.

A cross-sectional survey of all eligible 37 state, territorial and tribal beach program coordinators was conducted using a 15-item questionnaire to gather information about (1) current categories of beach notification employed (advisories vs. closures/swim bans), (2) the information used by beach managers in determining which categories of beach notification to issue, (3) the mode of communicating beach notifications (such as press releases, signs at beaches, color-coded flags and websites), (4) preference of beach program managers for a particular method of communication and (5) descriptions of any programs in their state considered to be a 'model program'. We also inquired about evaluation of elements of notification programs. This included (1) any research conducted to incorporate the public's input into the development of these communication systems, (2) steps taken to evaluate the effectiveness of elements of the notification program, (3) assessments of public adherence with swim bans or beach closures and (4) interest in implementing and evaluating new communication methods in the future.

The survey was conducted between March 30–June 30, 2009. Up to 10 attempts were made to reach each state, territory and tribal beach program coordinator. For states in which state beach program coordinators noted that they used both beach advisories and closures/swim bans, as some counties differed from the statewide approach in elements of notification programs, we looked at the data posted on the EPA BEACON website in order to determine why the practices varied within the state. Data on this website were only available till 2002 for most states, therefore

we attempted to contact at least 2 such counties in each state to obtain more current information about within-state variability.

In order to characterize the rationale for the unique aspects of the local programs we asked these local beach program managers additional questions as to whether notification practices varied by beach usage (heavily used vs. less frequented beaches) or if they used any other triggers for graded responses to beach notification. We also attempted to contact beach program managers at all county or local beach programs identified as 'model programs' by state beach program coordinators. The goal was to determine what made these model programs unique, particularly regarding public notification. We verified the information provided in the telephone interviews by conducting an in-depth search of the states' websites and the EPA BEACON website. In addition, state beach program coordinators and local beach program managers provided copies of communications materials (signs, brochures, fact sheets) developed and used as part of their beach notification program. These materials were mailed to our office and reviewed in order to understand the content and presentation of this information. If a program used Twitter or Facebook as part of their public notification system, we reviewed these sites as well.

RESULTS

We reached 35/37 (94.6%) of the currently funded beach programs. This included state beach program coordinators in 29/30 states (excluding Alaska), 4/5 territorial beach programs (excluding the Virgin Islands in EPA Region 2) and both the Grand Portage and Makah Tribe beach programs. Although the survey was designed to last about 15–20 min, many program managers were enthusiastic about sharing information and some interviews lasted 45 min. Data presented in the following results section are for the 35 state, territory and tribal beach programs we interviewed.

Public notification systems

Although traditional methods such as press releases, hotlines and beach signs were still very popular risk communication methods used to notify beachgoers, many programs were using new communication methods to accommodate the changing needs of the public with the use of e-mail alerts, text messages and notices on social networking sites such as Twitter and Facebook (see Table 1).

All 35 beach programs reported using communications methods that would provide information to the public prior to their arrival at the beach. Websites were used by 100% of the state, territory and tribal beach programs interviewed. For providing information to the public after their arrival at beaches, signage was the most widely used method.

Eighteen beach programs issued advisories only, but not beach closures or swim bans. Four used beach closures/swim bans when water quality standards were exceeded. The remaining 13 programs described variability at the county level, with some using advisories only, others closures/swim bans only and some using both (see Table 2). Thirteen out of 35 programs used some variation of a color-coded system as a method of communication (see Table 2). Six of these 13 programs used a three-tier color code of red (swim ban or beach closure), yellow (advisory) and green (open). Three of 13 programs used a two-tier approach of red and green, in which advisories are not used at all. The remaining 4 states used a mixed color-coded system that had either, orange, purple or black as one of the colors.

All 35 programs interviewed expected the public to comply with the closure/swim ban/advisory signs posted

Table 1 | Number and percent of the 35 beach programs using a particular method of communication/notification. Not mutually exclusive

Type of communication/ notification	Number (percent) of state beach programs
Posting signs	35 (100%)
Website	35 (100%)
Press release and local newspaper	29 (82.8%)
Radio	20 (57.1%)
Television	20 (57.1%)
E-mail alerts	17 (48.6%)
Hotline	16 (45.7%)
Text message	2 (5.7%)
Twitter	2 (5.7%)
Facebook	1 (2.9%)

Table 2 | Primary triggers of issuing notifications, use of color-coded communications and evaluation of beach notification programs by state, territory and tribal beach programs

State	Only advisory	Only closure	Advisory and/ or closure	Color-coded system	Triggers for advisories and/or closures	Other triggers	Pre-implementation pilot/post-implementation evaluation studies
Connecticut[a]			X		B, R, S		
Maine[a]			X	Other	B, R, S	Shark season	Pre/Post
Massachusetts		X		R–G	B, R, S, A	Rip tides	Pre/Post
New Hampshire	X				B		
Rhode Island		X		Other	B, R, S	Seaweed	Post
New Jersey		X		R–G	B, R, S, A		
New York[a]			X	Other	B, R, S, A		
Delaware[a]			X		B, R, A		Pre
Pennsylvania	X				B, R		
Virginia[a]			X	R–G	B, S, A		
Maryland[a]			X		B, R, S, A		
Alabama	X			R–Y–G	B		
Florida	X				B, R, A	Hurricane season	
Georgia	X				B		Post
South Carolina	X				B, R		
North Carolina	X				B, S		Post
Mississippi[a]			X		B, S	Hurricane season	Post
Illinois[a]			X	R–Y–G	B, R, S, A	Predictive modeling	
Indiana			X	R–Y–G	B	Predictive modeling	Post[b]
Michigan[a]			X	Other	B, R, S, A	Predictive modeling	
Ohio	X				B	Predictive modeling	Post[b]
Minnesota	X				B, S		Post
Wisconsin[a]			X	R–Y–G	B, R, S	Weather trends	Pre/Post[b]
Louisiana	X				B		
Texas	X				B		Post[b]
California[a]			X		B, R, S		Post[b]
Hawaii	X				B, R		
Oregon	X			R–Y–G	B, S		Post
Washington[a]			X	R–Y–G	B, S		
Puerto Rico	X				B, R		
American Samoa	X				B, R	Closures as an emergency spill response only	
Guam	X				B, R	Closures as an emergency spill response only	
Mariana Islands	X				B, R	Closures as an emergency spill response only	Post
Grand Portage	X				B		Pre/Post
Makah		X			B		Pre/Post

Key: Color-coded system: Red–Yellow–Green (R–Y–G), Red–Green (R–G) or other colors (Other).
Triggers: Bacteria or FIB (B), Rainfall (R), Sewage (S), Algal Blooms (A).
Evaluation studies: pre-implementation pilot study (Pre), post-implementation notification evaluation (Post).
[a]States in which we contacted at least one county or local level beach program manager, including managers of 'model programs'.
[b]5 states from whom we received written reports of evaluation summarized in Table 3.

without any formal enforcement action. Closing or locking parking areas was used in three states, while lifeguards on duty, and/or police patrols, provided enforcement support at locations in 12 states (though only for a portion of the day).

As mandated by the ambient water quality criteria guidelines for recreational waters (US EPA 1986), levels of fecal indicator bacteria (FIB) exceeding the US EPA standards (*Escherichia coli* in freshwater at 126/100 mL, *Enterococci* at 33/100 mL in freshwater and 35/100 mL in marine water) was an absolute trigger for closures/swim bans or advisories in all 35 programs, but not all programs identified high levels of indicator bacteria as the primary reason for public notification. These values are the geometric means (GM) of a minimum of five samples collected over a 30-day period. Some states/local entities use single sample maximum limits (with higher thresholds) instead of, or in addition to, the 30-day geometric mean for public notification. The standard beach monitoring methods usually take up to 24 h to complete and the notifications for closures/swim bans, or advisories, are sometimes issued a day or more after a contamination event has occurred. The survey did not specifically inquire about pre-emptive advisories or closures/swim bans: however, more than half the programs noted that they pre-emptively (without, or prior to, results of FIB levels) issued advisories or closures/swim bans for various reasons (see Table 2). A certain amount of rainfall in the preceding days was a trigger for pre-emptive advisories or closure/swim bans, because rain can cause an elevation of bacteria levels either due to stormwater runoff or sewage discharge from point sources. Fifteen programs used rainfall or sewage as a trigger and 11 used both. Nine programs identified algal blooms as a trigger for a swim advisory. Beach program managers in several areas also use 'real-time' predictive models to augment this decision-making process (such as Nowcast in Ohio, Project SAFE in northwest Indiana and Swimcast in Lake County, Illinois). These models may use wave height, turbidity, wind direction, precipitation or algal bloom concentrations to predict concentrations of bacteria in the water. Although we did not specifically ask our survey participants about the use of predictive models, or rapid methods for measuring FIB, we are aware of 5 states currently using these methods to augment their beach monitoring program. The EPA has developed one such program called Virtual Beach (VB). This program provides a user-friendly interface for local beach managers to build, test and execute predictive models. Local beach program managers at various Great Lakes beaches (including Wisconsin) have already tested a version of this program.

Fourteen out of 35 programs had a notification program for inland lakes and river waters, which is not required under the BEACH Act. Programs in five states (MA, RI, MD, MI and WI) have implemented programs at inland beaches modeled after EPA's beach program, while others had fishing advisories or algal bloom programs at inland waters. These programs are unique as they already address ambient water quality for inland waterways, though this is not required in order to receive BEACH Act funds.

Nine county or local beach program offices were identified by their state beach program coordinators as 'model programs'. We did not use specific criteria to define a 'model program'; rather, we asked state beach program coordinators if they thought of any local or county level programs as 'model programs'. We were able to contact beach program managers at 7/9 of these model programs (New Haven County, CT; Anne Arundal County, MD; Harrison County, MS; Door County, WI; City of Racine, WI; Orange County, CA; Pierce County, WA). State beach program coordinators often identified these 'model programs' based on the enthusiasm of local staff for their notification program or the effort that went into maintaining beach monitoring and notification practices. This did not reflect the use of any novel notification practices or effectiveness of the current notification practices in changing public behavior (such as avoiding beach swimming when water quality is impaired). Two of the model programs (Anne Arundel County, MD and Orange County, CA) had some elements of beach monitoring and public notification in place before they became a part of the EPA Beach program. Although there is no report of a formal evaluation of the notification program at Anne Arundel County, they do focus on educating the public and encourage the use of their website. In addition, they used seven different methods to communicate with the public, including Twitter. Orange County has been consistently monitoring its beaches over the last 40 years using the California Ocean Water-Contact Sports Standards. They also conduct outreach programs to

educate the public about water quality, but did not provide any formal reports of evaluating their notification system.

Six programs (including 4 states and the 2 tribal beach programs) conducted pilot studies to identify their target audience or assess the public's needs before implementing their notification system, and 16 programs (including 13 states, 1 territory and the 2 tribal beach programs) had evaluated their public notification system post-implementation. These pilot studies or post-implementation evaluations present largely informal and qualitative assessments of beach user feedback on beach sign content and design via intercept interviews, or surveys conducted by phone or via the internet. Also evaluated were awareness of local beach programs, water quality issues and the use of websites created to provide beach information for the public. Twelve states noted that they used anecdotal data to evaluate the success of their notification system by tracking website hits or reviewing public feedback by interviewing beachgoers or conducting web surveys, but did not report their findings. Lack of funding, inadequate staffing and time were some of the reasons offered to explain why beach program officials had not been able to do more about formally evaluating the effectiveness of these beach notification programs.

The Makah Tribe's beach program is new and is modeled after (and assisted by) the Washington State Department of Ecology Beach Program. The public's input was included during the program development phase and they plan to conduct annual and bi-annual evaluations with public input. The Grand Portage Tribe beach program worked closely with community members, including youth, before selecting the methods of notification. They have since had several meetings with community members, especially targeting the youth to receive feedback on their message delivery methods. The American Samoan territorial beach program uses bilingual signs at all beaches and works closes with yacht clubs and paddling groups to provide up-to-date water quality information. The Mariana Islands beach program conducted a brief survey of beachgoers in 2007 and found that tourists, compared to locals, were more likely to be unaware of the beach signs. This led to the development of multilingual signage and posting of signs in major hotel lobbies to better inform tourists of water conditions at various beaches. The Island's beach program staff also routinely conduct educational and outreach activities involving high school students.

We received 5 written reports of evaluation of elements of the beach notification programs (see Table 3). The state of Wisconsin conducted intercept interviews asking the public for their input about beach signs, hotline numbers and other preferred communication methods prior to the implementation of their beach program in 2002. Data from this study were used to develop a color-coded beach notification system, website and public e-mail alert system in 2004. The Wisconsin Beach Health website (http://www.wibeaches.us) surveys its website users about what information they want and how they use the information posted on this site. We received four reports of post-implementation evaluation of elements of the notification system at specific locations within four states (California, Ohio, Indiana and Texas). The evaluations focus on awareness of water quality information, message delivery and content, but not effectiveness of notification practices in changing behavior.

Although the Indiana Department of Environmental Management (IDEM) conducted an evaluation of the 'flag-based' warning system commonly used as a message delivery method in many beach notification programs, none of the programs surveyed had information about the public understanding, or interpretation, of the color codes used currently or in the past. The actions taken on the part of the bathing public in response to advisories has not been evaluated. States also had no formal system in place for evaluating the effectiveness of a beach closure, i.e. ensuring adherence to swim bans. Wisconsin and Oregon have conducted surveys to assess swim ban/beach closure adherence, but no formal report has been presented as yet.

State beach program coordinators in 13 programs noted variability within the state in notification programs. For example, some states have an advisory-only system but certain counties within that state have their own notification system that includes both advisories and closures/swim bans. For other states, this is reversed, with two levels of notification at the state level (advisory and closure) but only one level for a particular county. We attempted to contact at least two county or local beach program offices in these 13 states. During the time interviews were conducted, the

Table 3 | Summary of key findings of one pre-implementation pilot study (WI) and the four post-implementation evaluation studies (OH, CA, TX, IN)

Location	Wisconsin State Beach Program, WI (Wisconsin Dept. of Natural Resources 2002)	Santa Monica Pier, CA (Heal the Bay 2008)	Texas GLO Beach Watch Program, TX (unpublished report)	Ogden Dunes, OH (unpublished report)	Indiana State Beach Program, IN (Indiana Department of Environmental Management 2007)
Time	September, 2002	Summer, 2008	May, 2008	Summer, 2008	July-September, 2007
No. of participants	164	1,007	325	34	350
Type of survey	Pre-implementation pilot study via intercept interviews at beaches	Post-implementation evaluation via intercept interview at beaches	Post-implementation evaluation via telephone survey among Texas Gulf beach visitors	Post-implementation evaluation via mail with link to an online survey sent to 130 residents. Included website link to beach signage in the survey Beach signage material was posted at 18 access ways to the beach, and at the entrance to the town and Town Hall	Post-implementation evaluation via intercept interview at beaches Conducted in two stages to evaluate the 'warning-sign system' at two beaches, and the 'flag-based warning system' used at a third beach
Findings: evaluation of quality, content and location of signage	Participants wanted health risk information; contact information; signs posted in parking lots	55% did not understand permanent beach water quality sign; 21% did not understand a beach closure; larger signs in color and with multiple languages preferred. 23% of beach visitors aware of water quality issues at the pier	63% surveyed aware of water quality advisories; Hispanics less likely to have seen or heard this information	Over 70% of respondents were aware of the signs, and understood the wording and more than 64% of participants wanted larger signs with fewer words	Less than 10% of beachgoers saw the warning signs posted at the 2 beaches with the 'warning-sign-system'. About 20% of the beachgoers saw the flags used in the beach with the 'flag-based warning' system
Findings: effectiveness of signage in changing behavior		Of the visitors already aware of water quality issues at the pier 9% ignored possible risk		Over 70% said the information on the signs would impact their decision to swim;	Approximately 83% of the respondents at the beach with the 'flag-based warning'

		health risks of entering water despite this knowledge		about 35% said there is a need to educate the residents about water testing procedures and *E. coli* levels. This may help change behavior of public that does not respond to signs about water quality	system believed that the flags adequately notified them of the water conditions. Of those who saw the flag, approximately 23% indicated that the flag caused them to change their mind regarding contact with the water Over 70% of those who saw the signs at the beaches with the 'warning-sign' system indicated that they would use the information on the signs to make decisions regarding water contact
Findings: awareness of water quality reports and websites		5% of California residents aware of the beach report card	24% had heard of the Federal beach watch program that monitors water quality at Texas' recreational beaches and issues advisories; only 6% of these ever visited the website		Beachgoers' knowledge of current beach water conditions was limited at all 3 beaches; only 6% of beachgoers obtained any information on beach water quality prior to coming to the beach
Findings: current and desired future sources of water quality information for public	Television and newspapers most popular sources of current water quality information, followed by the radio and internet These were the preferred future methods as well		Internet most popular current source of information followed by local TV and radio Preferred future methods were television followed by beach signs and internet	Town of Ogden Dunes produced an educational video to show at town meetings and community-specific websites for future use	Over 60% of the respondents indicated that a combined warning sign/warning flag system was preferred. The most frequently cited reason for the choice was the ability of the system to 'cover all the bases'

beach season had begun, which made it difficult to reach some county and city officials to complete the survey. Therefore, personnel at only 11 programs were reached. Some counties with beaches that have a point source of pollution, or history of algal blooms, preferred issuing a swim ban/closure instead of an advisory. Although the triggers used to issue a swim ban/advisory could vary within a state, the FIB levels used to make the decisions were the same. None of these programs had any notification practices that varied by beach usage (heavily used vs. less frequented beaches).

DISCUSSION

Aspects of monitoring and notification not specified under the BEACH Act

While the EPA provides guidance to beach programs about the types and content of beach notification (http://www.epa.gov/waterscience/beaches/grants/guidance/chapter5.htm#section1), specific message content and delivery methods are not mandatory. While referred to as 'risk communication,' this may be more appropriately referred to as 'water quality communications', as risk *per se* is generally not communicated. For example, the public is not told 'an excess number of cases of illnesses are expected for every 1000 users' or 'the risk is 50% higher than usual'. EPA provides suggestions for soliciting public input before developing communications programs, evaluating the public's reaction to beach notification and the public's willingness to adhere to such notifications. Such program evaluation, however, is not mandatory. An EPA link to 'Beach Notification-Effective Practices' is under development, and in the future may provide information regarding evidence-based best practices for beach notification. In the absence of effectiveness data, beach managers have little data to use in choosing one message or message delivery method over another.

Rapid methods for measuring FIB have progressed from the laboratory to the implementation phase in research studies (Wade *et al*. 2006, 2008) and are expected to be part of new or revised ambient recreational water quality criteria due to be issued in 2012. Additionally, modeling approaches have been developed and can be expected to develop further as a priority area under the Great Lakes Restoration Initiative (http://www.epa.gov/glnpo/glri/). While a substantial effort will go into reporting or modeling same-day water quality, a parallel effort is required to maximize the prevention of recreational waterborne illness through the development of effective communication methods.

Local innovation with limited evaluation

Since passage of the BEACH Act, local beach managers in all state, territory and tribal beach programs have developed and/or implemented a variety of approaches towards communicating water quality to the public. This innovation could provide an opportunity to identify best communications practices. We found that all 35 programs surveyed used websites and signage at beaches to notify the public about water quality on a given day. Media, hotlines and websites are widely used to inform the public prior to visiting a beach, while beach signage and colored-flags are frequently used to communicate a closure/swim ban or swim advisory at the beaches to prevent the public from using the water for recreational activities. At the time of the survey more than half the states were using e-mail alerts and only three states were using social networking sites such as Twitter and Facebook, but more than 50% of the state beach program managers mentioned interest in testing new communication methods to accommodate the changing needs of the public. Considerable variability was found in the content of communications, with 13/35 (37.1%) of programs categorizing beach status into one of three levels ('open' 'advisory' and 'closed/swim ban') while 4/35 (11.4%) used two ('open' vs. 'closed/swim ban'). Thirteen of the 35 (37.1%) beach programs utilized color coding to communicate the status of coastal beaches, and of those about 46% used a three-tier system of green–yellow–red to communicate water quality ('open', 'advisory' and 'closed/swim ban'). The triggers for beach notification vary as well, with some states supplementing their monitoring programs with predictive models, or recent rainfall, or sewage releases to issue an advisory or closure/swim ban, while 9/35 programs (25%) rely only on prior-day FIB measures.

In 40% of surveyed programs, lifeguards are expected to assist in the enforcement of swim bans or beach closures to

reduce the incidence of recreational water illnesses. At locations or times when lifeguards are not present, programs expect the public to adhere to notifications posted at the beach and/or through the media. The extent of such adherence is not known but the relatively low levels of awareness of water quality reports issued at the Santa Monica pier among California residents (only 5%), the very limited use of the Texas GLO Beach Watch program website by Gulf residents (only 6%) despite being aware of this Federal water quality program, and the extremely low awareness/observation of signs/flags posted at Indiana beaches suggest that such adherence to posted advisories is unlikely to be complete. At least half the programs said they had attempted to solicit public input in the development of notification programs, or receive feedback on their beach notification practices post-implementation, but that with a few notable exceptions at the local level, beach notification practices have not been formally evaluated for effectiveness nor has the effectiveness of various message content or message delivery methods been compared. Due to limited resources, not because of lack of interest, most programs (including the model programs) have only anecdotal information about the usage or impact of elements of their beach notification programs. The pilot or post-implementation evaluation studies presented in this survey (see Table 3) at five beach locations suggest that beach notifications are often not noticed by beachgoers and that those who are aware of the notifications have questions about the meaning of the information. Beach users in Wisconsin and Ohio want more information about health risks and current testing methods to help them make informed decisions about using the water on a given day. The studies conducted so far focus on the effectiveness of the process of notifying the public (for example, how many people are accessing a website or how many are aware of a beach water quality report card) or provide qualitative information about what beach-goers have to say about the size, color or content of a beach sign. Evaluations are needed of the effectiveness of notification methods in actually changing behavior. For example, if current approaches are not stopping people from going into the water during a closure/swim ban, it is critical to identify alternative approaches that will promote adherence to future swim bans.

The critical role played by water quality communications

Figure 1 is a schematic framework for the critical role played by effective communications in preventing recreational waterborne illness (RWI). In the language of the BEACH Act, monitoring and notification programs are to provide a level of protection 'necessary for the protection of public health and safety'. Effectively communicating water quality may contribute to the behavior change – such as the avoidance of beaches during closures/swim bans or advisories – which ultimately leads to reductions in the incidence rate of RWI. The ideal way of demonstrating the success of the beach monitoring and notification programs would be to identify declines in rates of RWI at beaches after the implementation of such programs. However, RWI is only captured by existing surveillance systems in the context of outbreaks, not sporadic disease (Yoder *et al.* 2008), even though sporadic disease clearly occurs (Wade *et al.* 2006, 2008). Determination of the 'number of illnesses prevented by beach closures' has been identified as a near-term research need important to EPA (US EPA 2007). Because the data do not exist to compare disease rates before and after the implementation of beach monitoring and notification programs, other endpoints must be studied to evaluate the effectiveness of such programs.

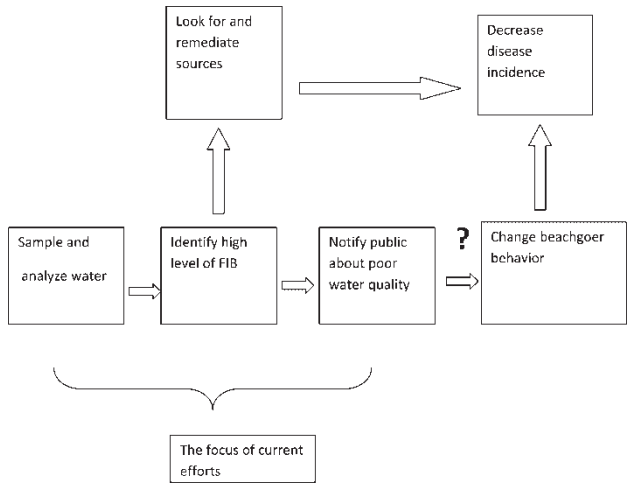

Figure 1 | Schematic framework for the critical role played by effective communications in preventing recreational waterborne illness. The '?' identifies a critical knowledge gap translating monitoring and notification into reduction in recreational water-borne illness.

Research and implementation needs

Outcomes intermediate between the issuance of beach advisories and possible impacts on RWI rates can be studied. A critical step toward developing evidence-based best management practices would be to evaluate such endpoints, such as the public's awareness and utilization of beach notification information. Table 4 summarizes several aspects of communications that can be evaluated and divided into pre-arrival and following-arrival time periods (http://www.greatlakes.org/). An expert panel convened by EPA cited the need for social science research to improve recreational water illness risk communication strategies along with improved approaches for water quality criteria development (Boehm *et al.* 2009).

Typically, a person's initial perception of water quality is based entirely on the aesthetic characteristics (such as color, clarity, odor and the existence of waste material) of the water and the surrounding environment (House 1996; Pendleton *et al.* 2001). It is only when water quality issues become a health threat, such as when beaches are closed because of fecal pollution, that the public concern for water quality becomes a top priority. Public perception of water quality has direct implications on a person's behavior (Pendleton *et al.* 2001). Therefore, a combination of intercept interviews, focus groups, surveys conducted on the internet or via text messaging, and observations at beaches could be utilized to assess beachgoers' needs. States must continue to focus on developing message content with information about the reason for the specific notification, possible health outcomes and information about nearby beaches that do not have advisories that day. Newer technologies for delivering notification messages have the advantage of being rapid, and could be communicated to the individuals before they arrive at a beach. While text messaging has been shown recently to increase adherence to medication use among asthmatics (Strandbygaard *et al.* 2009), its use for communicating environmental information to at-risk groups has not been evaluated.

Table 4 | Endpoints that can be measured in water quality communications research

	Before leaving for beach	At beach
Message content	Content elements that effectively lead to avoidance of beaches with advisories/bans	Content elements that effectively lead to avoidance of swimming
Message delivery method	Media that various demographic groups of beach users actually check prior to leaving for a beach	Sign size, design features, languages, and placement location that beachgoers attend to

The diversity of approaches currently in use as part of the beach programs is an opportunity to identify best practices for standardization and implementation on a national scale. There is a need for a more standardized system such as a universal color-coded system to effectively communicate to the public. The EPA's Air Quality Index (AQI) values are divided into ranges, and each range is assigned a descriptor and a color code. Standardized public health advisories are associated with each AQI range. Research has been done to evaluate how the public understands information used in the AQI system (Johnson 2003). To help address the European Union's updated bathing water directive (European Parliament Council 2006), which places greater emphasis on providing information to the public on the quality of bathing areas, the European Environment Agency (EEA) and Microsoft have developed a portal, 'Eye on Earth'. This website shows not only the latest information on water quality but also user ratings and comments, pictures and live webcam streaming (http://eyeonearth.cloudapp.net/). Another system that could be evaluated for effectiveness is the Scottish Environment Protection Agency (SEPA) real-time bathing water quality communication system (http://www.sepa.org.uk/water/bathing_waters/bathing_water_signage.aspx). This includes modeled predictions posted on electronic signs that can display variable messages at beach locations. The signs are networked to a central communication center and updates are simultaneously made on the SEPA website, phone and text message service. It is possible that efforts funded through the Great Lakes Restoration Initiative 'Communicating Beach Monitoring to the Public' will lead to implementation and evaluation of some of these message content and message delivery possibilities.

Our findings in context

We are aware of no prior reports in the peer-reviewed literature that have addressed wide-scale evaluation of recreational water quality communications. The range of communications practices we described has been noted in

the Natural Resources Defense Council's annual 'Testing the Waters' reports (NRDC 2008, 2009). The lack of consistency in the information the public receives and the triggers for issuing that information have not previously been reported nor has the finding that very little effectiveness data and no comparative effectiveness data exist.

Strengths and limitations

Interviewing more local/county beach programs would have provided additional perspectives. However, surveying the state/territory/tribal beach program coordinators was considered to be the most feasible (in terms of time and resources) way of compiling information about what states do to fulfill and evaluate the requirements of the BEACH Act-funded public notification and risk communication criteria. Coordinators at half the programs were aware of some form of a pilot or post-implementation evaluation that was conducted in their beach program, but not all of these were available as comprehensive reports or accessible to us. We only received five written reports of evaluation studies that were done either prior to or after implementation of beach programs. While the evaluations for which we did not have information were thought to be informal and qualitative, it is certainly possible that those investigations contained useful information, and what information the public needs in order to avoid swimming when notifications are in effect. Additional information from the 13 beach programs about the effectiveness of the color-coded system they used would have been valuable in considering the design of a uniform color-coded communication scheme for water quality similar to the AQI in the future. While we did visit websites and read reports produced at the state, territory and tribal level, our data collection was limited to interviews rather than direct observations of signage use at beaches.

The recent catastrophe in the Gulf of Mexico highlights the need to clearly and effectively promote behavior change by the public at beaches in response to changes in environmental conditions. Local and state departments of health could work in coordination with beach program staff in an effort to track changes in disease occurrence in coastal counties before and after implementation of new or enhanced beach communication programs.

CONCLUSION

The EPA's Beach Program has successfully accelerated efforts by states to develop and implement communication systems to inform the public about beach water quality. The communication systems vary in terms of the content and format of notifications, the triggers used for notifications and the methods of communicating the notifications. Lacking are systematic evaluations of the effectiveness of these systems in changing beach user behaviors. Also lacking are comparisons of the effectiveness of various messages or message delivery approaches in terms of use and comprehension by likely beachgoers. Ongoing and future epidemiologic studies related to water quality should include evaluations of communication with the public. It would be useful at the local level if the beach programs were to develop guidelines for evaluating the effectiveness of the notification programs. In order to go beyond notifying the public and to effectively promoting behavior change through water quality communications, there is a need for research focused on two time windows: before potential swimmers go to the beach and after they arrive there. Best notification practices and models for standardized and timely environmental quality communications are available and should be evaluated for their ability to promote the utilization of water quality information to prevent illness. The BEACH Act goals may be best met through the evaluation of notification practices by beach program managers. Including a step-by-step guide to evaluate effectiveness of messages content and delivery methods, including how to obtain public feedback, as part of the public notification criteria will be helpful. For future beach programs, developing a formal system to involve the public in the development of a beach notification program may help in streamlining the evaluation in future.

ACKNOWLEDGEMENT

Preethi L. Pratap and Samuel Dorevitch are supported in part by the Metropolitan Water Reclamation District of Greater Chicago.

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First received 19 October 2010; accepted in revised form 6 February 2011. Available online 27 June 2011