ORIGINAL RESEARCH

Communication of Urgent Public Health Messages to Urban Populations: Lessons From the Massachusetts Water Main Break

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ABSTRACT

Objective: To study when and how an urgent public health message about a boil-water order reached an urban population after the Massachusetts water main break.

Methods: In-person surveys were conducted in waiting areas of clinics and emergency departments at a large urban safety net hospital within 1 week of the event.

Results: Of 533 respondents, 97% were aware of the order; 34% of those who lived in affected cities or towns were potentially exposed to contaminated water. Among those who were aware, 98% took action. Respondents first received the message through word of mouth (33%), television (25%), cellular telephone calls (20%), landline calls (10%), and other modes of communication (12%). In multivariate analyses, foreign-born respondents and those who lived outside the city of Boston had a higher risk of exposure to contaminated water. New modes (eg, cellular telephones) were used more commonly by females and younger individuals (ages 18 to 34). Individuals who did not speak English at home were more likely to receive the message through their personal networks.

Conclusions: Given the increasing prevalence of cellular telephone use, public officials should encourage residents to register landline and cellular telephone for emergency alerts and must develop creative ways to reach immigrants and non–English-speaking groups quickly via personal networks.

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Key Words: urban population, disaster, crisis communication, public health

Communication of disaster information is critical to the public health. The frequency and severity of natural epidemics and disasters seem to have increased since the 1970s.[1,2] Although there are varying explanations for this increase, including global warming,[3,4] improved disaster reporting, and active case finding,[5] there is little doubt that disasters are more visible than ever. Recent events such as the severe acute respiratory syndrome outbreak, Hurricane Katrina, the earthquake in Haiti,[6] and the earthquake and tsunami in Japan received extensive media coverage. Acts of bioterrorism such as the 2001 anthrax attacks in the United States[7] also have created a new form of public health emergency. As the world becomes more interconnected, the effects of these events are no longer isolated to specific regions, but instead reverberate throughout society.[8,9] Furthermore, as the concentrations of people living in high-risk areas have risen, the impact of disasters has become more serious.[10] It is thus increasingly important to examine the effectiveness of current strategies for quickly communicating risks and disaster information to the public during a crisis.

Public health messages do not reach all populations equally.[11] Cultural barriers, language barriers, socioeconomic disparities, and distrust of authority can reduce the effectiveness of health information delivered to racial and ethnic minority populations in urban areas.[12-16] This also is true for people who are mentally ill, elderly, visually impaired, economically disadvantaged, and who have low literacy levels.[17] Despite these known challenges to communication, messages historically have not been tailored to reach minority groups. In addition, although new modes of communication (eg, Internet) have become popular since the turn of the century,[18-21] there is evidence of a "digital divide," with differential access to technology based on socioeconomic status, race, and language.[22] For example, about half of African Americans and Hispanic Americans do not have Internet access at home, compared to about one fourth of whites.[23] Because minority populations have been disproportionately affected in emergencies,[24] it is particularly important to understand how to communicate urgent public health messages to these groups.

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In this article, we describe how patients and families at Boston Medical Center (BMC), a large urban safety net hospital, which predominantly serves Boston's indigent populations, learned about a public health message related to the Massachusetts water main break, which occurred on Saturday, May 1, 2010. The water supply to Greater Boston was compromised when a 10-ft-wide pipe broke at 10:33 AM, causing 8 million gallons of water per hour to spill.[25] The broken main was shut down for repairs and untreated secondary water sources were redirected to serve approximately 2 million residents in Greater Boston. Because of possible microbial contamination, the Massachusetts Water Resources Authority issued a boil-water order to affected communities at approximately 4 PM on May 1.[26] The order remained in effect until May 4, when repairs were completed and water test results were satisfactory.[26] The boil-water order served as a natural experiment for examining the receipt of an urgent public health message by an urban population.

METHODS

To obtain a cross-section of an urban population quickly without using modes included in our outcome variables (eg, landline), we surveyed individuals in 5 clinics and emergency departments at BMC from May 7 to 11, 2010. We included those who were older than 18 years, in the Boston area during the emergency, and comfortable speaking English, Spanish, or Haitian Creole. The survey was verbally administered in the subject's preferred language. This study was considered exempt by the Boston University Medical Campus institutional review board. All of the subjects verbally assented to participate.

Survey Content

We developed a 12-item survey to assess the receipt of the public health message following the Massachusetts water main break (see Supplemental Appendix). Participants were first asked whether they were aware of the boil-water order. If they were aware, they were asked the approximate day and time at which they first received the message (eg, Saturday before dinner, Saturday after dinner) and the mode by which they first received the message (eg, landline telephone, cellular telephone, text message). Those who were contacted by someone about the boil-water order were asked who delivered the message (eg, family/friend, community group). Respondents were then asked whether they took action in response to the message (ie, whether they used boiled, unboiled, and/or bottled water). Demographic information, including race and ethnicity, was also collected because barriers exist in communicating with minorities during emergencies.[13-16] Respondents selected 1 of the National Institutes of Health's 5 racial categories (or "other"); Hispanic ethnicity was reported separately.[27]

Key Outcome Variables

Awareness and Potential Exposure to Contaminated Water

For the outcome of potential exposure to contaminated water, the analysis was restricted to respondents who lived in affected cities or towns. We classified respondents as "exposed" or "unexposed" based on 3 criteria: awareness of the order, timing of receipt of the message, and action taken upon receipt of the message (Table 1). The boil-water order was issued at approximately 4 PM on Saturday, May 1, which made it possible for people to receive the message before dinner and take precautions for cooking, eating, and drinking. Therefore, respondents who stated that they received the message "Saturday before dinner" and acted on it were classified as unexposed. To generate a conservative estimate of exposure, we also categorized those who responded "Saturday (time unknown)" and "unsure" as unexposed (Table 1 contains details of the exposed and unexposed classifications). Exposed respondents included those who were either unaware of the order, received the message "Saturday after dinner," "Sunday," "Monday," or "after Monday," or took no action after learning about the order.

Mode of First Message Delivery

We categorized the mode of first message delivery based on whether new technology was used. New modes included cellular telephone calls, e-mail, text message, and online social networking or news sites. We included cellular telephone calls as a new mode because although cellular telephones have been available to the public since the late 1970s, it has taken nearly 40 years for them to become commercially accessible for people in all demographic groups in the United States.[28,29] Moreover, cellular telephone use increased 10-fold (from 7% to 70%) between 1998 and 2008, whereas use of landline telephones remained constant, at around 20% during the same period.[30] All of the other responses (eg, television, radio) were categorized as "traditional" modes of communication.

Receipt of First Message Through a "Personal Network"

Respondents were classified as receiving the first message through a personal network if they heard via landline telephone call, cellular telephone call, e-mail, text message, or word of mouth from family/friends, a community group, school/work, or another acquaintance (eg, landlord) or via an online social networking site. We included online social networking sites as part of the personal network because sites such as Facebook and Twitter allow direct messages between family, friends, coworkers, and other contacts. Mass media (eg, online news sources, television, radio) and public announcements by the cities affected were not considered part of the personal network because these methods do not involve conveying direct personal messages to individuals. Respondents who selected "other" methods indicated that they received the message via highway billboards, newspapers, flyers, and hospital staff; therefore, they were not classified as receiving the message through a personal network.

Action Taken Based on the Message

We classified respondents as having taken action based on the message if they perceived that their city was affected and they used only boiled and/or bottled water while the order was in effect.

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TABLE 1

Demographics of Sample Population and Major Outcome Distributions

Sample Characteristics	Frequency	%
Sex, n = 525		
Male	163	31.1
Age group, y, n = 532		
18-24	76	14.3
25-34	154	28.9
35-44	140	26.3
45-54	95	17.9
55-64	47	8.8
≥65	20	3.8
Location survey was administered, n = 533		
Pediatric ambulatory care center	225	42.2
Family medicine clinic	78	14.6
Urgent care center	19	3.6
Adult emergency department	183	34.3
Pediatrics emergency department	28	5.3
Language survey was administered, n = 533		
English	479	89.9
Spanish	39	7.3
Haitian Creole	15	2.8
Education level, n = 529		
≤8th grade	33	6.2
Some high school, but did not graduate	81	15.3
Graduated high school/GED	189	35.7
Some college/associate's degree	119	22.5
Graduated college/bachelor's degree	86	16.3
Graduate work	21	4.0
Hispanic or Latino, n = 523		
Yes	124	23.7
Race, n = 532		
White	92	17.3
Black	294	55.3
Asian	15	2.8
Other*	131	24.6
Born in the US, n = 529		
Yes	291	55.0
English spoken at home, n = 528		
Yes	362	68.6
Primary residence, n = 533		
Shelter	17	3.2
Nonshelter	516	96.8
Outcome of Interest	**Frequency**	**%**
Exposure status,† n = 479		
Potentially exposed, n = 164		
Aware and did not take action	5	3.0
Unaware	12	7.3
Learned Saturday after dinner	92	56.1
Learned Sunday	41	25.0
Learned Monday	9	5.5
Learned after Monday	5	3.0
Unexposed, n = 315		
Learned Saturday before dinner	269	85.4
Learned Saturday at unknown time	24	7.6
Learned, unsure of date	19	6.0
Unclear when message received or missing data on city/town of residence	3	1.0
How message was first received, n = 515		
Traditional modes, n = 373		
Telephone call (landline)	49	9.5
Television	131	25.4
Radio	9	1.8
Word of mouth	170	33.0
Other‡	14	2.7

(continued)

Data Analysis

Only subjects who completed the survey were included in the analysis. Descriptive statistics were calculated for all of the outcome and demographic variables. Some individuals who selected a National Institutes of Health category for race were reclassified to "other" because by themselves their numbers were too small to be analyzed. We conducted bivariate and multivariate logistic regressions for 3 key outcome variables: potential exposure to contaminated water, mode of first message delivery (new vs traditional), and whether the message was received through a personal network. Two other outcome variables, awareness of the water message and whether action was taken, showed too little variation in responses for logistic regressions to be meaningful.

Demographic variables were selected for inclusion in the multivariate regressions based on the available literature and our own hypotheses about factors related to the key outcomes. The literature suggests that demographic characteristics such as sex, race, language spoken, age, and literacy may play an important role in the receipt of public health messages.[12,13,17,31,32] When 2 demographic variables were known to be collinear (eg, survey language, length of time in the United States), only 1 was included in the multivariate model.

Based on the available literature and our own hypotheses, we believed that the predictor variables potentially associated with each outcome were not necessarily the same. Therefore, different predictor variables were included in each model. For example, we used an age cutoff of 65 years in the multivariate models for 2 outcomes: potential exposure to contaminated water and receipt of the first message via a personal network because elderly adults are known to be at risk for both delayed receipt of public health messages[17] and social isolation.[33] For the outcome "mode of first message delivery," we used an age cutoff of 35 years in the multivariate model because differences in the use of technology have been documented among those older than age 35 as compared with younger individuals.[34] Data were analyzed using Stata 10 (StataCorp, College Station, TX).

RESULTS

Among those who met the eligibility criteria and agreed to participate (n = 553), 20 participants were called to their appointment before completing the survey. For the 533 respondents who finished the survey, <1% of the data was missing.

Characteristics of Respondents

A total of 89.9% of the surveys were conducted in English (Table 1). Most respondents were female (68.9%), which is consistent with mothers accompanying children to health care visits. Less than half (42.8%) had more than a high school education, and more than half were African American (55.3%). Slightly more than half of the sample was born in the United States (55.0%). Among foreign-born respondents, 10.5% had lived in the United States for ≤2 years, 22.3% for ≤5 years, 45.0% for ≤10 years, and 64.3% for ≤15 years (data not shown).

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Awareness and Potential Exposure to Contaminated Water

The vast majority of respondents (97.5%) stated that they were aware of the boil-water order. Of those who were aware, 88.5% said their city was affected by the order, 9.2% said their city was unaffected, and 2.3% were unsure (data not shown). Using our definition of exposure (see Methods), 34.2% of respondents who lived in affected cities or towns were likely exposed to contaminated water. Even if we calculated exposure as those who received the message on or after Sunday, 72 respondents who lived in affected cities or towns (15%) would be considered exposed Table 1).

In the bivariate analyses, respondents who were foreign-born or resided outside Boston were more likely to be exposed. A multivariate model, which included the predictor variables survey language, age (18–64 years vs ≥65 years), race, foreign-born status, and city of residence, showed that foreign-born respondents were more likely than US-born respondents to be exposed (odds ratio [OR] 1.71, 95% confidence interval [CI] 1.11–2.66). Similarly, respondents who lived outside Boston were more likely to be exposed than residents of Boston (OR 1.69, 95% CI 1.02–2.79; Table 2).

Mode of Delivery of First Message

The 3 most common modes for learning about the message were word of mouth (33.0%), television (25.4%), and telephone calls (29.7%: 9.5% landline, 20.2% cell [Table 1]). A total of 27.6% of respondents received the initial message via a new mode. Of those who received the message via a new mode, 73.2% heard via cellular telephone and 21.2% received it via text message. Only 8 respondents (5.6%) heard through e-mail, online social networking sites, or an online news source.

In the bivariate analyses, females and those aged 18 to 34 years (vs ≥35) were more likely to have received the boil-water message via a new mode. In a multivariate model that controlled for education, the use of new modes remained significantly associated with those who were girls or women (OR 2.20; 95% CI 1.37–3.54) and younger (18 to 34 years vs 35 years or older; OR 1.88; 95% CI 1.26–2.81). Models using other demographic variables showed no significant association (Table 3).

Receipt of First Message Through a Personal Network

Nearly half (49%) of the respondents received the message through their personal network (vs mass media or city) (Table 1). Of those, 80.4% learned about the boil-water order from family or friends, 16% heard at school or work, 1.2% heard from community groups, 1.2% heard from another acquaintance (eg, landlord), and 1.2% heard via an online social networking site (data not shown).

In bivariate analyses, people who did not speak English at home were significantly more likely to receive the message via a personal network. This association remained significant (OR 1.63; 95% CI 1.10–2.41) in the multivariate analysis, after controlling for age and education (Table 4).

TABLE 1

Demographics of Sample Population and Major Outcome Distributions (continued)

Outcome of Interest	Frequency	%
New modes, n = 142		
Telephone call (cell)	104	20.2
E-mail	4	0.8
Text message	30	5.8
Online social networking (eg, Facebook, Twitter)	3	0.6
Online news source	1	0.2
Who first contacted the respondent?§ n = 359		
Friend/family member	201	56.0
Community group	3	0.8
School/work	40	11.1
Health care provider	7	2.0
My city or town	85	23.7
In public place	9	2.5
Other	14	3.9
People who found out through a personal network,|| n = 511		
Personal network	250	48.9
Nonpersonal network	261	51.1
Action resulting from message, n = 466		
Boiled water/bottled water	455	97.6
None	11	2.4

N=number of people who answered question

*"Other" includes a few who identified themselves among the National Institutes of Health categories Native Hawaiian or Pacific Islander (n=2) or American Indian or Alaska Native (n=1). A total of 76 self-identified as Hispanic, 36 gave their nationality (eg, Cape Verdean), and 16 did not specify.

†For exposure status, the analysis was restricted to respondents who lived in cities or towns affected by the boil-water message.

‡"Other" traditional modes (n=14) included highway billboards (n=5), flyers (n=5), newspapers (n=3), and the hospital as an inpatient (n=1).

§Question applicable to respondents who were first contacted by individuals or institutions (via telephone call, text message, word of mouth, and e-mail) rather than mass media

||Personal network includes landline telephone call, cellular telephone call, e-mail, text message, or word of mouth from family/friends, a community group, school/work, or another acquaintance (eg, landlord), and online social networking site.

TABLE 2

Bivariate and Multivariate Analysis of Risk Factors Predicting Exposure

Variable	Odds Ratio (95% Confidence Interval)	
	Bivariate	Multivariate
Survey not in English (vs English)	1.67 (0.93-3.00)	1.25 (0.64-2.44)
Age 18 – 64 y (vs ≥65 y)	0.50 (0.20-1.29)	0.39 (0.15-1.06)
Race		
White	Reference	Reference
Black	0.79 (0.47-1.32)	0.73 (0.42-1.28)
Asian	0.46 (0.12-1.82)	0.33 (0.08-1.33)
Other	0.76 (0.42-1.36)	0.60 (0.31-1.16)
Foreign-born (vs born in the US)	1.55 (1.06-2.27)*	1.71 (1.11-2.66)*
City of residence not in Boston (vs in Boston)	1.69 (1.02-2.79)*	1.74 (1.03,-2.95)*

*$P < .05$.

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Action Taken Based on the Message

Of those who were aware of the boil-water order and perceived that their city was affected, 47.0% reported using a combination of boiled tap water and bottled water, 41.0% used bottled water exclusively, and 9.6% used boiled tap water exclusively. Only 2.4% reported consuming unboiled tap water between May 1 and May 4 (data not shown).

COMMENT

This study provides a snapshot of how a public health message was communicated during the Massachusetts water main break. Many of our respondents received the message in a timely manner and were able to take recommended preventive measures; however, approximately one-third of respondents in affected cities were potentially exposed to contaminated water because they were unaware of the message, received the message late, or did not take action. Timely communication of public health messages can save lives.[35] For example, during the 2001 anthrax attacks, antibiotic treatment could have averted some deaths.[36] Our results suggest that efforts to make the delivery of public health messages more efficient are needed and offer important insights into how best to accomplish this in an urban population.

More than one-fourth of our respondents received the message through new modes of communication. This was more common among female respondents and those aged 18 to 34 years (vs 35 years or older). Our findings are consistent with previous studies showing that younger female respondents are more likely to be on the Internet and send/receive more e-mail than males respondents[12] and suggest that this association also may hold true for the receipt of public health messages. Although e-mail and online resources are becoming more popular, only 5.6% of our respondents received the message via these modes. This may be because of the well-documented "digital divide" in access to technology among minorities and people of low socioeconomic status.[22] In the study population, cellular telephones were the most prevalent new mode for receiving the boil-water message. Public health departments may want to consider allowing residents to register for emergency updates via cellular telephone or other new modes, as is mandated on many college campuses.

Our results also suggest a need to develop tailored strategies to reach immigrant and minority populations in a timely manner. Foreign-born respondents were more likely to be exposed than US-born individuals. It is known that the duration of stay for immigrants in the US predicts health care utilization[37]; it is possible that it also may influence the receipt of public health messages, perhaps because of issues of language or acculturation. We found that individuals who reported not speaking English at home were somewhat more likely to receive the boil-water message through their personal networks (vs the mass media). Personal networks are known to be minorities' preferred avenues of informal communication,[38] perhaps because of a lack of trust of the network media.[39] Research indicates that minorities are more likely than whites to contact relatives and community or religious organizations for public health information.[40-42] Therefore, to ensure that minorities and immigrants receive public health information quickly, it may be useful to tailor these messages to known personal networks such as religious groups and community organizations for widespread dissemination.[43]

Our study has certain limitations. First, because we sampled patients and families from 1 major urban hospital, the results may have limited generalizability; however, our findings show gaps in public health communication and suggest that more research on how to reach diverse, urban populations is warranted. Second, we used a convenience sample of subjects. This allowed us to conduct the survey within 1 week of the water main break, which helped minimize recall bias. Population-based sampling would have delayed fielding and likely would have required telephone recruitment, which would have biased our assessment of the mode of message delivery. Third, recruiting participants in person at BMC could have led to an overestimate of exposure if our participants were at the hospital for water-related illnesses; however, the Massachusetts Department of Public Health saw no significant increase in disease reports over those expected in the affected areas in the subsequent 2 months (A. DeMaria Jr, MD, personal communication, July 2010). Fourth, the survey asked respondents only about the first message they

TABLE 3

Bivariate and Multivariate Analysis of Factors Predicting the Receipt of Boil-Water Message Using New Modes

Variable	Odds Ratio (95% Confidence Interval)	
	Bivariate	Multivariate
Female sex	2.27 (1.41-3.63)*	2.20 (1.37-3.54)*
Age 18-34 y (vs ≥35 y)	1.95 (1.32-2.89)*	1.88 (1.26-2.81)*
Education: high school graduate or more (vs some high school or less)	1.33 (0.82-2.18)	1.27 (0.77-2.11)

*$P < .01$.

TABLE 4

Bivariate and Multivariate Analysis of Factors Predicting the Use of a Personal Network to Communicate the Boil-Water Message

	Odds Ratio (95% Confidence Interval)	
Variable	Bivariate	Multivariate
Age 18-64 y (vs ≥65 y)	1.67 (.65-4.32)	1.52 (0.58-3.96)
High school graduate or more (vs some high school or less)	1.40 (.92-2.15)	1.49 (.97-2.32)
No English spoken at home (vs English spoken)	1.51 (1.03-2.20)*	1.63 (1.10-2.41)*

*$P < .05$.

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received. Depending upon the level of threat, the timing of the first message may be critical for people to take necessary preventive measures.[44]

Despite these limitations, our study captures an urban population's receipt of and response to a public health message related to an actual event. The lessons regarding new and traditional modes of communication and the importance of tailoring messages to at-risk groups can inform future efforts to relay information to this population during a public health crisis. Even as social networking tools (eg, Twitter, Facebook) are becoming increasingly important for rapid dissemination of information, traditional modes remain a vital way of communicating with underserved people in urban areas, probably because of the well-documented digital divide.[45] Public health officials should be cognizant of the evolving digital environment and disparities in access to technology[22] when developing customized approaches to reaching their target populations. They should use a combination of new and traditional modes of sharing information to most effectively reach diverse populations based on the most up-to-date understanding of communication during public health emergencies.

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