CROWDSOURCING FOR NATURAL DISASTER RESPONSE:

AN EVALUATION OF CRISIS MAPPING

THE 2010 HAITIAN EARTHQUAKE

by

Annie Feighery

Dissertation Committee
Professor John P. Allegrante, Sponsor
Professor Tom Chandler

Approved by the Committee on the Degree of Doctor of Education

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ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
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ABSTRACT

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On January 12, 2010, a magnitude 7.0 earthquake struck Haiti, causing catastrophic damages that resulted in at least 300,000 dead, 300,000 serious injuries, and 1.8 million homeless. The destruction was so complete that roads were no longer visible. While buildings, roads, power, and other infrastructure have taken years to restore, mobile phone service was restored almost immediately. A communications network based on mobile phone text messages became an innovative and valuable tool for relief.

Within four hours of the earthquake, a crisis map was established, geocoding messages for inclusion in a freely accessible, online database. Over the next three months, over 3,600 messages would be translated, mapped, and coded with labels indicating the messages' actionable topics. This undertaking involved over 2,000 online volunteers from around the world. Analyzing and evaluating what happened, what worked, and what went wrong from a programmatic perspective is critical for the future use of crisis maps in disasters and for the future integration of new technologies into large bureaucratic entities.

The purpose of this study was to investigate the diffusion of a novel innovation; analyze aspects of the maps' deployment that limited success; and posit solutions for improving crisis mapping in natural disasters. The manuscript comprises three papers, beginning with a review of literature and emerging tools for social media and health promotion. The second paper developed an automated algorithm to code the need expressed in texts and compared its reliability to the actual human-derived codes. The findings suggest that automated algorithms can enhance speed of response and overcome human biases. The result is improved situational awareness. Algorithm codes revealed a pattern of message topics, which transitioned from emergency needs, including finding missing persons, to health infrastructure requests, primarily for food and water. The third paper employed a social capital framework to understand the system users' intents. The findings revealed that individuals far outnumbered aid organizations in users of the system. Also whereas the traditional rapid analysis takes six weeks, the messages revealed real-time needs. These findings suggest that machine coding methodology could increase accuracy of situational analysis and speed response in future disasters.

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INTRODUCTION

> The world is getting flatter faster in technology than health and wealth so we should all be using technology to achieve our goals in health and wealth. (Rosling, 2006)

On January 12, 2010, the same day a large earthquake struck Haiti, Stacy Delince, in Montreal, Canada, was catching up with friends on Facebook when she noticed a particularly urgent status update:

> Jean-Olivier Neptune is caught under rubbles of his fallen house. He is alive but in very bad shape. please please hurry and get there as soon as you can and please put this info in your statuses, * rue Mont-Joli Turgeau ! URGENT !

Ms. Delince did not know Jean-Olivier Neptune, but immediately reacted by calling the Haitian Emand, the Red Cross, and news organizations in an attempt to alert someone in Haiti as to Mr. Neptune's urgent request and his location (Samuel, 2010).

The victim, Mr. Neptune, had been able to text his relatives in the United States about his situation and, within hours, his message was noticed and relayed through online communities. In Washington, D.C., Claire Berlinski, a journalist, reported that she felt "distraught" because she had relatives in Haiti and no way to help (Berlinski, 2010). However, she did find a way to get involved with a network of volunteers, calling themselves crisis mappers, who were implementing a novel approach to disaster response known as crowdsourcing. Ms. Berlinski, along with thousands of other volunteers from

around the world, translated messages from Haitian Creole and attempted to determine their location, allowing them to be immediately displayed on a public website with a map interface. By 3:00 p.m. that afternoon, Mr. Neptune was rescued.

The global collaborative response to the Haitian earthquake marked an important moment in the evolution of disaster preparedness and response. The emerging paradigm of participatory (interactive), porous (where organizational communication boundaries are no longer fixed and impenetrable for external ideas), and nimble (easily changing) management structures contrasted with the traditional, hierarchical, information-controlled structure of the UN Cluster Response system. Initially overwhelmed by more than 2,000 "volunteers" who wanted to help, many UN agencies and organizations were reluctant to engage with this community. What ensued in the following months was the diffusion of an innovation, crisis mapping, through the management infrastructure of international disaster responders, resulting in acceptance and adoption of participatory approaches to disasters.

Background

Social network theory comprises a field of study that seeks to understand ideas, knowledge, and behavior as they move through interpersonal networks. Early research conducted by a foundational group of researchers that included Syme, Breslow, Berkman, and Granovetter helped establish the understanding that causal forces for health and well-being were not only influenced by individual behavior choices, but rather by a complicated web of causation that includes the social environment in which individual behavior takes place (Krieger, 1994). The field's cohesion is largely credited to the foundational text, *Diffusion of Innovations*, by Everett Rogers, which was first published

in 1962 and updated five times until the last edition emerged in 2002, two years before Rogers' death.

In a discussion of ideal types of social networks, Lin (2001) explained that dense, closed networks are ideal for "preserving or maintaining resources," citing the example of children's safety in a cohesive community. However, a less dense, open network may be more suitable for "searching for and obtaining resources" (Lin, 2001). In the context of a natural disaster, the most disadvantaged individuals might be expected to prefer the protected nature of closed networks even though their access to resources might be improved by participating in more open networks. Likewise, disaster response organizations might prefer closed networks to preserve precious resources such as time and access to communication networks, with the unintended consequence of becoming isolated from individual expressions of need. Following a disaster, perhaps the most important resource to be obtained by responders is information: who and what is in need, in addition to questions about resources and availability of support. Thus, a loose, open social network may be theoretically ideal for integration with the traditional vertical nature of disaster response. Crowdsourcing has emerged as one such strategy for improving traditional bureaucratic response by incorporating data obtained from more open and accessible networks.

Theoretical Foundation

Social Capital Exchanges in Social Networks

The majority of research on social networks involves one of two methodologies. The first, and most feasible, is an individual level, called ego-centric, approach that first identifies the participant, and then maps the participant's social connections as if the

participant is the hub of a wheel and the connections are the wheel's spokes (Smith & Christakis, 2008). The second begins at the social level by defining a population and attempts to map each participant as a node in the network with interrelationships to other nodes (Smith & Christakis, 2008).

In the past, the fields of health education and health behavior have often followed the ego-centric approach as the model of health behavior (Hochbaum & Services, 1958). In a longitudinal study of 10 community-based participatory health promotion projects, lack of utilization was the primary problem discovered (Altman et al., 1991). However, in surveys, the program directors listed problems with funding and program promotion above effectiveness of their programs (Altman et al., 1991). As opposed to ego-centric models, broader, network-centered models of health behavior provide a view of causal forces. Social network theory offers health researchers an opportunity to study human behavior and collective action at a more comprehensive level than is offered when the individual is the variable measured. Rogers (2003) explained that the system-level focus in social networks research allows the researcher to analyze the success or failure of an innovation to disseminate in terms of the system design, as opposed to the irrationality of individuals within the system. In health research, the innovation is often a new approach to increasing help-seeking behavior. This can be a technology, such as a new mobile phone app, or a communication pattern, such as motivational interviewing. McKenzie et al. (2005) asserted that successful health promotion program implementation depends on this broader, systems-level approach. Diffusion of successful health innovations depends on the network in order to avoid what Rogers (1953) termed "the individual blame bias."

In social networks research, individuals are conceptualized as nodes. Relationships are either analyzed at a dyadic, micro level among pairs of people or a supradyadic level among the entire network in the sample population. In both cases, measuring social capital is an informative means of characterizing the connections. Relationships can be evaluated through measures of structural social capital with features such as interpersonal trust, social support, and the degree of homophily or heterophily between the two individuals in the pair—bonding and bridging (Harpham, Grant, & Thomas, 2002). The network itself can be evaluated with measures of cognitive social capital such as values and norms that might define an orientation toward cooperative behavior (Putnam, 2001).

Individuals or organizations that move freely between closed networks are termed boundary spanners (Burt, 2001; Kapuku, 2006; Williams, 2002). Because they share features of both a closed group and an external group, they can be seen as a safer source of new ideas than an individual from a bridged network. As a result, Rogers (1953) suggested they be seen as change agents, or opportunities to insert a new innovation in a closed group.

Social Capital and Health Outcomes

In terms of health outcomes, social networks have the biggest impact based on two features: size of the network and type of connections that dominate an individual's network. The positive impacts on health well-being from larger social networks are theorized to result from a greater social surface area, or exposure to more information and new ideas and innovations. In his initial exploration of this relationship, Granovetter (1973) examined whether individuals seeking a job were more likely to be successful if

their social networks were comprised of mostly strong or weak ties. The concept of weak ties has conceptually developed into what is now termed “bridging relationships” and the concept of strong ties has developed into what is now termed “bonding relationships” (Lin, 2002). Granovetter found that weak ties provided people with more job opportunities because they offer greater access to information and resources due to the network diversity and larger surface area. He postulated that the advantage of these resources outweighed the advantages of the more established, tightly bonded network.

Beyond size, the connections among individuals are characterized in two ways: strong ties versus weak ties and hemophilic relationships (with a high degree of likeness) versus heterophilic relationships (with a high degree of difference). These two often correlate within each other, as seen when strong ties are formed most often with homophilic, or likeness relationships, and weak ties are most common with heterophilic, or difference relationships (Lin, 2002, p. 39). Strong networks of homophilic individuals are ideal for preserving resources and culture. Lin gives the example of elite or privileged groups when explaining the social situation in which this is ideal. However, this kind of network often does not allow an inflow of new ideas and innovations (Rogers, 2003, p. 19).

While heterophilic, weaker, and larger networks allow for improved diffusion of ideas, new research indicates that a network that possesses features of both extremes is actually ideal. In an online simulated model of diffusion, Centola (2010) demonstrated that a “clustered-lattice” network out-performed a strictly heterophilic network of greater size. This finding echoes Rogers’ (2003) method for diffusion, which discussed the need to “bridge the heterophily gap” (p. 28). Rogers recommended change agents that are

heterophilic to those that seek to employ an aide from that network to introduce the new idea. In practice, this is the role of peer leaders in health interventions.

Research has demonstrated that the types of connections that characterize individuals' social networks have profound impacts on health and well-being. Lin (2002) established that the functional benefit networks provide for individuals stems from the social capital resources embedded within the connections that comprise the network. In a cross-sectional study of mothers and children in the Andhra Pradesh state of India, researchers found a positive relationship between a mother's level of social capital and her children's level of nutrition (Moestue, Huttly, Sarella, & Galab, 2007). The study differentiated measures of social capital by network size, heterogeneity (bridging), and maternal age. The findings reinforced Granovetter's (1983) hypothesis that the risks of poverty can be mitigated by a network composed of many diverse ties. The authors found that the mothers in this study were specifically using their network to communicate health information and a greater number of sources resulted in improved information and, consequentially, health outcomes for their children (Moestue et al., 2007). An interesting additional finding was that the protective relationship was stronger for mothers over the age of 25 than under, which was theorized to indicate that younger women still put a greater value on information from their strong ties, i.e., mother-in-law or spouse, as opposed to their social network (Moestue et al., 2007).

Diffusion of Information Within Social Networks

Social network theory is based on the diffusion paradigm, which suggests that new ideas and behaviors tend to follow specific patterns as they become adopted by a community, or clique. It involves five stages: knowledge, persuasion, decision (to reject

or accept), implementation, and confirmation (Rogers, 2003). It is further influenced by five categories of adopters: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003). Diffusion tends to follow an S-shaped curve marking the slow adoption in early stages, the rapid adoption as the early and late majority take up the idea or behavior—whereupon a critical mass occurs, preventing any halting of the rate—and a slow rate of adoption once only laggards remain.

The earliest diffusion study on record is an analysis of the diffusion of hybrid seed corn among farmers conducted by Ryan and Gross (1943). The earliest health-related diffusion study was conducted by Columbia University researchers Coleman, Katz, and Menzel (1957) on the adoption of the antibiotic, tricyclene, among New England physicians. Both studies independently found the classic S-shaped curve of diffusion. Even more striking, both studies found that early adopters tended to be more "cosmopolite"—marked by either the farmer's or physician's exposure to big cities (Rogers, 2003, p. 67).

Rogers (2002) found that individuals' exposure to new ideas was itself one of the critical aspects of the diffusion process. While individuals are more likely to consider a change in their behavior or thinking as observed by someone very similar to themselves, homophily by definition inhibits new ideas or behaviors because of that similarity. As a result, heterophilic relationships are a greater source of innovation. Rogers identified a process in which an aide can be employed to assist a change agent in the case that too much heterophily exists. In this case, a person who is very similar to the target clique "bridges the heterophily gap" (p. 28).

A key advantage of conducting research on social networks is the focus on the systems-level success or failure of behavior change, as opposed to what Rogers (2002) explained as the individual blame bias of social research. Because the primary tool of social scientists is the survey, administered at an individual level, assessments of success or failure often fall on the individual and miss the opportunity to see the individual's logical response to a larger system (Rogers, 2003).

Help-Seeking Behavior in Natural Disasters

In a sense, disaster response is and always has been crowdsourced, or outsourced to a large, informal network of people with resources to solve a problem. In a study of earthquake relief, Hilhorst (2004) found that at least 90% of the assistance people receive is from informal means of support, as opposed to organizational or governmental means of support. This is likely due to two factors: 1) the inability of organizations and government entities to reach more individuals in a setting with destroyed infrastructure, and 2) a phenomenon of social ties that results in a social norm that makes a taboo of accepting formal means of support.

Applying a theory first identified as amoral familism by Banfield (1958), Gans (1965) conducted an ethnographic study of a Boston slum inhabited mostly by Italian immigrants, and found that the group behavior self-regulated against new innovations with both subtle and overt tactics like ridicule and exclusion. Even when the innovations were clearly in the best interest of the individuals, such as organizing to block the impending razing of the neighborhood, the group behavior shunned change. Consequently, this bonding group tended to make bridging behavior into a taboo, or an

out-group behavior for fear of losing the cohesion and exclusiveness that marked the bonding group.

The health outcomes of this finding are readily apparent in disaster response, such as with a Hurricane Andrew case study conducted by Hurlbert et al. (2001). The authors followed individuals' help-seeking behavior in response to the hurricane's devastation and found that people in tightly-knit, bonded groups were least likely to seek or accept formal means of support, such as food vouchers. Instead, they turned to each other for support. This finding was reinforced in a study of Hurricane Floyd's aftermath, which found Medicaid applications did not increase despite widespread financial shock to already-vulnerable households (Domino, 2003). A study on the social capital of Hurricane Katrina's aftermath also showed that the bonding behavior quickly bankrupted groups' resources, with the result being an increase in their vulnerability (Hawkins, 2010).

The Sociology of Disasters

Within the academic literature of the field of sociology, the sub-discipline of disasters includes a deep discourse of the nature of disasters, organizational behavior, and community responses. Two key concepts about how people organize themselves in a disaster are emergence and convergence. Emergence refers to newly arising organized structures and convergence refers to people and organizations coming together for a united purpose of disaster response (Tierney, Lindell, & Perry, 2003).

A guiding principle is that of the ordering of magnitude of social problems, ranging from emergencies, which may be serious everyday problems, to disasters, to catastrophes, which are far larger social problems than disasters (Quarentelli, 2006). The

ordering is important to note because of the patterns sociologists have observed in disaster responses. Under the criteria Quarentelli (2006) established for determining the difference between disasters and catastrophes, the Haiti 2010 earthquake was assuredly a catastrophe because: 1) most or all of the built structures were heavily impacted; 2) local officials were unable to fulfill their roles because they were dead, injured, or also seriously impacted; 3) multiple communities were impacted so that help from nearby communities was not available; 4) most or all of everyday community functions could not continue; 5) mass media sources constructed a discourse of disaster; and 6) the national government and top officials became involved—in Haiti, this was true to the extreme extent in that top government officials from many nations became involved.

Using the term major disasters rather than catastrophes, Smith (2011) explained that, when integrated with local input, financial and technical assistance has the potential to strengthen communities undergoing disaster recovery. However, all too often, federal centralized administration of disaster response results in inefficient responses. Smith explained that responders' ability to integrate local needs into their programming depended on "the ability of assistance recipients to communicate their needs through their involvement in the collection, analysis, and display of pertinent information."

The History of Crisis Mapping

The use of mobile phone communication networks for health responses has been especially successful in monitoring the advance of viral outbreaks, as in the case of H1N1 (Brownstein et al., 2010), and even stemming the scope of outbreaks, as in the case of the Global Public Health Information Network created for SARS (Eysenbach, 2003). The various technological participatory platforms have differed widely on their targeted end

users (Donner, Verclas, & Toyama, 2008). While many are based on Ushahidi and FrontlineSMS technology platforms, the communication may be unidirectional from aid organization to individual, as in the case of Google and Grameen's project to share farming tips with farmers in Malawi (Donner, 2009), or participatory, as seen in the WHO's inclusion of SMS-based communication in its tuberculosis protocol for its drug treatment-short course (DOTS) (Barclay, 2009).

Developing advances in uses of SMS are now moving beyond health interventions into health systems and infrastructure. For instance, Vodafone collaborated with USAID on a project that utilized FrontlineSMS to transfer money in Afghanistan, where 98% of the population is not connected to a banking system (Himelfarb, 2010). In addition, researchers are utilizing FrontlineSMS to replace paper-based surveys and reach larger numbers of participants in rural and resource poor regions (Jeffrey-Coker, Basinger, & Modi, 2010).

The first widely used platform that mapped humanitarian event data through crowdsourcing (crisis mapping) was Sahana, developed in 2004 in response to a perceived need to coordinate humanitarian efforts during the South Asian tsunami (Perera, 2008). Similarly, in 2007, when the Kenyan election threatened the country's political stability, a small group of bloggers and software developers combined forces to write a software code for a program based on Google Maps that would allow people to report incidences of violence (Ushahidi, 2011). In January 2010, when a devastating earthquake occurred in Haiti, volunteers from around the world simultaneously began using the Ushahidi platform, and a few other crisis mobile networks, to share information on missing persons, health service needs, and available resources (Okolloh, 2009). The

efforts of volunteers resulted in a sudden flood of information that the traditional UN cluster response was not prepared to manage (Crowley, 2010). The initial result was a distrust of technology and non-hierarchical organized responses to relief by traditional disaster response organizations. Over time, however, crisis mapping became acceptable to UN agencies.

The Haitian Earthquake and the Crisis Mapping Response

On a Tuesday afternoon in January 2010, a 7.0 magnitude earthquake struck near the capital of Haiti. The Haitian government estimated that over 300,000 people lost their lives and an additional 300,000 were injured (Bilham, 2010). An estimated 1.8 million people lost their homes (CATDAT, 2010). The Haitian population—already marked by significant disparities in health and resources before the event—was devastated by the almost complete destruction of local and national infrastructure, ranging from households and neighborhoods to municipal entities and medical services. The central Haitian government sustained a total loss of its fragile infrastructure, causing it to be almost powerless to respond in an organized manner.

The international community's response was quickly organized by the United Nations (UN) Cluster System, which instituted a hierarchy for communication among all UN agencies and NGOs approved to assist and named entities in charge of needs assessments. The UN explained the purpose of the Cluster: "to strengthen partnerships and ensure more predictability and accountability in international responses to humanitarian emergencies, by clarifying the division of labour among organisations, and better defining their roles and responsibilities within the key sectors of the response" (Office for the Coordination of Humanitarian Action [OCHA], 2013).

Simultaneously, an international online community of crisis mappers, almost entirely comprised of volunteers, began to organize for a crowdsourced response through Internet communications technologies (ICT). Volunteers around the world began capturing text messages sent via the SMS network, translating them into English and Creole, coding them with locations for use in a geographical information system (GIS), and mapping the information in crisis maps hosted on Ushahidi's open source website. While early messages tended to be requests for assistance finding missing persons, the overwhelming majority of incoming messages reflected the Haitian population's need for food and water support in the weeks after the disaster occurred.

To some, crisis mappers represented a growing cultural evolution of structuring the management of organizations that are borderless, collaborative, and pervasively networked (Rogers, 2011). The earthquake recovery in Haiti was possibly the first time in history when a large-scale, traditionally-led public health response directly encountered a large-scale crowdsourced public health response, largely due to rapidly advancing cell phone and Internet technology that previously had not existed.

Within the UN and other traditional bureaucratic institutions, decisions are made in a hierarchical chain of command. However, the crowdsourced theoretical foundation behind crisis mapping ascribes validity to an increasing sample size as opposed to the source of the information in communication and information gathering. This type of information gathering has been referred to as non-probabilistic sampling (Meier, 2011). As a piece of information is reinforced with increasing related messages, for example, that a certain neighborhood needs water, it becomes more likely that this information is valid. Incoming information with only a single source presenting the information is less

likely to be true than information with multiple sources communicating a related need. Importantly, all aspects of a crowdsourced effort are free and open to public involvement, from writing the software tools that are to be deployed to accessing the information gathered.

Following the deployed Cluster Response, UN agencies were reticent to incorporate the volunteer ICT community, which gathered information and passed it along to Cluster agencies with the expectation that action would result. In one account, a UN worker explained that his department was too overwhelmed with the task of conducting a needs assessment with its own methodology to also subsume the needs conveyed through crisis mapping (Harvard Humanitarian Initiative, 2011). The efforts of volunteers resulted in a sudden flood of information that the traditional UN Cluster Response was not prepared to manage (Crowley, 2010). A summative evaluation conducted in collaboration with the UN Office for the Coordination of Humanitarian Action (UN OCHA), summarized the UN response to the crowdsourced effort as not equipped to handle "the mobilized swarm of globalized volunteers" (Harvard Humanitarian Initiative, 2011). The result was a growing distrust of technology and non-hierarchical organized responses to relief. Among its key findings, the report recommended a training curriculum for future volunteers on the workings of the UN history and cluster response. However, in the months following the earthquake, as the views of high-level managers shifted toward acceptance of the new tools made available by crowdsourcing, middle management efforts were created to subsume the tools, if not the culture of crisis mapping into the Cluster Response (Harvard Humanitarian Initiative, 2011).

Dissertation Structure

Purpose

The purpose of this study was to conduct an in-depth analysis designed to assess the systems-level interactions between and among established formal disaster response organizations and new and emergent groups of crisis responders following the Haitian earthquake and the ensuing health disasters. By examining the complex behavioral interactions between an established cluster-based disaster response and the inserted innovation of crowdsourcing for disaster response, this study explored the limitations and successes of what has since become a successfully adopted technological innovation in disaster response.

Significance

The results from this study have policy implications for large bureaucratic institutions seeking to adapt to the emerging paradigm of participatory management, marked by increasingly porous information exchange and flatter levels of hierarchy (Rogers, 2011). The findings also comprise the only summative analysis of crowdsourced crisis mapping response to the Haitian Earthquake that has been conducted to date and which includes both the UN and crisis mappers in the analysis. Finally, these results contribute to the emerging canon of methodology that will be required to analyze social and participatory health interventions that are delivered through social media.

In addition, this study contributes to the objectives of *Healthy People 2020*. Now in its third iteration, *Healthy People 2020* puts forth a decade-long, comprehensive agenda aimed at improving health for all Americans (U.S. Department of Health and Human Services, 2011a). The baseline data, goals, and targets delineated within the

agenda establish the nation's priorities and strategies for improving population health. This study addresses two *Healthy People 2020* Topic Areas in the current agenda: Topic Area 12, Environmental Health, which includes a focus on disaster preparedness, stating, that

> Preparedness for the environmental impact of natural disasters as well as disasters of human origin includes planning for human health needs and the impact on public infrastructure, such as water and roadways

and Topic Area 17,

> Health Communication and Health Information Technology. (U.S. Department of Health and Human Services, 2011b)

The latter is highly relevant to this study to the extent that it addresses the potential for technological platforms to impact public health through participatory approaches to health promotion and disease prevention. These impacts include:

1. building social support networks,
2. enabling quick and informed action to health risks and public health emergencies, and
3. increasing Internet and mobile access. (U.S. Department of Health and Human Services, 2011c)

Definitions of Key Terms

Crisis Mapping

Crisis mapping is the collective action of online communities to collect real-time event data and create geocoded maps, providing critical information for the rapid response to complex emergencies across the globe. Crisis mappers define themselves as an online community that collectively "leverage mobile and web-based applications,

participatory maps and crowdsourced event data, aerial and satellite imagery, geospatial platforms, visual analytics, and computational and statistical models to power effective early warning for rapid response to complex humanitarian emergencies" (Crisismappers.net, 2011). Crisis mapping is a global phenomenon for which inclusion is based on network access, as opposed to geographic location. Crisis mappers utilize a crowdsourced management structure to establish communication networks for situation awareness in emergency response, such as a natural disaster or political revolution.

Crowdsourcing

Crowdsourcing is a term first coined by Jeff Howe in an article written for *Wired Magazine* in 2006 and later developed into a book by the same name. It denotes an emerging phenomenon in management that may represent further evolution of Max Weber's classic forms of leadership in government: despotic, charismatic, and bureaucratic. A portmanteau of the words *crowd* and *outsourcing*, crowdsourcing is "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call" (Howe, 2006).

Free and Open Source Software

Denoting software that is not protected by copyrights for usage and changes to its code, Free and Open Source Software (FOSS) has also become a cultural movement in Web 2.0. The creation of the operating system code, UNIX, is widely acknowledged as the first crowdsourced, open software (The Open Group, 2011). Beyond open code, the cultural side of FOSS is closely tied to the emergence of crowdsourcing as a type of organizing and management in organizations (Shirky, 2009).

Participatory Epidemiology

The emerging field in which crowdsourced methodologies for health promotion are situated is titled participatory epidemiology (Friefeld et al., 2010; Jost, Roeder, & MacGregor-Skinner, 2007). This field applies fundamentals from the theoretical foundations of participatory-based community research and participatory action research.

Organization of the Dissertation

This dissertation includes five chapters. Chapter II comprises an annotated bibliography of state of the art resources for social media and health promotion. Chapter III is a descriptive study of the Haiti crisis map in the context of a case study of the diffusion of crisis mapping through the UN Cluster Response compiled via qualitative interviews. Chapter IV is a social network analysis of the SMS messages in the crisis map database. Chapter V presents a discussion of this study's findings, including recommendations for future research.

Chapter II

SOCIAL MEDIA AND HEALTH EDUCATION

Abstract

Background

Online tools and platforms are rapidly emerging and evolving, often at a faster pace than health promotion research or interventions can adapt to them. However, these technologies are ideal for integrating known successful approaches in the health canon. Summaries of state of the art online communities and tools and recent research are required for health professionals to stay abreast of technology.

Objective

This annotated bibliography aims to provide a thorough but brief overview of the current state of the art in online tools and platforms that are relevant to health promotion.

Methods

Through exploring online tools and social platforms and following trends over time, the authors compiled resources and grouped them by major categories that can guide health professionals in integrating their work with online communities.

Results

Findings were grouped into three overarching categories: crowdsourced tools, eHealth, and participatory epidemiology. Within these groupings, 18 websites and 12 articles and books are summarized and discussed.

Conclusion

Ongoing efforts are needed to update such lists, which are often out of date by the time of their publication. Ample opportunities exist for health professionals to engage technology with traditional approaches, usually with very low programmatic costs. Health promotion is at the entryway of an exciting new expansion of venues and applications through Web 2.0 and social computing.

Introduction

Online tools and platforms emerge and evolve rapidly, often exceeding the pace of health promotion research on their effectiveness. However, these technologies are important because they have the potential to enhance the applications and effectiveness of existing approaches to improving population health and increase the rate of knowledge sharing and replication of successful approaches. This annotated bibliography provides a brief overview of the current state of the art in tools and platforms that are relevant to health promotion to facilitate health professionals in their efforts to synthesize their work with emerging technologies. Social media, or Internet-based communication platforms, refer to the way in which Internet users interact with each other and information sources online. The current era of social media began with a movement known as Web 2.0, in which websites transitioned from being unidirectional repositories of information from a single source to hosted online interactions between many different users. Social media have since emerged as a decentralized form of communication and community organization that is resistant to attempts to apply a hierarchical management structure such as government or corporate control. As a result, social media could hold the potential to reinvent health communication and decrease barriers to obtaining and using

health information, producing flatter (less hierarchical) social networks. Increased access to information has resulted in empowered patients who seek to be partners in their health, but has also concerned healthcare providers, who worry that the general public lacks the medical background or experience needed to assess the quality of the large body of information now available. Social media have become so pervasive in the global economy that they have produced new ways of managing businesses, governments, and organizations, making governance structures less hierarchical and more porous to flows of information into and out of the institutions. In relation to health, this shift has increased the capacity of people to directly seek improved health outcomes rather than being the subjects or targets of intervention. Perhaps the greatest achievement of social media has been to reduce the disparities in access to knowledge and resources in impoverished regions and crisis situations caused by natural disasters and conflict. The mechanisms of this ongoing transformation include new developments in crowdsourcing, eHealth/mHealth, participatory epidemiology, and platforms for crisis mapping.

Crisis Mapping

Crisis mapping emerged from the integration of the open-source software movement, crowdsourcing, and geographic information systems (GIS) with the needs of disaster management. The craft thrived because of the parallel emergence of short message service (SMS) mobile phone texting technology and the Web 2.0 cultural revolution that encouraged interactive management systems and non-centralized, organic organization of movements and ideas. This was made possible through virtual networks that dramatically increased connectivity between individuals who were previously separated by geography and social structures. Crisis mapping tools tend to be organized

into platforms, a term that simply refers to the collection of computer software, online databases, and methods of communication that allow users to interact with each other. Crisis mapping was originally created in response to natural disasters, producing an early platform called Sahana. However, it rose to global awareness with Ushahidi, which was developed in response to violent conflict. During the disputed and violent 2007 national elections in Kenya, a group of Kenyan programmers who previously did not know each other shared a desire to create an online tool that could provide assistance to those whose lives were being impacted by violence and conflict. This origin strongly influenced the crisis mapping culture that would follow, as the violent conditions required a level of security that natural disasters did not. A preference toward centrally-verified field updates, as opposed to unverified updates, is a key example of this impact. Crisis mapping depends on individuals in a geographic region to provide data which are parameterized for the benefit of improved information and response regarding resource need and allocation. Crisis mappers define their activity as an online community that collectively "leverage mobile and web-based applications, participatory maps and crowdsourced event data, aerial and satellite imagery, geospatial platforms, visual analytics, and computational and statistical models to power effective early warning for rapid response to complex humanitarian emergencies" (Crisismappers.net 2011). Rogers (2011) explained that crisis mappers represent a growing cultural evolution of structuring the management of organizations that are borderless, collaborative, and pervasively networked. Most aspects of crowdsourced efforts are free and open, from writing the code of the technology to be deployed to storing the information gathered. As academic

institutions take up crisis mapping, this tradition of open-source and open-access protocols is not always maintained.

Crisis Mapping Platforms

Sahana [now part of www.sahanafoundation.org]

The first widely used crisis mapping platform, Sahana was developed in 2004 in coordination with IT volunteers, the Lanka Software Foundation, and the Swedish International Development Cooperation Agency. The Internet- and software-based program was created in response to a perceived need to coordinate humanitarian efforts responding to the South Asian tsunami. Its largest deployment in Sri Lanka was largely unsuccessful because it predated cloud computing, instead requiring installation on computers in NGO and multilateral agency offices that were involved in disaster response. However, one of Sahana's stated goals was to empower disaster victims to help themselves, making it an important early precursor of the paradigm shift in disaster response that would later be apparent in the deployment of the Ushahidi crisis map in Haiti's 2010 earthquake.

Ushahidi [www.Ushahidi.com]

Ushahidi spontaneously formed in 2007, when the Kenyan election threatened the country's political stability. A small group of bloggers and software developers combined forces to write a software code for a website that would allow people to report incidences of violence by geocoding their text messages and displaying them on a website. Based on the Google Earth platform, Ushahidi provides an open-sourced, crisis mapping global communication network, deployed on a web-

and FrontlineSMS-based texting network to coordinate reports of need and response. When the January 2010 earthquake occurred in Haiti, a volunteer network, already formed for a previous Chile earthquake, simultaneously began forming a crisis mapping network to share information on the locations and identities of missing persons, health service needs, and the locations of available resources on the Ushahidi platform. In contrast to the UN's hierarchical approach with a centralized chain of command, the crowdsource foundation of crisis mapping ascribes validity to an increasing sample size as opposed to the source of the information in communication and information-gathering (Meier, 2011).

Stand-by Taskforce [blog.standbytaskforce.com]

The Stand-by Taskforce has established a verification team so that volunteers who join in the crowdsourced effort to analyze incoming data can be tasked specifically to validation measures. Sources that are authenticated can be tagged as trustworthy and sorted accordingly using SwiftRiver.

SwiftRiver [www.ushahidi.com/products/swiftriver-platform]

In an effort to improve the reliability of information sources, Ushahidi has developed the SwiftRiver platform, which sorts information collected through various channels, such as twitter or email, by pre-set filters, such as known information sources. SwiftRiver also allows for rapid analysis for pattern frequency. Incoming messages that share a location and subject, for example, the bridge is out, can be raised in priority because of their multiple sources.

Crowdsourcing

Crowdsourcing is a term originally coined by writer Jeff Howe to mean "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call." This means of organizing follows a series of technological innovations collectively termed Web 2.0, in which the Internet transitioned from a one-directional communication platform to a unidirectional interaction platform. Web 2.0 is denoted by the advent of blogging, microblogging or tweeting, and social media. The explosion of Internet participation allowed exposure to individuals who share their interests that might have previously seemed obscure, due to geographic distances and other factors that separated them. Micro-celebrity emerged as a kind of high-profile popularity one could gain in unique circles of interests online. One important function of micro-celebrity is its encouragement of collaboration and achievement in crowdsourced endeavors. A small number of writers has emerged as thought leaders in this still emerging field.

Related Literature on Crowdsourcing

Howe, J. (2006). The rise of crowdsourcing. *Wired Magazine, 14*(14), 1-5.

> In this 2006 article on an emerging business trend, Howe officially coined the term *crowdsourcing* as a portmanteau of the words outsourcing and crowd. The article included the case study of Innocentive, which epitomizes the trend's impact on health, as it crowdsourced its R&D for pharmaceutical development with open calls paying $10,000-$100,000 to hobbyists who come up with solutions to previously-unsolvable hurdles.

Howe, J. (2008). *Crowdsourcing: How the power of the crowd is driving the future of business.* New York, NY: Century.

Howe developed the article's key concept into a full-length book in 2008, which traced the origins of crowdsourcing to the open source movement in software, with more in-depth case studies including the creation of Linux and SETI@Home, a crowdsourced attempt to find extra-terrestrial life. Howe explored why people participate in crowdsourced endeavors even when financial gain is not an outcome, i.e., for the enjoyment of collaborating. Howe also explained that the concept of the dilettante and its connotation have become negative since industrialization ushered in an age of specialization; however, most of the great advances in the Enlightenment were made by people dabbling in fields other than their primary occupation or specialization. Crowdsourcing returns civilization to an ability to harness the mental power of dabbling.

Jarvis, J. (2011). *Public parts: How sharing in the digital age improves the way we work and live.* New York, NY: Simon & Schuster.

The author provided the most up-to-date explanation of how the paradigm shift toward sharing and participation is impacting major institutions. Jarvis' first break-out book was *What Would Google Do?*, which discussed how Google changed business and lifestyles around the world. He built on that theme in this text to further explain how the interactive web has resulted in interactive institutions. The author discussed motivations for collaborating in crowdsourced ventures.

Shirky, C. (2009). *Here comes everybody: The power of organizing without organizations.* New York, NY: Penguin Group USA.

This book is an exploration of the management structures of crowdsourced organizations that reduce the transaction costs otherwise incurred by layers of bureaucracy. The participatory paradigm is marked by flat hierarchies, which Shirky showed through a number of case studies has the potential to be leaner and more productive than traditionally-organized management. Shirky's view of the difference between crowdsourced management approaches and traditional management is primarily marked by the absence or presence of layers between the boss, the product, and the target audience.

Shirky, C. (2010). *Cognitive surplus: Creativity and generosity in a connected age.* New York, NY: Penguin Press HC.

Howe's notion of powerful dabbling was further developed in Clay Shirky's book, which termed the otherwise wasted abilities of people who only focus on their narrow field of work *cognitive surplus*. Shirky claimed 50 years of television masked cognitive surplus because one's interests could be pacified during leisure-time hours by watching TV. However, the new media, especially the hyper-interactive Web 2.0, has allowed people easy access to opportunities to re-engage their minds during leisure-time hours. The book is replete with case studies of impressive endeavors accomplished by the crowd.

Surowiecki, J. (2004). *The wisdom of crowds.* New York, NY: Random House.

This book explored an aspect of crowdsourcing in which a large number of people can be smarter than any one of its parts. Surowiecki's notion of the wisdom of

crowds is related to the academic consensus-based method, the Delphi Technique, a methodology for utilizing the estimations of many individuals to approximate a solution or answer when it is not possible to obtain exact information. The book includes many case studies demonstrating that a group of people was more accurate or achieved more than any one individual would have been able to achieve on his or her own.

eHealth and mHealth

As terms, eHealth and mHealth exemplify the terminology that demarcates most literature regarding social media applications to health improvement from more traditional approaches. A new jargon has arisen, largely based on combining words into portmanteaus—a functional consequence of communicating with URL addresses, which cannot include spaces, for titles or terms. eHealth was originally the term used to describe help-seeking individuals or health providers who made use of the Internet, while mHealth referred to the seeking of health information or providing healthcare services using a mobile device. Given the rapid growth of mobile devices in Internet-based communications—mobile devices (with approximately 1 billion of these being smartphones) now outnumber humans on the planet—the term eHealth has been eclipsed as the more common means of referring to the integration of the Internet with health access and provision. In terms of population and funding, the greatest growth in mHealth has taken place in low- and middle-income countries, where access to and use of mobile devices continues to rapidly outpace the physical infrastructures of medical clinics and laboratories that traditional health care provision relies upon. Peer-reviewed monitoring and evaluation of mHealth practices have lagged behind the pace of intervention and, as a

result, little is currently known about best practices for integrating traditional health with emerging technological platforms.

A common cause of program failure is to apply a traditional health approach directly over mobile devices without embracing the cultural shift of participatory interaction that marks the mobile user interface. The health and medical fields are thus now faced with a paradigm shift away from being the sole providers of health information to being facilitators in a patient-initiated process of navigating health information. This paradigm shift has coalesced in the academic literature under the term *participatory epidemiology.* Once considered patients, individuals seeking information or guidance about health issues are now perhaps more accurately conceptualized as curators—providing, editing, seeking, and sharing information about health. The increase in access to online information made possible by now-ubiquitous mobile devices has had a profound impact on the way the public finds, evaluates, and uses health information. People can access health research that was once only available to universities, hospitals, and professionals. The ability to acquire information directly, rather than relying on topical health books or physicians and other professionals to filter the information for them, coupled with the ease of forming communities online, lead to numerous social groups formed by people with similar conditions, symptoms, and diagnoses. Participatory health-based interactions can be very well organized and documented, as in Wikipedia articles, or completely informal, as in Quora questions.

Related eHealth and mHealth Sources

Google Search [www.google.com]

The single most popular source for seeking information in the United States, Google Search is a search engine that ranks results for search queries with a mechanism called *Pagerank*. The algorithm prioritizes highly linked-to and often-visited websites in query results. Pagerank is also the mechanism for sorting results in its specialized academic article and law patents search tool, Google Scholar. Outpacing competitors PubMed and MedLine in growth, Scholar is growing in popularity among academic and medical professionals for seeking peer-reviewed health information.

FrontlineSMS [www.frontlinesms.com]

This free and open source software is widely used for health projects and interventions in areas with limited Internet access. The software allows a computer to receive, store, and send mobile phone text messages. The technology played a particularly notable role in Arab Spring of 2011, when governments sought to shut down Internet connections to squelch popular uprisings. Specifically for health needs, the software has been essential in natural disaster recovery, and is most known for its application for Ushahidi's crisis mapping activities in response to the 2011 Haitian Earthquake (see also *Crisis Mapping*).

Magpi Mobile Data [www.magpi.com]

Formerly known as EpiSurveyor, this free and open source software enables the rapid design and deployment of a mobile-based data collection system. With a free account, users can design a form, download it to mobile phones, and begin

collecting data immediately. So far, an estimated 250,000 completed forms have been uploaded to the system from mostly health workers in 170 different countries.

MajiData [www.majidata.go.ke]

This Kenyan database system epitomizes emerging participatory health applications for low-resource areas. As an open source water and sanitation geomapping database, MajiData is a reference source for the existence and status of essential services. Residents of rural and urban areas are encouraged to provide information to the database in order to help government and NGOs identify priorities for health activities.

Patients Like Me [www.patientslikeme.com]

Created by three brothers in response to one of them developing ALS, this company offers a communal experience of illness. The website interface collects personal experiences with illness, medicines, and treatments. The resulting aggregate information is a crowdsourced depiction of illness that can be sorted by symptoms, treatments, and outcomes. While accessing the website is free for the public user, the company monetizes the site by making the information collected available for datamining to partners, including drug companies, insurance providers, and medical services operations.

PLoS Medicine [www.plosmedicine.org]

PLoS Medicine is an open access, peer-reviewed, online academic journal published by the Public Library of Science. Largely because it is open source and does not require expensive memberships to access articles, this and other PLoS

journals are highly valued by the international eHealth/mHealth community. The journal features articles on various aspects of determinants of health as well as a Health Systems Guidance series with information specifically aimed at health systems in low- and middle-income countries.

Quora [www.quora.com]

This website is a social search tool with a crowdsourced question-answer interface. Members require accounts to post questions, but anyone can read answers. Answers are ranked by usefulness by the larger community of readers. Especially regarding health, questions are often of a subjective nature, such as what does it feel like to have this condition, but also include the more objective, factual questions such as what are the symptoms of this condition.

VitalWave Consulting. *mHealth for development: The opportunity of mobile technology for healthcare in the developing world.* Washington, DC and Berkshire, UK: UN Foundation-Vodafone Foundation Partnership, 2009 [www.globalproblems-globalsolutions-files.org/unf_website/assets/publications/technology/mhealth/mHealth_for_Development_full.pdf]. This United Nations-commissioned report is a comprehensive guide to applying mobile technologies to health interventions in the context of international development. The guide includes conceptual models to explain the integration points for technology in the path to engagement from patient to health worker and concludes with detailed descriptions of 51 projects successfully integrating mobiles in health-related projects.

Wikipedia [www.wikipedia.org]

> The largest source for curated health information, Wikipedia is a collection of 21 million articles (at this writing), 3.9 million of which are written in English and the remainder in 282 other languages. An estimated 365 million people access information on Wikipedia each year. As per its wiki structure, articles can be edited by anyone, but edits themselves are now edited due to increasing mechanisms for fact-checking and requirements for citations.

Participatory and Digital Epidemiology

Participatory epidemiology is a newly emerged, rapidly growing field with profound implications for public health. Based on the technological advances and paradigm shifts inherent in Web 2.0, participatory epidemiology is a public health approach that engages public collaboration in non-hierarchical methodologies. Given that approximately three quarters of the seven billion people living on the planet have access to mobile devices, the advent of health programming over mobile devices is significantly shaping the future of public health. The field has its theoretical roots in community-based participatory research and participatory action research, two areas of public health that also sought more egalitarian methodologies for developing health interventions. The field is largely dedicated to free and open source (FOSS) values, which shun domains and ownerships in process planning and communication of results. Because of the reduced cost of interacting with large numbers of participants over technological platforms, participatory methodologies are ideal for health programs with limited resources.

The ecology community was the first to use wide-scale participatory disease surveillance and, termed it *participatory epidemiology* when tracking the cattle plague

rinderpest across African countries with qualitative interviews, as opposed to the more widely used approach of quantified reports and analysis. The World Organization for Animal Health now recognizes this methodology as participatory animal surveillance. Within the field of public health, participatory epidemiology was first widely applied by Freifeld et al. (2010) in a review of mobile phone-based applications to community-level health problems. Recent conferences have also used the term *digital epidemiology*. The largest such event is the annual Conference on Digital Disease Detection, hosted at the University of San Francisco and co-hosted by HealthMap.org. The most literal application of participatory methods for epidemiological use occurred in 2007, when Google researchers collaborated with epidemiologists at the Centers for Disease Control to document the successful use of Google analytic investigations for the surveillance of seasonal flu. The resulting website, Google Flu Trends, raised awareness in the health community about emerging applications of participatory data sources to health surveillance. Building on that success, Google launched Google.org, a philanthropic constellation of participatory epidemiological platforms, including Google Flu Trends and Google Crisis Response. In 2011, the United Nations launched a new agency, UN Global Pulse, dedicated to more participatory means of monitoring and evaluation for health and well-being. The agency recently conducted a five-country effort to crowdsource data collection over mobile phones that investigated how vulnerable populations are coping with the economic crisis, the results of which are forthcoming.

Related Literature on Participatory and Digital Epidemiology

Braga, M. The rise of the digital epidemiologist: Using big data to track outbreaks and disasters. *Financial Post.* [http://business.financialpost.com/2013/09/10/the-

rise-of-the-digital-epidemiologist-using-big-data-to-track-outbreaks-and-disasters/?__lsa=ec79-ee24]

The article provides an explanation of the growing field of digital epidemiology, in which disease detection that was once conducted by analog means is increasingly conducted digitally. Examples of digital epidemiological projects include Google Flu Trends and BioDiaspora, which model disease movement with airline traffic data.

Freifeld, C. C., Chunara, R., Mekaru, S. R., Chan, E. H., Kass-Hout, T., Iacucci, A. A., & Brownstein, J. S. (2010). Participatory epidemiology: Use of mobile phones for community-based health reporting. *PLoS Medicine, 7*(12), 21-27.

This article is a review of literature and case studies, primarily from lay sources. It documents the emerging trend of using advances in technology, particularly FrontlineSMS, for participatory health campaigns. The authors provided the first known use of the term, *participatory epidemiology*, to indicate interactive methods for human-based health promotion, noting that previous uses of the term were limited to zoonotic studies.

Ginsberg, J., Mohebbi, M. H., Patel, R. S., Brammer, L., Smolinski, M. S., & Brilliant, L. (2008). Detecting influenza epidemics using search engine query data. *Nature, 457*(7232), 1012-1014.

By evaluating search queries conducted between 2003 and 2008, the authors found a correlation between searches and locally-reported cases of influenza. They theorized that the model could provide an early warning system for future pandemics. This study gave way to relationships that later formed between

Google and The Centers for Disease Control and Prevention to enhance the capabilities of the search engine in participatory epidemiology.

Google flu trends: How does it work? [http://www.google.org/flutrends/about/how.html]

Beginning in 2007, Google researchers observed that their search analytics predicted peak flu activity by region, by following frequencies in flu-related search queries. This website offers a FOSS platform for further applications of search analytics for surveillance.

Jost, C. C., Mariner, J. C., Roeder, P. L., Sawitri, E., & Macgregor-Skinner, G. J. (2007). Participatory epidemiology in disease surveillance and research. *Revue Scientifique et Technique-Office International Des Épizooties, 26*(3), 537-549.

The authors explained that their methodology was an adaptation of Chambers' Participatory Rural Appraisal and applied community interviews to the problem of disease surveillance for animal health.

UN Global Pulse [http://www.unglobalpulse.org]

UN Global Pulse is a new UN agency centered on *digital smoke signals*, new sources of data generated by digital behavior that can provide a real-time understanding of human well-being. This website includes case studies of the agency's first wave of projects.

Careem, M., De Silva, C., De Silva, R., Raschid, L., & Weerawarana, S. (2006). Sahana: Overview of a disaster management system. International Conference on Information and Automation (ICIA).

This article documents the innovated place Sahana holds as the first FOSS application for disaster response. It includes effectiveness evaluations of updated

deployments in the years following the Sri Lanka experience: the Pakistan earthquake in 2005 and the Philippines landslides in 2006.

Perera, M. (2008). Ex ante preparedness for disaster management: Sahana in Sri Lanka. In S. Amin & M. Goldstein (Eds.), *Data against natural disasters: Establishing effective systems for relief, recovery, and reconstruction* (p. 273). The World Bank.

Commissioned by the World Bank, this article is a thorough case study of the deployment of Sahana in Sri Lanka in 2007. Functionally, the article is a failure analysis, documenting what went wrong with the software creation and distribution. Among the problems was the heavy management infrastructure establishing by the Lanka Foundation to oversee the program.

Sahana Software Foundation [http://www.sahanafoundation.org]

In 2009, The Lanka Software Foundation spun off the oversight of Sahana FOSS to an independent entity, the U.S.-based Sahana Software Foundation. The website serves as a portal for projects with its *clients*, including the U.S. National Library of Medicine's People Finder Project and the City of New York's Office of Emergency Management. The site also includes case studies of past deployments.

Liability Issues for Participatory Methods

The issue of liability is a recurring concern regarding participatory approaches to health promotion and public health, especially in the case of emergencies, such as disaster management or government-provided health services. Legal precedents from analog health service provision may be held to digital health services. For example, when

the government provides health services such as 911 emergency response, it can be held legally liable for not responding to every call. It remains to be tested if government responses to information shared digitally on social media platforms (Facebook, Twitter, etc.) or email will also be held to this standard.

Anderson, K., Blumensaadt, L., Grunwald D., Palen L., & Sicker, D. (2010). Policy issues facing the use of social networking information during times of crisis. [http://epic.cs.colorado.edu/wp-content/uploads/sicker_2010.pdf]

The article explains protective legislation options for liability risks raised by social media use in disaster response. Liability from inaction includes ignoring a warning because of improper use of technology, failure to respond and/or inadequate response. Recommendations to address this include backup processing systems, regulation that addresses these instances, and organizational protocols.

Disaster 2.0: The future of information sharing in humanitarian emergencies. (2011). [http://www.unfoundation.org/what-we-do/legacy-of-impact/technology/disaster-report.html]

This UN-commissioned report was written in response to the crisis mapping crowdsourced response to the Haiti earthquake in 2011. The authors recommended open standards of geospatial data to provide the best foundation for what the authors termed Volunteer and Technical Communities (V&TC). The report suggests more formal partnerships be formed in advance of a disaster in order to establish integration of new technologies and to leverage available technology and information.

Marks, J. (2011). Social media brings new capacities and liabilities. *Nextgov.* [http://www.nextgov.com/technology-news/2011/08/social-media-brings-new-capacities-and-liabilities-to-crises/49704/]

This article explains potential liability for social media emergency responses, which include responders being open to civil lawsuits if they are not monitoring a site when urgent information comes in. The author focused on the hypothetical situation that if a text message is sent, people assume it has been read and expect help. Sites should put a blanket statement up when they are not monitoring and send automatic texts that say their text may not be read and a response is not necessarily being enacted.

Meier, P. (2011). New information technologies and their impact on the impact on the humanitarian sector. *International Review of the Red Cross, 83*(884). [http://www.961.ch/eng/assets/files/review/2011/irrc-884-meier.pdf]

This article was written by renowned crisis mapping expert, Patrick Meier. The author reviews data protection standards developed by humanitarian organizations and finds no reference to social media. The author noted that the majority of crisis maps are launched by individuals, not humanitarian organizations and, therefore, while appropriate guidelines for crisis mapping need to be put in place, it will not be possible for them to be globally enforced or to ensure that every mapper abides by them.

Mier, P. (2013). Data protection protocols for crisis mapping. *iRevolution*. [http://irevolution.net/2013/04/11/data-protection-for-crisis-mapping]

Patrick Meier provided a comprehensive evaluation of the new protection standards of data protection in the ICRC's 2013 Edition of the Professional Standards for Protection Work. Key points include: security safeguards appropriate to the sensitivity of the information must be in place prior to any collection of information; when handling confidential and sensitive information protection, actors should endeavor (when appropriate and feasible) to share aggregated data on the trends observed; and to the degree possible, protection actors should keep the victims and/or communities who have transmitted the information on abuses and violations informed of the action they have taken on their behalf and of the ensuing results.

Robson, E. (2011). Potential liability for crowdsourced disaster response groups. *Commons Lab Blog*. [http://wilsoncommonslab.org/2011/09/26/potential-liability-for-crowdsourced-disaster-response-groups]

An overview of the three clauses that obligate a person to rescue another person: 1) a person undertakes rescue; 2) a person's conduct puts another in danger; and 3) a special relationship exists between the rescuer and the victim. The author examined where crisis mappers fit into this legal realm, pointed out particular areas of liability, and offered suggestions for addressing those areas.

Robson, E. (2012). Responding to liability: Evaluating and reducing tort liability for digital volunteers. [http://www.wilsoncenter.org/sites/default/files/responding_to_liability_0.pdf]

The article recommends preemptive liability strategies for digital volunteers, noting that many of these currently more ad hoc groups will evolve into

bureaucratic organizations and eventually integrate into the civil system. Robson's liability strategies include: 1) policy creation; 2) informed choice of organizational structure; 3) purchase of insurance; 4) use of agreements and disclaimers; and 5) consultation with counsel.

Wassom, B. (2011). Google Maps shows the path to avoiding liability for user injuries. [http://www.wassom.com/google-maps-shows-the-path-to-avoiding-liability-for-user-injuries.html]

This article analyzes the case of Lauren Rosenberg vs. Google. Rosenberg sued the company when she was injured using a Google Maps route. The court found that Google was not liable because it did not owe any "special duty" to Rosenberg. The findings can be applied to a broad range of digital media. Though Rosenberg argued that Google was not a mass market producer but a service provider, the courts relied on the legal precedent that said mass-market book publishers owe no duty to their readers to ensure that all content in their books is accurate. They categorized Google as a mass market product and, as such, errors are considered inevitable. The court also noted that the user will always be considered in the best position to apply Internet-provided data to real-world conditions.

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Chapter III

CRISIS MAPPING: A VALUABLE NEW TOOL IN RESPONDING TO A PUBLIC HEALTH DISASTER?

Abstract

Background

The earthquake that struck Haiti on January 12, 2010 resulted in a humanitarian and public health disaster of catastrophic proportions. Multilateral and non-governmental organizations responded with a crisis management system known as a Cluster Response. In addition, Ushahidi, an open-sourced, online crisis mapping global communication network based on SMS texts, was deployed to coordinate reports of need and response. Ushahidi was not considered to be part of the Cluster Response.

Objective

To document the successes and failures of crisis mapping for disaster response.

Methods

Utilizing a rapid assessment qualitative evaluation methodology, 21 interviews were conducted with key stakeholders involved in the Cluster Response and crisis mapping responses during the Haiti disaster. Responses were coded and ordered by frequency to identify prominent themes that defined the case study. The SMS messages were analyzed based on the frequency over time of the coding of particular topics. An

algorithm was developed to search messages for the occurrence of certain keywords associated with one of the categories that were being manually applied by the crisis mapping volunteers. Results of the machine-coding algorithm in four major categories of need were compared to the manually-assigned categories.

Results

Initial hostility between the two principal entities prohibited the maximizing of available resources and the dissemination of information. However, by the second wave of the disaster, marked by the cholera epidemic, the Cluster organizations had largely accepted the value of crisis mapping. Consequently, it was soon adopted as a valuable in-house tool. The quantitative analysis in this study revealed that needs shifted over time. Initially, emergency requests were prominent. After the first few weeks of the disaster, food, water, and supply shortages supplanted the need for emergency help, eventually accounting for 81% of all messages. The machine-coding algorithm tracked closely with manually-coded results for water shortages and security needs. The algorithm also detected many more messages about fuel shortages and chronic health needs than the volunteer coding effort identified, thus adding great value to the response effort.

Conclusion

There is increased potential for managing large-scale public health disasters with additional information gained through crisis mapping and other emerging technologies for rapid analysis. The analysis of codes revealed the extent to which the crisis map SMS messages might have been used to inform a situational analysis of the crisis. As future technologies become available for disaster response, the Haiti earthquake remains an important case study for the diffusion of innovations in the Cluster Response.

Introduction

At 4:52 p.m. on January 12, 2010, an earthquake of the magnitude of 7.0 occurred in Haiti. It caused the worst natural disaster ever recorded in the western hemisphere. Haitian officials estimate that over 316,000 people lost their lives and more than 300,000 were seriously injured (Bilham, 2010; Kolbe et al., 2010).

The cataclysmic nature of the damage and especially the loss of infrastructure such as roads, ports, and airports made the first days of disaster response difficult. While the capital of Port-au-Prince was flooded with multilateral and non-governmental agencies' aid workers, a lack of communication among them resulted in poor coordination of the services they struggled to provide. The United Nations (UN) immediately implemented the Cluster Response, based on UN General Assembly resolution 46/182 (United Nations, 1991), which calls for grouping all the agencies and organizations working within a sector, such as health or security, into clusters with a single point of contact for the response effort and appeals to donors. This management system designates one agency as the lead for each sector and determines which NGOs should act in which official capacities.

In accordance with procedures within the Cluster Response, a committee was convened to conduct a post-disaster needs assessment (PDNA) to determine the planning and spending priorities for recovery efforts in future intervals of 6 and 18 months, then 3 and 10 years (Haiti PDNA, 2010). The committee began their investigation on February 18, 2010 and concluded with the report's public release on March 24, 2010.

Concurrent with this formal response from the UN, a global movement of volunteer responders also initiated a response (Heinzelman & Waters, 2010). Within four

hours of the earthquake, Patrick Meier, his colleagues at Ushahidi, and his fellow graduate students at Tufts University launched a crisis map. They soon began receiving messages, translating them, coding them by type and actionable need they communicated, and mapping them on a publically-accessible crisis map online. The team secured a shortcode phone number, which went active on January 16, 2010 (Meier, 2012). This made it possible to send SMS messages from a Haitian mobile phone free of charge (Project 4636, 2010). NGO workers quickly used the system to coordinate with other NGOs. In an early news conference, Hillary Clinton recognized the crisis mappers, saying, "The technology community has set up interactive maps to help us identify needs and target resources" (Clinton, 2010). Earthquake victims communicated urgent needs such as the specific locations in which they were trapped in rubble. Additionally, the global public communicated their search for missing loved ones. By January 18, 2010, local radio stations, the main source of information for most Haitians, began broadcasting information on the crisis map (Nelson, 2010).

Crisis mapping originated several years prior to the Haitian earthquake. Volunteer and crowdsourced communities spontaneously responded to catastrophic events such as the Asian Tsunami in 2004 and the Kenyan election violence of 2007 (Meier & Munro, 2010). Crisis mappers defined their activity as that of an online community which collectively "leveraged mobile and web-based applications, participatory maps and crowd-sourced event data, aerial and satellite imagery, geospatial platforms, visual analytics, and computational and statistical models to power an effective early warning for rapid response to complex humanitarian emergencies" (Crisismappers.net, 2011).

The cultural phenomenon of Web 2.0 resulted in more opportunities for interaction and more technological solutions to elevate interactions in more meaningful ways (Nelson, 2010; O'Reilly, 2005). Within a week of the disaster, a self-organized, global team of over 2,000 volunteers was actively coordinating communications related to earthquake relief. Despite this large number of volunteers, Ushahidi's Patrick Meier and other crisis mapping leadership turned down the opportunity to send a text message to every mobile phone subscriber in the country, inviting them to engage the crisis map communication system—because they feared their volunteer force was not big enough to handle a massive onslaught of incoming messages, each requiring translation and geocoding (Heinzelman & Waters, 2010).

In the three years since the Haiti earthquake, crisis mapping quickly diffused through the UN as an emerging innovation, to the degree that UN agencies now employ in-house teams that create and manage their own crisis maps. However, meaningful evaluation of how to best use the crowdsourced information has not kept pace with the technology's rapid uptake (Reyes, Laredo, & Vukovic, 2010).

This study was motivated by the potential for crisis mapping to be used to augment or even replace the traditional rapid assessment of need in a region impacted by an enormous natural disaster. Findings indicated that existing crisis map procedures can be improved with automated coding, which is faster, requires less manpower, and is often more accurate that human coding. The needs communicated in the Haiti crisis map were valid reflections of those found by the traditional assessment tools, but were also available to responders in near real-time rather than months after the event.

Methods

Qualitative Methods

This qualitative investigation was guided by the question of whether the introduction of these novel technologies and their rapid diffusion lead to changes in communication structures among organizations and between organizations and the populations they exist to serve. Further, were there features that changed the rate of diffusion that could be scaled or transferred to other situations when new technologies become available?

A combination of qualitative and quantitative methods was used to evaluate crisis mapping as a rapid response tool for disaster relief. First, key informants were identified through online blogs, twitter conversations, three early reports on crisis mapping, and the volunteer effort conducted by the UN (Crowly, 2010; Nelson, 2010; Ushahidi, 2011). Of the 20 individuals identified, 15 agreed to be interviewed. At the conclusion of each interview, participants were asked to identify other key informants that could provide a more complete understanding of the issues involved. This snowball sampling added 6 additional people, for a total of 21 interviews. These people represented multilateral organizations and the volunteer crisis mapping community (see Table 1). Participants representing multilateral organizations worked for United Nations agencies, the World Bank, and major NGOs. Members of the volunteer crisis mapping community were all U.S.-based and were primarily active in coding and geocoding incoming messages for inclusion to the map. While participants from multilateral organizations tended to be above the age of 41, most of the crisis mapping volunteers were younger than 41.

Table 1

Descriptive Statistics of Participants Interviewed

Age	N	%
< - 30	2	9.5
31-40	8	38
41 - >	11	52
Role		
Managers from multilateral organizations/NGOs	16	76
Volunteers	5	24

The interview structure was adapted from the Rapid Assessment Model developed by Bolton, Wilk, and Ndogoni (2003). For this study, this qualitative evaluation procedure utilized semi-structured interviews. It also produced a coded evaluation of the sum total of the interviews. All interviews took place between May and August, 2011. Each individual was asked a series of open-ended questions. After each question, the person was prompted to make additional comments. The aim of exhausting the subject was to avoid gathering only the information that came quickly to mind, perhaps due to recent events or experiences.

When all interviews were completed, each topic raised in the responses was listed and ordered by frequency among all of the participants, regardless of the question that produced that response. The five most frequently mentioned topics were assigned to represent the most important areas of focus for the creation of the case study.

Quantitative Methods

Ushahidi, the organization hosting the crisis map online for the first three months, maintained the database of SMS messages. All originating phone numbers were removed. These were located in an open source, downloadable file attached to the map. IRB approval was obtained to analyze the database that included 3,589 messages sent between January 12 and April 27, 2010. This study does not include messages sent after this date. Nor does it include messages managed by Noula, an organization created to be the sustainable, ongoing crisis map that is still in use today in Haiti.

Quantitative analysis focused on the labels with which SMS messages were coded by volunteers. The message date, text, and assigned labels were imported into the statistical software package R (version 2.14.2). The label column was parsed to form individual factors for each of the 49 possible labels, indicating whether or not a particular message received each label. Some messages received multiple labels.

To compare the manually coded labels of the crisis mapping volunteers to an automated computer process, the text of each message was parsed for a set of keywords that would be associated with certain manually coded labels. For example, the category *water shortage* was approximated by any messages that contained the words water, drink, and thirst. *Fuel shortage* was approximated by the key words fuel, diesel, and gas. *Security threats* used the words police, gun, robber, and loot. “Chronic care needs” were approximated by *diabete* (to include diabetic and diabetes), insulin, and medication. The machine-coded messages were compared with the volunteer-coded messages, creating two-by-two tables of counts for each category.

Results

Qualitative Results

All interviews were coded by topics they raised and ranked for topic frequency. The top five topics were summarized below and as these topics were discussed by multiple respondents, common themes were identified. The most frequent topics raised in the responses and the context in which they were made are delineated below.

1. There was a limited ability to use the information gathered to directly interact with the Haitians who provided it.

Ideally, crisis mapping is intended to generate a feedback loop. Individuals send an SMS such as "this neighborhood has a water shortage," information regarding the location and nature of the report. It is then communicated through a virtual map in which an aid worker has the ability to respond to that location. However, neither the aid managers nor the crisis mappers felt integration was sufficient to communicate back to the sender or even follow up with the sender at a later time. As opposed to using the system to respond to those in need, most NGOs used it instead to share information about their own needs to those in other affiliated organizations. This is illustrated in this SMS:

> U.S. established an air link to the airport after fixing the traffic control tower. Will send - over multiple shipments - enough food for 1.2 million people over 2 weeks, specifically 14,550 tons of food (7k rice, 4,500 corn-soy blend, 3k vegetable oil) to be distributed by UN and private orgs.

In the weeks after the earthquake, aid workers realized that the radio was the most valued source of information for many Haitians. Information gathered for the crisis maps became increasingly communicated over health-oriented radio programs, such as one established by Mission 4636 (Munro, 2012). Although the crisis map was available in both Haitian Creole and English, it was only accessible on computers. No interface was

possible for mobile phones. This created an absence of feedback mechanisms that was seen as the primary reason why more reports did not come from earthquake victims themselves. These people did not have access to the texted reports and most did not hear back from anyone after sending a report.

2. UN and other official entities were reticent to use the information gathered because they: a) were uncomfortable posting information online, and b) distrusted the validity of the information posted by others.

In the years leading up to earthquake in Haiti, the interviewed UN employees claimed they worried that creating Twitter accounts or being active in social media would result in termination of their employment. At that time, there was a growing concern that posting work-related information would be perceived as inappropriate, primarily due to privacy regulations. Similarly, UN officials were well aware that false information had been intentionally spread during previous emergency response situations. For instance, during the 2008 terrorist attacks in Mumbai, India, government agencies and media obtained much of their information from tweets as the terrible events unfolded. At one point, the gunmen discovered this and began sending out false tweets. As a result, many UN managers grew to distrust the use of tweeted information in crisis situations. Consequently, very little fluency existed in the technologies the crisis mappers represented.

Volunteers tended to counter the issue of validity by raising the point that information is so severely limited following a natural disaster, that even if those data gathered through text messages are not fully representative of the population, it is an improvement over the alternative of no data. Sewell (2011) studied the crisis mappers'

response for her master's thesis after herself participating as a volunteer with the Tufts University team. Paraphrasing a paper by Gonzales (2008), she explained that despite concerns around validity, crisis mapping filled a hole in disaster response such that:

> communication and situational awareness are manifestations of a need for intelligence because without timely and accurate information, decision making and action can be stymied. The scope of each organization is limited and as such, they are dependent on the information as well as the ability of other organizations to deliver it.

3. The discord that marked the initial stages of relief in Haiti was largely resolved by the time of the second wave crisis, the cholera epidemic.

The UN agencies representing the Cluster Response did not immediately adopt crisis mapping as an information resource, as clearly demonstrated in the UN report *Disaster 2.0* (Crowley & Chan, 2011). The report referred to the crisis mapping community as being "interlopers" who expected UN responders to answer their emails when they were already overburdened with routine post-disaster tasks (Crowley & Chan, 2011).

In October 2010, Harvard and Tufts Universities hosted an international conference on crisis mapping that included many stakeholders in the global volunteer crisis mapping community. Also attending were representatives from the UN agencies involved in Haiti. The event turned into a catalytic change agent, where members from each community could learn about one another and discuss strategy integration. Within months of the conference, participants from the UN agencies claimed to have organized in-house crisis map teams.

In addition to integrating crisis mapping, UN agencies began to break their silence in social media platforms, embracing Internet communications and technologies (ICT)

and launching agendas that were centered online. UN managers working with multilateral organizations rapidly integrated social media platforms into their communication strategies both internally and externally. Rather than relying on stand-alone communication departments to represent them online, departments now have communication managers. Additionally, employees are now encouraged to be active on social media platforms.

4. The geographic location of the "pipeline" or Internet data source was of critical influence.

With the communications infrastructure of Port-au-Prince demolished by the earthquake, Google Voice, Twitter, and other online tools became the only means of communication. One of the interview participants was a graduate student who led Columbia University's team of crisis mappers. He explained that many NGOs, including Ushahidi, were set up in the central city, very near the pipeline that provided Internet access. However, the UN cluster agencies established their base of operations outside of town which was too far from the pipeline to receive connectivity. This fact contributed to the lack of integration of ICT within the UN agencies. Crowley and Chan (2011) conducted an interview for their report, *Disaster 2.0*, that explained the pipeline access Cluster agencies did come with a cost dimension: "During the first 2 weeks of a major disaster, like Haiti, even though we had connectivity, we [did] not have the luxury of accessing the graphical web, at $6-8/MB for data. And you load a Facebook page, with photos/status page, that is 300-400KB. It quickly adds up."

Nelson, Sigal, and Zambrano (2011) discussed the lone role and particular effectiveness of Colonel Lee Harvis, Joint Special Operations Air Component Surgeon

for the U.S. Navy. As the top military medical officer, Colonel Harvis excelled at integrating online communication platforms into disaster management while situated near the pipeline. The team reported that Colonel Harvis was frustrated by his inability to find or delivery critical services. In an email interview, he explained, "That first day, we spent two hours—actually longer—searching for the Israeli hospital and my medics never found it." Independent of the crisis mappers' response efforts, Colonel Harvis began using his mobile phone on the back of a motorcycle to mark coordinates of roads for supply delivery. Because the management infrastructure of the shipyards and airports were both destroyed, incoming aircraft with aid and supplies were not able to land and ships were not able to dock until the facilities were repaired. Ultimately, through the work of Colonel Harvis and others, improved maps did help the greater effort of geolocating place names and delivering services.

Tasked with restoring infrastructure, Colonel Harvis utilized Google Voice to communicate with airplanes and ships. Once this task was accomplished, he further used crisis maps to orchestrate the evacuation of severely injured individuals from clinics and hospitals on land to the floating Navy hospital *USNS Comfort*.

Other collaborations to improve mapping and geocoding effectiveness included the collaboration between two private partners, GeoEye and Google, who "released high-resolution imagery of the disaster 26 hours after the quake. Digital Globe soon followed. What was remarkable was that these providers released the imagery under an 'attribution only' license, instead of the usual restrictive licenses that prevent derived works and redistribution via other online and offline channels" (Crowley & Chan, 2011).

5. The shifting paradigm of external organizations involved in the earthquake was a causal force in the differing approaches to disaster management.

Web 2.0 was not merely a revolution in social media online. It was the result of an evolution in management structures that redefined the financial cost of work (Rogers, 2011). This new era is marked by the emergence of highly participatory organizational structures. These structures are marked by collapsed levels of hierarchy, inclusively defined membership, and reduced transaction costs because of an efficient use of otherwise-wasted cognitive surplus. This often pertained to highly technical tasks conducted by individuals with unique skill sets, but who often worked in other fields (Shirky, 2008). Thus, the paradigm of traditional hierarchical response of disaster management entities was opposed. This stands in contrast to the cultural structure of the crisis mapping organizations and their thousands of crowdsourced volunteers.

During the interviews, a high ranking UN official explained how the UN has adapted since then. The culture shift is especially notable in creating its newest agency in response to the need for faster and more porous data flows, UN Global Pulse, "to get a real time indication of the level of stress on populations. We are looking for real time evidence of changes in collective behavior that tell us where we need to ask more questions." In explaining how this change in policy has a potential to impact other agency directives, he explained, "If we can learn to detect crisis-driven decreases in human wellbeing, we can also detect the opposite—the evidence that people's lives are improving. This type of evidence is no less important for leaders to gain access to, as it lets them do more of what is working well."

Quantitative Results

Crisis mapping volunteer coding analysis. A total of 3,587 individual messages were included in the analysis and 7,307 individual codes were applied. Most messages received either one or two categories. However, over 1,000 messages received three or more codes (Figure 1). The total number of codes assigned for each category and the percentage (based on the total number of messages) are provided in Table 2. Although the codes are organized by general thematic codes with related sub-codes, the system permitted a user to add the general code without specifying a sub-code. For example, the general "Emergency" code could be used without specifying the type of emergency, such as "People Trapped or Fire."

Food Shortage (44%) and Water Shortage (37%) were the most commonly assigned codes, followed by the general Vital Lines (14%) and Emergency categories (13%) and Shelter Needed (13%). The codes for Medical Emergency, People Trapped, Medical Equipment and Supply Needs, Services Available, Food Distribution Point, Hospital Clinics Operating, and Persons News were used in between 5% and 10% of messages. The remaining codes were used for less than 5% of the messages.

In the first 10 days after the disaster, most messages were focused on emergency situations and the availability of services (Figure 2). The introduction of the Mission 4636 shortcode on January 16 coincided with an across the board increase in frequency of all types of messages. By January 22 (10 days after the earthquake), the number of emergency reports began to decline while shortages of water, food, shelter, and medical equipment began to increase. These shortages peaked on January 23, declined, and then a smaller sustained increase was recorded over the first two weeks of February.

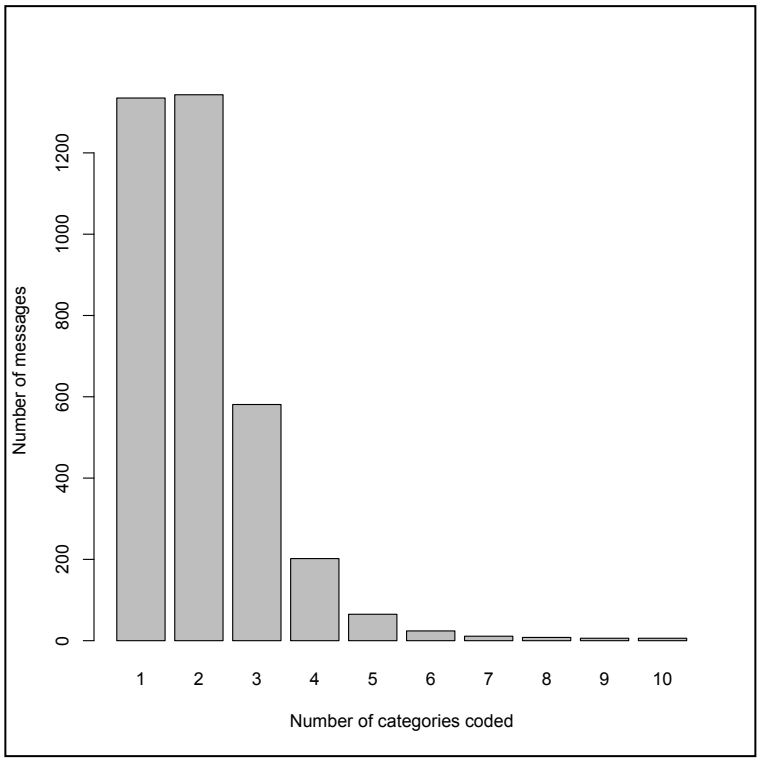

Figure 1. Number of messages receiving a single description label (left-most category) and those receiving between 2 and 10 categories.

(Messages included are those coded by the Ushahidi crisis mapping volunteers between January and May 2010.)

Table 2

Distribution of Messages by Type of Label

Category	Total Messages	% of Messages	Category	Total Messages	% of Messages
Emergency			**Natural Hazards**		
	483	13		4	< 1
Highly Vulnerable	2	< 1	Floods	0	
Medical Emergency	209	6	Earthquakes And Aftershocks	15	< 1
People Trapped	167	5	Land Slides	0	
Fire	7	< 1	**Services Available**	304	8
Vital Lines	496	14	Food Distribution Point	333	9
Food Shortage	1596	44	Water Distribution Point	5	< 1
Water Shortage	1333	37	Non-food Aid Distribution Point	77	2
Contaminated Water	9	< 1	Hospital Clinics Operating	258	7
Shelter Needed	476	13	Human Remains Management	37	1
Fuel Shortage	21	< 1	Rubble Removal	7	< 1
Power Outage	35	< 1	**Other**	163	5
PublicHealth	17	< 1	IDP Concentration	20	< 1
Infectious Human Disease	9	< 1	Price Gouging	1	< 1
Chronic Care Needs	2	< 1 percent	Search And Rescue	49	1
Medical Equipment and Supply Needs	305	9	Persons News	295	8

Table 2 (continued)

Category	Total Messages	% of Messages	Category	Total Messages	% of Messages
Security Threats			**Other**		
	74	2		4	< 1
Looting	25	< 1			
Theft of Aid	0				
Group Violence	1	< 1			
Riot	0				
WASH Promotion	240	7			
Infrastructure Damage	4	< 1			
Collapsed Structure	143	4			
Unstable Structure	33	< 1			
Road Blocked	29	< 1			
Compromised Bridge	1	< 1			
Communication Lines Down	1	< 1			

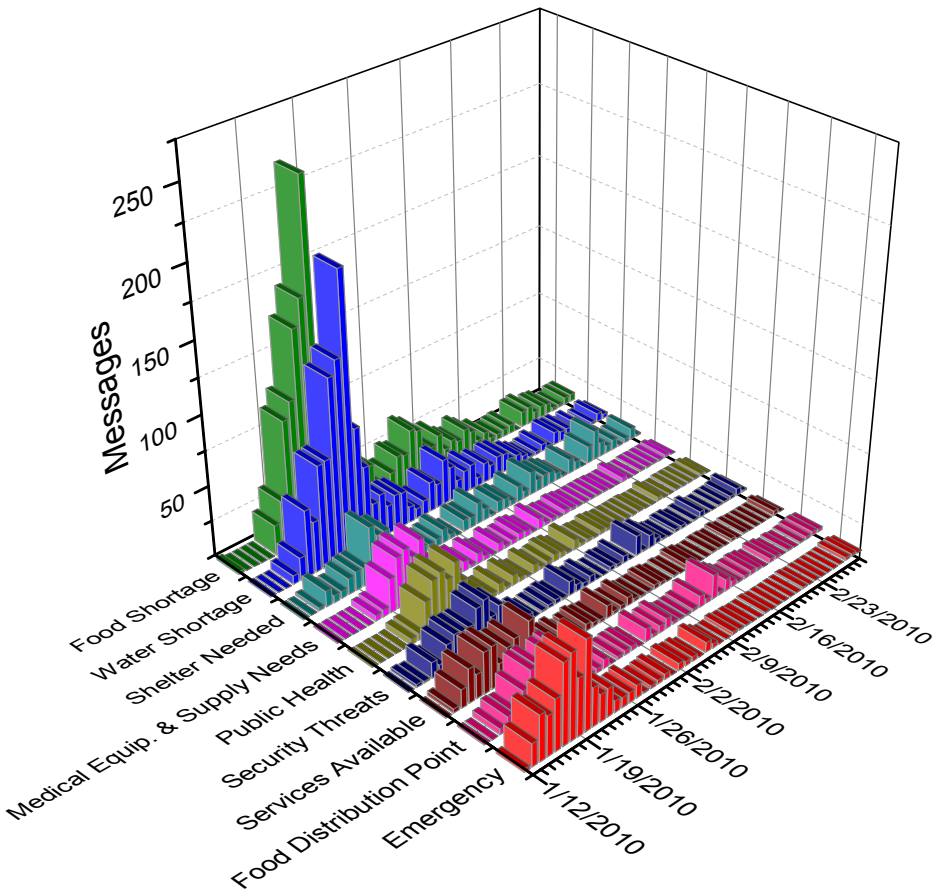

Figure 2. Time series of daily message totals (vertical axis) that were assigned a particular label (e.g., Food Shortage) by the crisis mapping volunteers

(Label categories shown are those that received at least 300 messages.)

Machine coding. The machine-coded labels closely tracked the volunteer-coded labels for the Water Shortage category (Figure 3a). This indicates a large spike in this need that occurred from January 20-25 and another smaller increase over the first two weeks of February. Security concerns (Figure 3b) determined by machine coding also closely followed the labels added by volunteers, detecting spikes on January 17 and January 24. The Fuel Shortage and Chronic Care Needs (Figures 3c and 3d) labels were seldom used by the volunteer coders. However, the machine coding algorithm detected many messages related to these needs. Overall, 74 Fuel Shortage messages were labeled by machine coding, compared with 21 by volunteer coding. Similarly, 65 Chronic Care Needs were labeled by the algorithm while only two were found by volunteer coding. These findings illustrate that a machine coding algorithm can be useful to track the relative intensity of particular needs over time, but also to identify very specific needs that might be missed by volunteer coding. One reason that the volunteer coding effort appeared to miss important actionable information such as the need for insulin or fuel for generators is that these messages often expressed other needs as well, such as food and water, which caused them to be identified with these categories. Computer algorithms can easily parse longer messages that express multiple needs at once, automatically delivering them to the appropriate cluster or local volunteers.

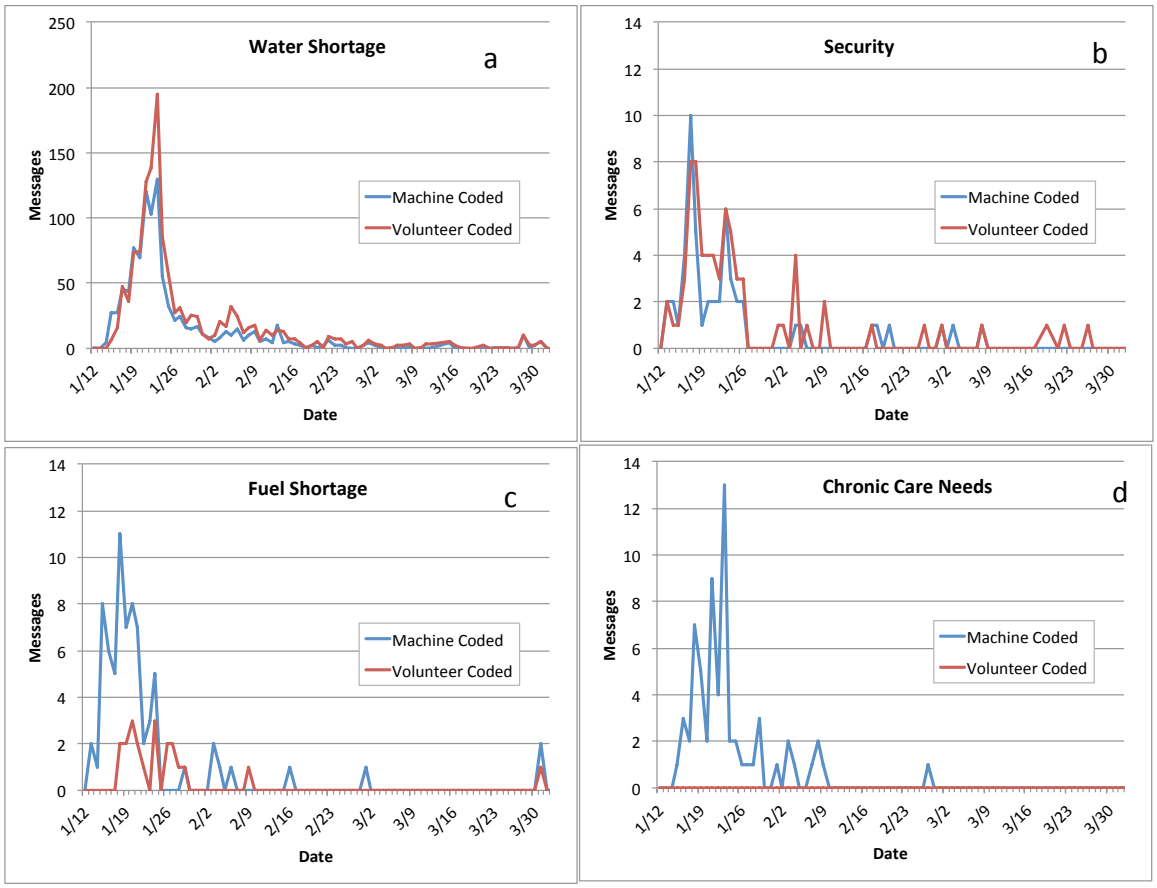

Figure 3. A comparison between the number of messages each day between January and March 2010 that were volunteer-coded (—) for a particular need and the number of messages identified by a machine-coding algorithm (—) based on key words associated with the need

The comparison was performed for water shortage (a), security (b), fuel shortage (c), and chronic care needs (d).

Discussion

The 2010 Haiti earthquake gathered together a unique group of global actors. It will be remembered for the change it affected in the way the world responds to crisis. Before the earthquake, crisis mappers and UN agencies were disparate entities, but within a year of the disaster, these two units were deeply intertwined. This evaluation helps shed light that a cultural evolution occurred in the UN, an entity which has traditionally been resistant to rapid changes. Further, it illustrates that crisis mapping could be even more valuable in future disaster response.

Crisis Mapping's Diffusion Through UN Agencies

Rogers' (1953) Theory of Diffusion of Innovations can be used to explain the stages social networks undergo when adopting a new idea or technology. Rogers contended that when a new technology or innovation is introduced to a social network, it is expected to pass through an S-shaped curve. This curve ranges from initial rejection, to a critical mass of acceptance, then finally to all but laggards in the network accepting the idea. The speed of an innovation's passage through this process depends on factors such as the presence of change agents or boundary spanners (Burt, 2001; Williams, 2002). These are individuals who share both the characteristics of the new innovation and those of the group to which the innovation is introduced. Kapuku (2006) showed that boundary spanners are especially important for organizations in natural disaster response because they connect the closed network of an organization to external networks, and hence enact the porous sharing of information beyond boundaries.

Conceptually, crisis mapping was a new technology. It diffused quickly through the multilateral organizations from the social network's initial hostile response to, within

10 months, complete acceptance. Soon after, it was adopted as a technological innovation with in-house crisis mapping teams within UN agencies. One explanation for the adaptation of this new technology occurring more rapidly than expected is a higher number of in-group individuals who had familiarity with key tools. Mobile phone texting/SMS could introduce it without the hostility that the out-group would cause. These technologies have infused themselves into our normal lives and this facilitates users' openness to the value phones can bring to other situations.

As shown in interviews, Web 2.0 was a larger cultural event than crisis mapping or communicating through SMS. During this period of time, leadership in multilateral organizations began to change in response to this shift—for example, to integrate border spanning flows of information such as social media; to engage their target audiences as partners with fewer layers of hierarchy between agency and recipient of aid. Especially within UN agencies, their engagement with crisis mapping in the Haitian Earthquake disaster response was a watershed moment. Regardless of the effectiveness of the approach, its potential was demonstrated on a large scale.

Mission 4636

The availability of the free shortcode for sending local SMS messages was critical to the success of the crisis map. The shortcode resulted in an increase in the number of messages sent and an increase in messages sent by earthquake survivors (data/volume increase), as opposed to relief responders.

The Potential for Crisis Maps to Inform Situational Awareness

While crisis mapping is known for the maps generated, coding messages for rapid response and situational awareness is arguably their greatest benefit in natural disaster

response. However, responders have yet to use emerging data analysis tools for real time awareness of needs and events.

Machine coding offers the potential to increase the capacity load of coding messages. This has the benefit of decreasing response time and standardizing the biases that coders may have, such as prioritizing messages that they themselves deem most important. For example, in this dataset, volunteers employed the code for security disproportionately often, and underused the code for chronic illness needs—perhaps due to the news coverage at that time that covered security issues most.

Coding SMS Messages

The Ushahidi-lead volunteer crisis mappers spent much of their time coding messages by various labels. In interviews, one participant explained that the number of labels made available to volunteers was limited only by the number of available fields written into the report interface of Ushahidi's software HTML code. Another participant reported that the labels themselves were chosen by UN OCHA in Colombia months before the earthquake. This occurred when they hosted a conference on Ushahidi's crisis mapping software.

By analyzing the frequency of labels used over time, certain patterns emerged that could be considered predictable for disaster response. For example, the earliest messages were predominantly emergency response oriented, with people looking for their missing loved ones. These messages gave way after the first week to strong trends in food and water shortages. In future disasters, knowledge of "normal" label patterns over time could inform the system to detect anomalies in need.

The use of labels to quickly gather information from the crisis map would be greatly improved by policy changes. Limiting messages to two labels and limiting total possible labels to choose from to a smaller list would increase the detection capacity of the database. The labels themselves, however, may become entirely unnecessary, given advances in auto-generated searches. By running the messages through a simple machine-generated sorting mechanism, the authors were able to create a labeling scheme that was at least as sensitive as the human coders and, in most cases, superior at detecting need. The most dramatic example was for chronic health needs, which human coders only labeled for 2 messages, while machine coding selected for 61 messages. Addressing chronic care needs for populations dependent on medications or regular medical treatments is a growing area of concern in post-disaster recovery (Fernandez, Byard, Lin, Benson, & Barbera, 2002; Jhung et al., 2007; Miller & Arquilla, 2008).

Among the greatest potential for improvement with crisis mapping is the advances in data analytics. An example of the opportunities for epidemiological uses of machine coding emerged in a retrospective analysis of data regarding cholera. In October 2010, the United Nations detected a cholera epidemic in Haiti, which, three years later, continues to be the worst cholera outbreak on the planet (Adams, 2013). By conducting machine analysis of informal sources including news reports, twitter, and SMS messages, a team of researchers found they could detect the epidemic up to two weeks earlier than traditional epidemiological detection methods (Chunara, Andrews, & Brownstein, 2012).

Machine coding could engage in a communication network with the participants who send messages. For example, an individual who sends an SMS that appears to be communicating a water shortage could then receive an SMS from the crisis map saying,

"You appear to be communicating a need for water. Is this correct?" Or alternatively, messages that arrive without embedded geocodes could automatically receive a reply that asks the sender to describe where they are located. Given that the most time-intensive tasks of the volunteers were translating, coding, and geocoding messages, this would increase their capacity to clean messages the coding machine could not read.

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Chapter IV

SOCIAL NETWORK THEORY AS A CONCEPTUAL MODEL FOR HELP-SEEKING BEHAVIOR: A CASE STUDY FROM THE 2010 HAITI EARTHQUAKE

Abstract

Background

Without question, the 2010 Haiti earthquake was an unprecedented natural disaster. The devastation and difficulties it posed for responders was massive. After rescue efforts began, crisis mapping and crowdsourced volunteer technical relief emerged as viable communication and assessment tools. The Haitian public and relief organizations sent SMS (Short Message Service) messages to a free shortcode, which became a crisis map to display situational awareness for the public and relief responders. This study provides an analysis of the public and official use of the Haiti crisis map.

Methods

An analysis of the database of SMS messages sent during the first three months after the earthquake was undertaken. Of particular note were indicators of social capital node types of bonding, bridging, or linking. For this analysis, bonding refers to relationships marked by likeness; bridging refers to relationships marked by differences; and linking refers to relationships with a vertical hierarchy, usually a dyad between an individual and a perceived authority. Each message was coded by the type of sender and the apparent intended recipient, namely, earthquake survivors or official relief

responders. Also coded was the type of information communicated, specifically requests for help and supplies or location.

Results

The vast majority (82%) of messages were sent by earthquake victims who were attempting to communicate their specific needs. These were usually for food, water (70%), and other supplies requested for a specific location. Patterns in these messages tended to match the changing nature of the disaster. For example, most early messages requested assistance in finding or unearthing people. Later messages focused on supply needs such as food and water.

Conclusion

Historically, after a natural disaster, reaching individuals in impoverished and tightly bonded communities has been a formidable challenge. This has most often been due to technical limitations and the difficulty of facilitating an adequate level of trust within a limited amount of time. As illustrated in past instances, socially vulnerable communities often discourage formal means of outside assistance. To help remedy this situation, the incorporation of crisis maps with geocoded mobile phone SMS message submissions are employed. This process changes the directionality of communication to help those in immediate need feel more confident in seeking aid from unfamiliar formal institutions and non-governmental organizations.

When responders become less hierarchical, crisis maps present an opportunity for increased engagement with a vulnerable population. The disaster response in Haiti did offer an adequate roadmap to use this new technology for more effective communication. However, the official help-providing entities did not use the crisis map to communicate

directly with the public. Instead, they used it to communicate with one another. Ways to avoid this unfortunate result warrant attention since the disaster response community considers the future use of crisis maps valuable in impacting socially vulnerable populations.

Background

On January 12, 2010, a 7.0 magnitude earthquake struck Haiti. This natural disaster has been considered to be the worst recorded in the western hemisphere. It resulted in at least 300,000 deaths and another 300,000 injuries (Bilham, 2010). Largely due to a catastrophic loss of urban infrastructure, immediate situational awareness was extremely limited (Kolbe et al., 2010). This, in turn, impeded the coordination of the relief response efforts (Nelson, Sigal, & Zambrano, 2011). Crisis mapping, a new innovation, emerged as a uniquely apt source of information for both earthquake survivors and official relief providers. This included the many agencies of the United Nations (Crowley & Chan, 2011; Meier & Munro, 2010).

Crisis Mapping

> Crisis mappers define themselves as an online community that
>
> collectively, leverage mobile and web-based applications, participatory maps and crowd sourced event data, aerial and satellite imagery, geospatial platforms, visual analytics, and computational and statistical models to power effective early warning for rapid response to complex humanitarian emergencies. (Crisismappers.net, 2011)

Crisis mapping is a global phenomenon for which inclusion is based on network access rather than geographic location (Bauday, 2010). Participation is open and voluntary. Crisis mappers utilize a crowdsourced management structure to establish communication

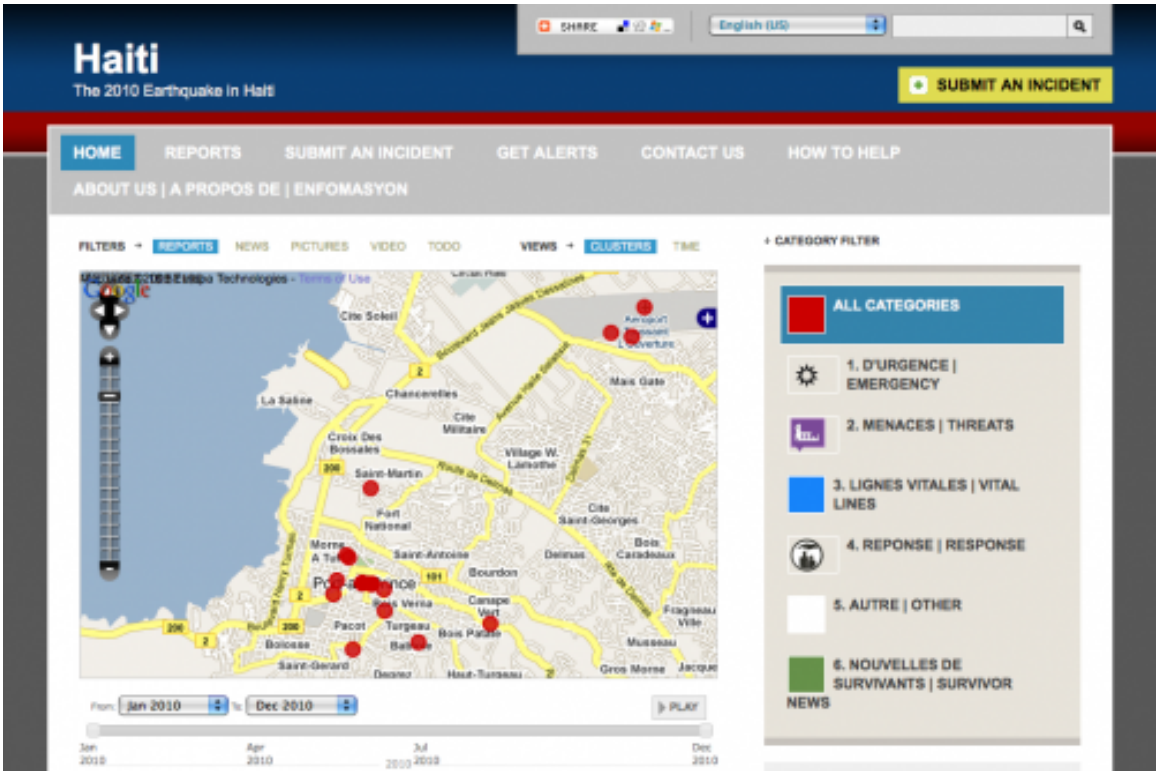

Figure 4. Image of the Haiti earthquake crisis map website

The map view (left panel) shows the location of each report (or incidence). Messages pertaining to particular categories can be selected to display using the Category Filter (right panel).

networks (Meier, 2012). This increases clarity in emergency response voluntary. Crisis mappers utilize a crowdsourced management structure to establish communication networks (Meier, 2012). This increases clarity in emergency response situations, such as a natural disaster or government revolution (Heinzelman & Waters, 2010; Zook, Graham, Shelton, & Gorman, 2010).

Crisis mappers reflect a cultural movement termed Web 2.0, in which information flows are interactive, as opposed to one-directional (O'Reilly, 2005). While Web 2.0 originally referred to the change in the social nature of websites on the Internet, it has recently been used more broadly as the social interaction online has impacted societal structures offline as well. According to Rogers (2011), crisis mappers are part of a growing cultural evolution of structuring the management of organizations that are borderless, collaborative, and pervasively networked. The earthquake recovery in Haiti was the first time in history when a large-scale, traditionally-managed public health response directly encountered a crowdsourced relief effort with no management ties to the traditional responders.

Within four hours of the earthquake, Patrick Meier, a founder of the organization, Ushahidi, began implementing an online interface that would eventually include approximately 2,000 volunteers worldwide (Meier, 2012). This is the primary crisis map tool examined for this study. This crisis map received messages sent by SMS/text messages on mobile phones and made them part of an actionable, mapped database that could be used for communication and situational awareness (Figure 5). For this effort, crisis mappers spent most of their time translating messages into English and Haitian Creole. They also coded them by the type of communication such as "emergency medical issue" or "need for food and water." Geocoding the message with latitude and longitude coordinates for inclusion in the interactive, online crisis map was also a major task of the volunteers (Ushahidi, 2010).

	Is Dr. Jean Pape of Gheskio okay?	1/13/10 1:28	port of port-au-prince	anyone know if Dr Pape is okay? What about the clinic. ps Port badly damaged. will post pix soon. Southern Command alerted to pix.	5a. Structure effondres | Collapsed structure, 8e. Nouvelles de Personnes | Persons News,	18.529096	-72.350464		YES	NO		
	Trapped in building	1/13/10 1:31	Mont Joli-Turgeau , 8 rue Mont-Joli Turgeau	To anyone in the MontJoli-Turgeau area....Jean-Olivier Neptune is caught under rubbles of his fallen house....he is alive but in very bad shape, please please please hurry and get there as soon as you can, and please put this info in your statuses. 8 rue Mont-Joli Turgeau! URGENT	1c. Personnes prises au piege | People trapped,	18.5352	-72.332954		YES	NO		
0	Looking for 3 Americans	1/13/10 1:35	Port Au Prince, Haiti	My family and I are desperately seeking the condition of our father, his wife and her daughter: Walter Riley Barbara Rhine Selena Rhine Their contacts in Haiti are as follows: Yvonne Kermizan Mario Joseph Any information you can provide is greatly appreciated. Thank You	8e. Nouvelles de Personnes | Persons News,	18.539269	-72.336408		YES	NO		
1	Hopital Albert Schweitzer Haiti inundated with patients	1/13/10 1:56	Desjardines, Haiti	We were not affected by the quake - only small tremors. However, since last night we have been inundated by patients, mostly from PauP and mostly with leg and arm, as well as crushing, injuries. At 20:30, we are still receiving patients who come in the back of tap taps, open-back pickup trucks which serve as taxis throughout Haiti. Every bed, gurney and bench is occupied, and we continue to do lab tests, X-rays and surgeries. Our all-Haitian medical and nursing staff have been excellent, serving without a break for 20 hours.	7d. Services de sante | Hospital/Clinics Operating,	19.073962	-72.493861		YES	YES		
2	Looking for UN Member	1/13/10 2:18	port-au-prince	help!!! ask for information! I need information about Maria Antonieta Castillo Santa Maria she's memeber of the United Nations solicito informacion acerca de Maria Antonieta Castillo Santa Maria es miembro de la mision de Naciones Unidas thanks a lot! Gracias! Jorge Garcia Castillo	8e. Nouvelles de Personnes | Persons News,	18.539269	-72.336408		YES	NO		
				If you have any information, please email								

Figure 5. Example of the SMS message database of SMS messages produced from the Haiti earthquake crisis map

(Each row is comprised of one message and the different data fields are stored in columns that include the date/time of the message, location, title, and finally the category labels applied by the crisis mapping volunteers.)

The majority of the messages sent within the first 48 hours after the earthquake reported trapped individuals and requested help searching for lost loved ones. Two days after the earthquake, crisis mappers created a free shortcode mobile phone number, known as Mission 4636, which Haitians could use to send SMS messages (Mission 4636, 2010). The Knight Rider Foundation and local telecommunications companies helped implement this process. Haitian telecommunication officials offered Patrick Meier and the leadership of Ushahidi an opportunity to send every mobile phone subscriber in Haiti a text message about the crisis map and encourage their use of the system. Fearing their inability to code and respond to such a massive number of people—at that time, there

were over two million mobile phone accounts in the system—Ushahidi's leadership rejected this offer (Meier, 2013). Nonetheless, the use of the crisis map by Haitians quickly expanded even without this outgoing text message. Requests for food and water dominated the map.

Social Network Theory and Social Capital

Social network theory is a widely applied tool for analyzing individual and group behavior (Borgatti, Mehra, Brass, & Labianca, 2009). It is important for the disaster response community to find frameworks within which emerging technologies can be understood in relationship to the canon of knowledge already gained. Social network theory and its applications of social capital to describe behavior offer an opportunity to conceptualize help-seeking and help-offering behaviors. In the changing reference points of traditional versus emerging communication methods in natural disaster response, social network theory is valuable.

Within social network theory, the relationship between two people is referred to as an edge and the two people connected are together referred to as a dyad. Relationships between dyads are either analyzed among pairs of people or between people and their collective network in the sample population (Lincoln, 1984). In both cases, measuring social capital conferred between dyads is an informative means of characterizing the connections. Types of dyadic relationships can be evaluated through measures of structural social capital with features such as interpersonal trust, social support and the degree of homophily versus heterophily, or likeness versus difference, between a pair of individuals or an individual and a group (Lin, 1999). This is referred to in the literature as bonding (homophilous relationships) or bridging (heterophilous relationships) (Harpham,

Grant, & Thomas, 2002). People with lower levels of education, lower incomes, and increased age tend to have social networks dominated by bonded relationships (Lin, 2002). People who regularly engage with institutions such as a school or their workplace, where they are exposed to people from different backgrounds from their own tend to have social networks dominated by bridging relationships.

Focusing on health outcomes, social networks have patterns of influence on individuals' health based on the network size and the tie type that dominates their social network. Connections between individuals are also explained as strong or weak, which indicates the cohesive power of the relationship (Granovetter, 1973). Strong ties are most typically found in homophilic (bonded) relationships and weak ties are most common in heterophilic (bridging) relationships (Lin, 2002, p. 39). Strong networks of homophilic individuals are ideal for preserving resources and culture. For instance, Lin (2002) noted that elite or privileged groups often carry out communication in such a manner. However, this type of network does not allow an inflow of new ideas and innovations (Rogers, 2003, p. 19).

While heterophilic, weaker, and larger networks allow for improved diffusion of ideas, more current research indicates that the ideal network possesses features of both extremes. In an online simulated model of diffusion, Centola (2010) demonstrated that a "clustered-lattice" network out-performed a strictly heterophilous network of greater size. This finding supports Rogers' (2003) method for diffusion, which, in turn, addresses the need to "bridge the heterophily gap" (p. 28) by incorporating change agents that are heterophilous to those they seek to impact. In health promotion activities, this often happens when peer leaders become involved in health interventions.

Generally, bonding is associated with negative health outcomes while bridging is associated with more positive ones (Berkman & Kawachi, 2000). The structural causes of these relationship patterns lie in: 1) the store of resources a network can offer without becoming depleted, and 2) the exposure of individuals in the network to innovations, group membership, and the flow of new information. The social isolation that marks bonded networks results in less available information when a crisis, such as a natural disaster, occurs. During a disaster, when information is critical to survival and recovery, the usage of crisis maps offers a sudden ability to share and receive details. Examples include locations of food, water, supplies, and aid. This was the single most common reason individuals accessed the crisis map in Haiti (Feighery, Chandler, & Allegrante, 2013).

Social Capital and Help-Seeking Behavior Following Natural Disasters

In a discussion of ideal types of social networks, Lin (2001) indicated that dense, closed networks are ideal for "preserving or maintaining resources." Children's safety in a cohesive community is an example of the benefits of a tightly tied homophilic network. However, a less dense and open network is conducive for settings such as "searching for and obtaining resources" (Lin, 2001). Following a disaster, information is the most important resource heeded by responders, especially for determining whose skills are needed and what equipment is in demand. Given these issues, a loose and open social network is theoretically best for disaster response. Crowdsourcing has emerged as a viable alternative to the traditional bureaucratic response that is typically laden with hierarchical assessment and communication mechanisms.

In a sense, disaster response is and always has been crowdsourced. In a study of earthquake relief, Hilhorst (2004) found that at least 90% of the assistance people received came from informal sources rather than organizational or governmental means of support. This is likely due to two factors: first, the inability of official organizations to reach individuals in a setting with a destroyed infrastructure; and, second, the likelihood of social behavior phenomena of the most vulnerable disaster victims who interpret formal means of support as taboo. Crowdsourced natural disaster response may be a more advantageous approach to overcoming this taboo (Turoff, 2009).

Applying a theory first identified as *amoral familism* by Banfield (1958), Gans (1965) demonstrated the cultural taboo against formal means of support when he conducted an ethnographic study of a Boston slum inhabited by Italian immigrants. Gans found that group behavior was self-regulated against any new innovations. This regulation was accomplished by using subtle and overt tactics such as ridicule and exclusion of outsiders. Even when new innovations were clearly in their best interest, such as organizing to prevent the razing of the neighborhood, group behavior shunned change. Bonded groups tended to prohibit bridging behaviors for fear of losing the cohesion and exclusiveness that marked the group.

The health outcomes of this tendency are visible in disaster response. This was described in research following Hurricane Andrew conducted by Hurlburt, Beggs, and Haines (2001) and Jenkins (1997). The authors followed individuals' help-seeking behavior in response to the hurricane's devastation. They discovered that people in tightly-tied, bonded groups marked by high a degree of homophily were least likely to seek or accept formal means of support, such as food stamps. Instead, they turned to each

other for support until the informal support network was entirely drained of resources. This finding was strongly supported in a study of Hurricane Floyd's aftermath, which found that Medicaid applications did not increase despite the widespread financial shock to already-vulnerable households (Domino, 2003). Similarly, in a social capital study of impoverished New Orleans communities after Hurricane Katrina, bonding behavior quickly bankrupted groups' resources, resulting in an increase in their vulnerability (Hawkins, 2010).

Social Capital and Organizational Communication in Disaster Response

Communication networks within and between organizations in disaster response has previously been analyzed in terms of social capital. Kapucu (2006) investigated patters of inter-organization communication network performance following the 2001 World Trade Center attack in New York City. The author invoked the social capital role of boundary spanners (Williams, 2002), also called change agents (Rogers, 1953), which are individuals or entities that communicate between two closed networks, sharing the ideas or innovations from one to the other. Following a disaster, when communication between information networks is critical, boundary spanners become key decision makers. Their importance is so foundational to organizations that Kapucu (2006) recommended creating organizational structures with boundary spanners in place as a means of building resilience and capacity in advance of a disaster.

This study investigated ways in which the availability of a crisis map changed traditional patterns of help-providing and help-seeking behavior after the Haiti earthquake, through an analysis of the bonding and bridging communication approaches that transpired. Providing the free access code 4636 was a defining moment that resulted

in thousands of Haitian earthquake survivors seeking help from and sharing information with formal support providers. Unfortunately, with no previous engagement in a participatory mechanism to inform their response, most NGOs did not use the online Ushahidi system to communicate with survivors. Adequate usage of this new technology was simply too much of a formidable challenge in the first few months. Instead, NGOs used it to communicate with each other about their internal movements and needs. Individual use of the shortcode to request help was limited by the crisis mappers' ability to code and respond to messages. An automated coding system would have allowed them to take advantage of two-way communication, namely, sending an introductory text message about the existence of the crisis map to the entire Haitian mobile phone population.

Methods

A database of 3,587 translated SMS messages was coded to categorize the location of the sender, the identity of the sender, the topic of the message, and its intended recipient (Table 3). The Type of Sender and the Intended Recipient categories were designed to provide some insight into the type of social dyad that the message would represent, assuming it was received by the Intended Recipient. For example, an earthquake victim reaching out to another victim would be more likely to represent a homophylic, or bonded, tie, whereas the same victim attempting to communicate with a relief organization constitutes a heterophylic, or linking, tie.

Unlike the original message categorization scheme used by the crisis mapping volunteers, in the present analysis all messages were assigned a single code that best represented the main intent of the message. Less than 0.1% of messages within each of

the four categories found in Table 3 were not able to be assigned a code using this approach. The coded results were exported to the R statistical software package (version 2.14) where the categories were transformed into a daily time series. In addition, the results were summarized by the various combinations possible between sender and Intended Recipient.

Table 3

Coding Scheme for Messages

Location of Sender	Type of Sender	Topic of Message	Intended Recipient of Message
a. Within Haiti	a. General public outside of Haiti	1. Looking for missing person	a. Earthquake victims
b. Outside of Haiti	b. Earthquake victim inside Haiti	2. Report of individual needing medical assistance	b. Relief organizations
	c. Relief Responder from traditional NGO	3. Need for supplies	c. Public outside of Haiti
	d. Crowd sourcing volunteer	4. Report of infrastructure, i.e., road damage	
		5. Report of available supplies	
		6. General thoughts or prayers offered	

Results

The majority of the coded messages (Table 4) were found to have originated within Haiti (97%), primarily from earthquake victims (82%), and were intended for relief organizations (97%). When analyzed by message topic, 70% related to the need for supplies while only 6% reported on availability of supplies. Messages that concerned

missing persons and individuals needing medical assistance were much less frequent (7% and 6%, respectively).

When messages were categorized by the possible dyads between Type of Sender and Intended Recipient of Message, 94% of messages belonged to the six dyads that occurred between the types characterized by outsiders, earthquake victims, and relief organizations. Most messages from earthquake victims were intended for relief organizations (Figure 6), whereas most messages from relief organizations were intended for other relief organizations.

Table 4

Percentage of Messages Coded for Each Level of the Four Coding Categories

Location of Sender	% (n)	Type of Sender	% (n)	Topic of Message	% (n)	Intended Recipient	% (n)
Within Haiti	**97.2** (3488)	General public outside of Haiti	**3**.5 (124)	Looking for missing person	**7.0** (250)	Earthquake victim	**2.1** (74)
Outside of Haiti	2.7 (96)	Earthquake victim inside Haiti	**82.2** (2947)	Report of individual needed medical assistance	**9.4** (336)	Relief organi-zation	**96.8** (3472)
		Relief Responder from traditional NGO	**13.1** (471)	Need for supplies	**69.7** (2501)	Public outside of Haiti	**1.0** (37)
		Crowdsourcing volunteer	**1.1** (41)	Report of infrastructure, i.e., road damage	**6**.6 (237)		
				Report of available supplies	**5.6 (**202)		
				General thoughts or prayers offered	**1.6** (56)		
Unknown	**0.1** (3)	Unknown	**0.1** (4)	Unknown	**0.1** (5)	Unknown	**0.1** (4)

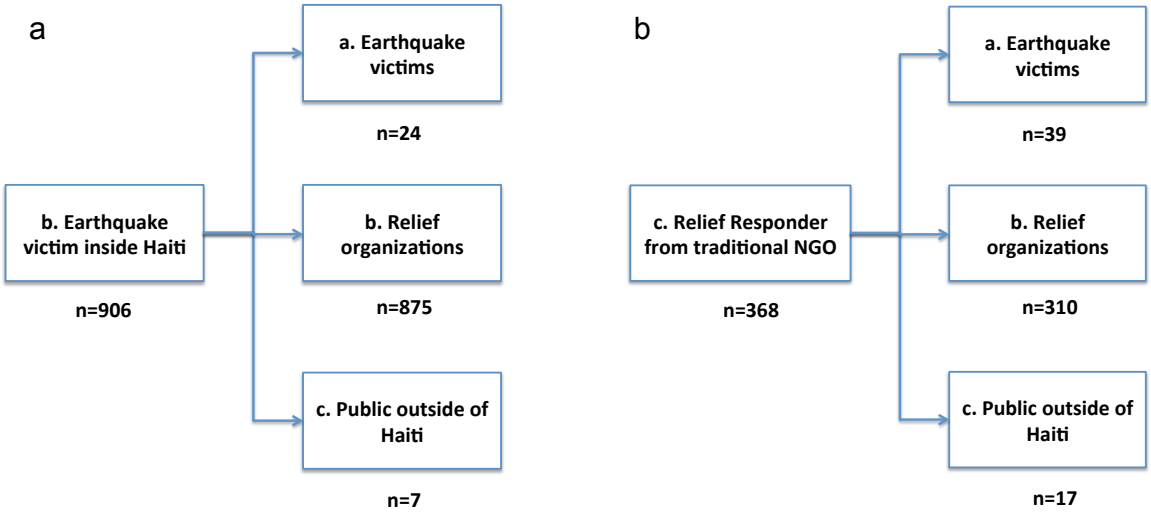

Figure 6. The intended recipients for messages originating from earthquake victims (a) and relief organizations (b)

(The number of messages in each category (n) are shown below each block.)

When categorized by message topic, "need for supplies" was by far the largest category within this dyad or any other, accounting for 2,378 of all messages, with the majority being requests for food and water (Table 5). The dyad with the next highest number of messages was relief organization/relief organization. However, this grouping contained a total of only 410 messages, with topics mainly reflecting the need for supplies, reports of infrastructure damage, and reports of available supplies. Individuals outside of Haiti mainly communicated with relief organizations. Most of these messages concerned missing persons and reports of individuals in need of medical assistance. Communications between earthquake victims and other victims or individuals outside of Haiti were rare, as were messages from relief organizations to earthquake victims.

Table 5

Message Topics by Dyads Between Type of Sender and Intended Recipient

	Topic of Message						
Dyad Type	Looking for missing person	Report of individual needed medical assistance	Need for supplies	Report of infrastructure, i.e., road damage	Report of available supplies	General thoughts or prayers offered	TOTAL
Outside/ Org	66	17	8	8	5	4	108
Victim/ Victim	8	0	0	7	6	4	25
Victim/ Org	153	290	2,378	67	14	13	2,915
Victim/ Outside	1	0	0	1	0	4	6
Org/ Victim	0	0	1	18	21	1	41
Org/ Org	5	21	105	120	149	10	410
TOTAL	233	328	2,492	221	195	36	3,505

When analyzed as a time series (Figure 7), an initial peak of over 50 messages per day was observed two to three days after the earthquake. An equal number of messages from earthquake victims to relief organizations and messages from organizations to other organizations were also observed. However, following the introduction of the Mission 4636 shortcode, messages from earthquake victims to organizations rose quickly to a peak of 350 messages per day within one week. Messages between organizations and from organizations to earthquake victims decreased during this time to only a few messages per day. After the initial peak, messages from earthquake victims to relief

organizations continued at a rate between 20 and 60 messages per day until mid-February.

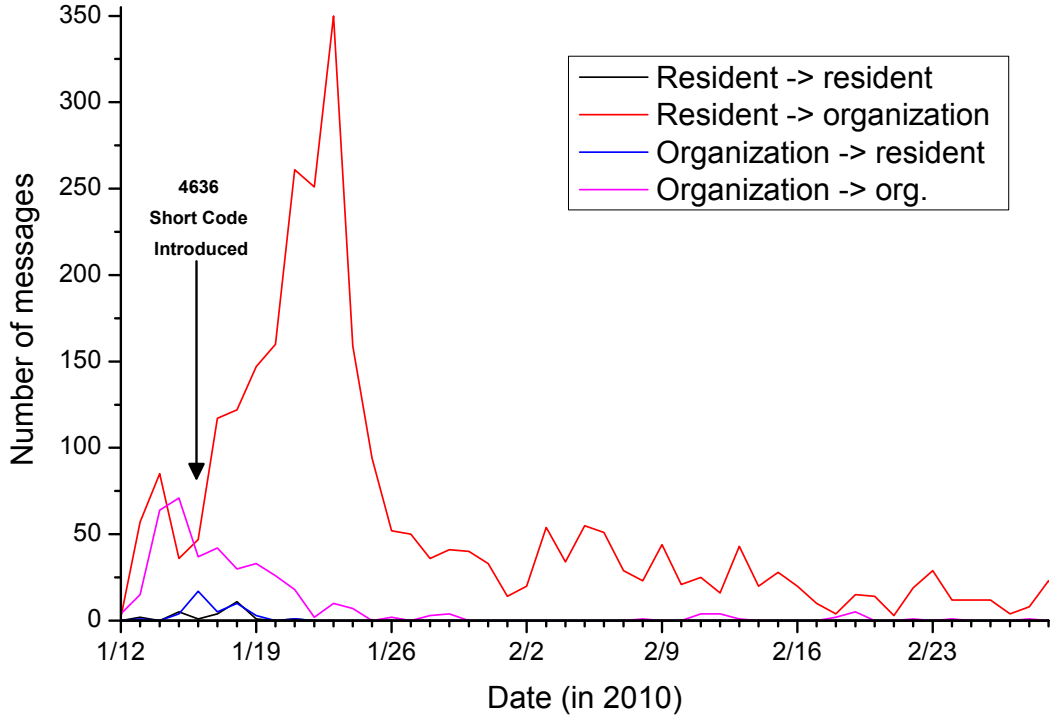

Figure 7. Haiti earthquake SMS messages, sent between January and March 2010, coded for social capital analysis by identifying the type of dyad, comprised of a sender and the intended recipient

The most common dyads were between residents of Haiti and relief organizations (—), relief organizations to other organizations (—), organizations to residents (—) and residents to other residents (—).

Discussion

The creation and growth of the crisis map after the Haiti earthquake is a historic moment of change in both the way people respond to disasters and the way disaster survivors seek help and information in their recovery. Project 4636, its funders, and the Ushahidi team that implemented the system intended it to be a one-way communication

medium (Nelson et al., 2011). However, the adaptation by both the Haitian public and disaster responders was different. Ushahidi documented at least one case of SMS and real world interaction. In this case, a coding volunteer saw a message regarding a medical emergency, found a volunteer to geocode the message, and contacted on-the-ground emergency workers who assisted in the delivery of a child (Project 4636, 2011). This is illustrated in Figure 8.

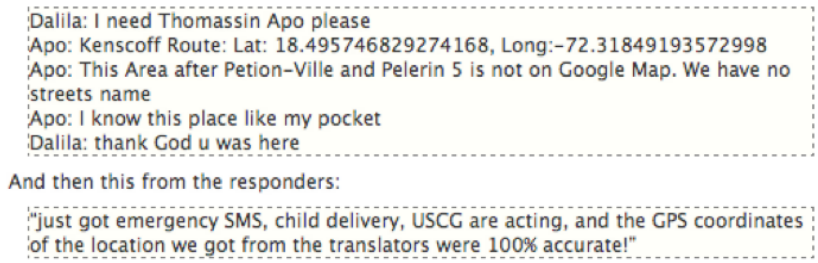

Figure 8. Example of an interaction between a crisis mapping volunteer coding an emergency message received via Project4636 (Dalila) and another volunteer who provided the geographic location (Apo)

(In this case, the coordinates were accurate and emergency responders were able to assist in the child delivery.)

The anecdotal accounts of emergency workers responding to the crisis mapping data serve to illustrate the potential benefits to be gained by improving the capacity of SMS relay/crisis maps to act as two-way communication platforms. In a summative report on the role of media and crowdsourced responders in the earthquake response, Nelson et al. (2011) suggested that more integration of media, especially radio, is an easy and effective way to respond to survivors. Advances in technology also offer potential for automated response mechanisms. Machine coding, specifically, would allow a faster

generation of messages and separate them between those requiring a response and those simply sharing details for improved situational awareness.

The results of this study showed the extent to which response entities communicated with each other through the crisis map. The low level of organization-to-organization communication (10%) immediately following the disaster (Figure 9) illustrates the strong need for coordination and information sharing among responders, which is an important role for this technology. However, it also indicated that opportunities were missed to interact directly with the public and receive more specific, actionable information on needs. Conversely, the Haitian public used the network both to send communications and receive information. The frequency of messages sent (Figure 9) suggest that the sharp increase in the use of the crisis map by earthquake victims may have continued to rise if there had been a feedback mechanism such as SMS replies. Failing that, use of the SMS communication system plummeted—marking a failed innovation launch and diffusion.

In terms of Kapuku's (2006) findings that boundary spanners are critical for organizations after a disaster, the organizations in Haiti missed the opportunity to use the crisis map as a boundary spanning tool or mechanism to share information between their closed network and the communities impacted by the earthquake. It was evident in the messages that many victims clearly sought help from the crisis map. Earthquake survivors who engaged in the crisis map by sending SMS messages intended their messages to be addressed as soon as possible. Their messages tended to be very specific. They were either crying out for help or sharing critical details that would help responders' efforts to provide emergency goods and services.

Using the Ushahidi crisis map for information and help seeking runs counter to the expected trends of individuals from highly bonded, homophilous communities who generally shun opportunities to access formal means of support. It is thus possible that the mobile phone itself has helped move the response from bonding to bridging. We posit two ways mobile phone-based communications engendered more engagement. First, individuals sending SMS messages saw themselves as help providers or members of the larger response to the earthquake relief effort because they were contributing to the community's situational awareness. Second, an individual's mobile phone is itself a bridging agent, making communications via the phone a larger in-group phenomenon.

This first explanation is supported by research that demonstrated very different ways people communicate over a technological medium. Research conducted by Kolko, Rose, and Johnson (2007) focused on the role of mobile phones and Internet communication in developing regions of Central Asia. They found that information seeking and communication are conceptually conflated for technology users. Especially in areas where people have minimal trust in government and official institutions, widespread use of text messages and social media for information gathering increases trust and reinforces social communication networks.

Rogers (2002) noted that closed, homophilous groups tend to reject new members and new ideas out of a need to protect existing norms and reinforce social identity. However, Rogers also explained that, in many instances, change agents can be deployed to overcome this and "bridge the heterophily gap" (p. 28). Kapuku (2006) also explained change agents as boundary spanners that can share information more safely between networks. Especially helpful, change agents such as health workers can be designed to

share both the traits of the target group and those of the new innovation. This results in a better chance for the acceptance and diffusion of outside ideas or individuals. In this context, these findings suggest that mobile phones may be conceptually functional as boundary spanners/change agents and that future disasters, such as earthquakes in developing countries, may further benefit health care workers who quickly embrace mobile phone technologies to communicate with both the impacted community and outside organizations.

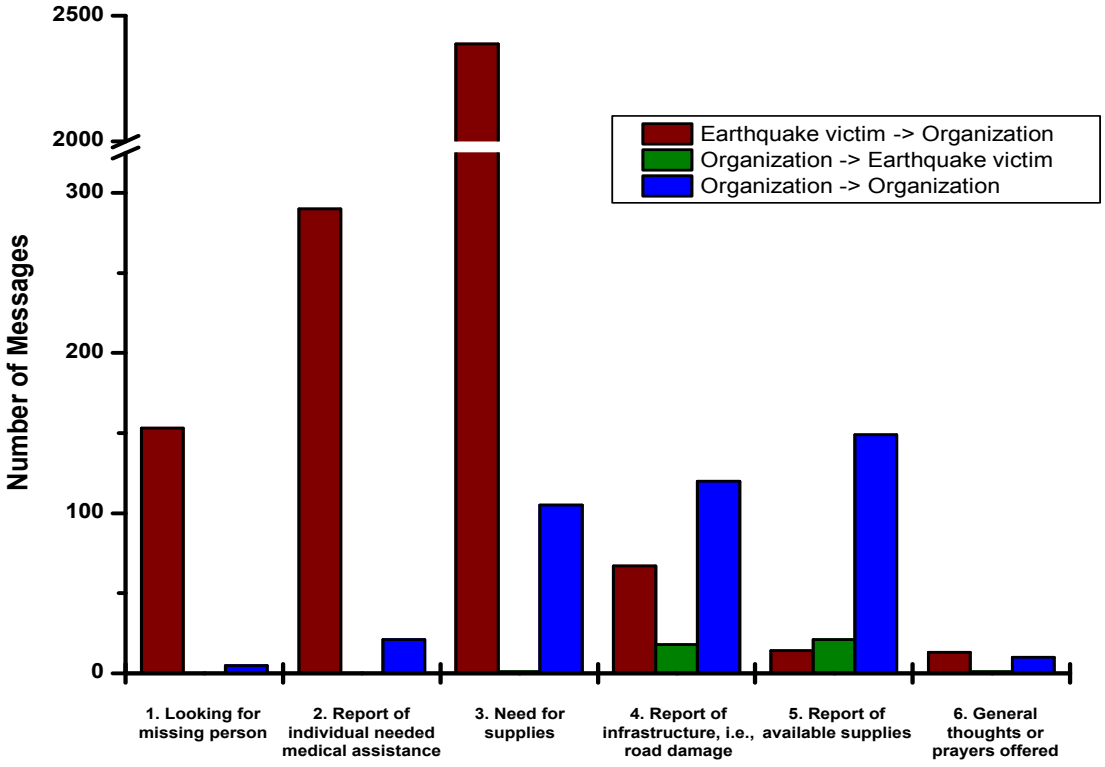

Figure 9. Number of Haiti crisis map messages identified in each major topic category (1.-6., horizontal axis), sub-divided into the major social capital dyads of resident to relief organization ( ), relief organization to resident ( ), and organization to organization ( )

Hossain (2012) examined incentives for public participation in crowdsourced endeavors; finding financial reward is seldom a reason or option for participation. Here, too, social network theory can provide insight. Within bonded networks, another common trait is social responsibility within the community. This counters individualism with an obligation to assist others who have been negatively impacted (Bobo, 1991). While it is taboo to ask for help in such a network, it is equally taboo to not offer it when needed. This is an important finding because crisis mapping's participatory nature makes individuals impacted by disaster an integral part of the system that provides assistance. As a result, the impetus for eschewing formal networks of assistance is counteracted by the responsibility to become part of those networks. Since the Haitian earthquake, Twitter has emerged as an additional social platform for emergency responders to engage with the public for real-time situational response (Bruns, Lyang, & Luxiang, 2012; Palen, Vieweg, & Hughes, 2010). Social communication platforms such as SMS and Twitter unite the resources of formal responders and the general public. Ersting and Kost (2012) pointed out that hyperlocal knowledge about the specific needs of the community makes public-based situational awareness a critical resource for first responders.

Mobile phones were already past the critical mass for social acceptance in a diffusion curve among the Haitian population. They effectively became change agents by allowing highly bonded individuals to engage with them without triggering the otherwise expected taboo response to help-seeking communications in linking directions with officials. More recent natural disasters such as the Japanese Tsunami and Hurricane Sandy along the New York/New Jersey coast illustrate that social media platforms beyond crisis maps are quickly diffusing into natural disaster recovery efforts. Continued

research is needed regarding liability and "dark" pockets of communities without mobile phones or access to social networks.

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Chapter V

DISCUSSION AND CONCLUSIONS

The purpose of this study was to create a rich case study of the introduction of a new social technology, crisis mapping, to formal disaster response. Overall, the interviews conducted and data collected showed that the social phenomenon of Web 2.0 has midwifed a revolution in formal disaster response. The Haiti earthquake was a watershed event for the crisis mapping movement and the current understanding of help-seeking behavior following a natural disaster.

This case study is limited in its transferability because few natural disasters match such a level of destruction and impact. The Haiti earthquake's vast international response was still inadequate for meeting the extreme resource and communication needs of disaster response. Recalling Quarantelli's (2005) discussion on magnitudes of social problems, the 2010 earthquake in Haiti easily surpassed the delineation between disaster and catastrophe—largely because Haiti was already struggling with a daily incidence of emergencies.

Two events were catalysts for change in this case study: the introduction of the shortcode 4636, and the conference in Boston in fall 2010 in which the two closed networks of crisis mappers and UN managers could meet and interact. The former was a catalyst because it removed a barrier—cost—of communication for the Haitian public. The extreme spike in SMS messages after 4636 was introduced demonstrates the

willingness for participation among the earthquake victims. The subsequent fall in frequency of SMS messages indicated that the public did not perceive enough of a value in participating to continue use.

Separately, the conference in Boston allowed the two closed networks to begin sharing ideas, information, and trust through the creation of change agents, or boundary spanners. Following this event, the literature generated by UN agencies regarding crisis mappers changed from a notable tone of annoyance to one of intrigue and acceptance. By the following year, most UN agencies formed in-house crisis mapping teams.

Despite its historical value, the crisis mapping response was not particularly effective at quantifiably saving lives in Haiti. Of the estimated 300,000 people who were buried in earthquake rubble, only 211 were rescued alive (Heinzelman & Waters, 2010). Although Ushahidi's Patrick Meier and other crisis map leadership were given the opportunity to send a blanket message to every mobile phone subscriber in Haiti, they turned this down out of fear their force of volunteer coders was not big enough to process an extremely high volume of incoming messages.

This study established that machine coding could help solve this limitation by providing an automated coding system based on keyword searches. Machine coding offers the benefit of standardized bias, rapid response, and unlimited load capacity. New applications of machine coding, such as the Boston team's findings regarding cholera detection, are among the most promising advances in the field of natural disaster response.

The annotated bibliography that comprises Chapter II discussed a wide array of new technological tools and platforms that are now available for health promotion efforts.

These new approaches are emerging at a rate that often exceeds the pace of the academic review cycle. In such an environment of rapid change, new approaches to knowledge-sharing, such as annotated bibliographies, will continue to make a contribution by combining the benefits of peer review with more frequent updates as compared to traditional review articles.

In Chapter III, interviews with responders and crisis mappers were combined with a quantitative analysis of the messages themselves to obtain insight into the diffusion of this technology into organizations responsible for disaster response. Initially, aid workers were not able to close the feedback loop and respond to messages because of general discomfort with the public nature of social media platforms and concerns about using resources in response to invalid or intentionally false information. As a result of experiences in the immediate aftermath of the Haitian earthquake, communication began between the crisis mapping community and UN agencies, prompting many to engage in social media, with plans for more formal means of communicating directly with the public. An analysis of the 3,587 messages that were analyzed found that emergency response and missing persons reports dominated immediately after the earthquake. However, water and food shortages were the most common concerns reported over time. It was demonstrated that a simple machine-coding algorithm applied to the messages was able to closely track the volunteer-coded labels and, in some cases, identified many more messages than volunteers had determined within certain categories. The authors noted that this form of analysis has great potential in better determining urgent needs during large-scale disasters.

Finally, in Chapter IV, the messages were coded according to definitions of dyads between senders and intended recipients, and subsequently examined within the framework of social capital theory. Whereas studies of previous disaster response efforts found that the communities most in need were composed mainly of tightly bonded individuals who resisted formal means of support, the crisis mapping messages were mostly intended for relief organizations rather than friends or relatives. Messages between organizations were roughly as frequent as messages from residents to organizations until the 4636 shortcode was established, after which time messages from residents to organizations greatly increased, providing some indication that the shortcode increased help-seeking behavior. While it was previously thought that bonded communities could not be reached by formal means of support, these findings indicated that technological innovations may overcome longstanding social customs that reject outside help.

The initial challenges people experienced in Haiti integrating crisis mapping into formal disaster response have largely been overcome in the three years that have passed since the earthquake. Today, large bureaucratic entities not only embrace such social platforms, but seek to employ experts in-house and actively fund the further development of Web 2.0 approaches for humanitarian response. Further advances in implementing machine coding and two-way SMS exchanges are needed to enhance crisis mapping's effectiveness.

Emerging Concerns Regarding Liability

Over time, the involvement at government levels in integrating innovative online technologies shifts because of concerns of liability. As social media expands its presence

in nearly every aspect of life, it offers both benefits and risks to disaster responders. As discussed in Chapter IV, mobile phones can be conceptualized as a close friend or bond, making people less reticent to use them to seek help from otherwise bridging or socially distant institutions. However, the legal precedent of phones being used to reach emergency responders means that messages on government social media platforms may also result in the government incurring liability beyond a practical extent. Currently, if a person dials 911 in the United States and their call is not responded to, they have a legal claim for restitution. U.S. 911 centers are working to add text messaging capacities to their communication networks (Marks, 2011). A foreseeable next step is the addition of social media platforms such as crisis maps, Facebook, and Twitter.

According to Anderson, Blumensaadt, Grunwald, Palen, and Sicker (2011), liability comes in two forms: action and inaction. Liability from inaction would involve ignoring a warning because of improper use of technology, failure to respond and/or inadequate response. This liability could be addressed by creating back-up processing systems, regulation that addresses these instances, and organizational protocols. Liability from action would involve the dissemination of false or misleading information and/or violations of privacy. Dissemination of false or misleading information is best addressed through an intricate filtering system such as indicators as remote locations or differing routing information, as well as establishing clear guidelines and protocols on how information is received.

In 2011, Craig Fugate, Director of the Federal Emergency Management Agency (FEMA), testified on the subject of social media and emergency management before the Senate Committee on Homeland Security and Governmental Affairs, Subcommittee on

Disaster Recovery and Intergovernmental Affairs (Fugate, 2011). Specifically addressing the question of risks the government may incur with increased interaction on social media platforms, Fugate (2011) said, "the notion of treating the public as a resource rather than a liability is at the heart of our emergency management framework." However, Edward Robson, a Philadelphia-based attorney, has led the national conversation questioning this policy, stating that at the very least, state and federal social media platforms should post statements warning the public they are not actively monitoring messages and cannot respond to all concerns (Nextgov, 2011).

Where government liability concerns may limit full engagement with the public, private individuals may be best suited to take up this cause. Meier (2011) noted that the majority of crisis maps and disaster-related social media sites are launched by individuals rather than government, and cannot be subjected to the same standards. Therefore, while appropriate guidelines for crisis mapping need to be put in place, it will not be possible for them to be enforced or to ensure that every mapper abides by them (Meier, 2011).

The closest U.S. federal courts have come to approaching this question of liability comes from the case of Lauren Rosenberg vs. Google. Rosenberg sued Google when she was injured using a Google Maps route (Wassom, 2011). The court found Google was not liable because it did not owe any "special duty" to Rosenberg and applied its finding to a broad range of digital media. The court also noted that the user will always be considered in the best position to apply Internet-provided data to real-world conditions.

Recent Events Integrating Social Media for Natural Disaster Response

The most recent major natural disaster response that exemplified this more complete integration of technological innovation was Hurricane Sandy, which struck the

New York and New Jersey coast in October, 2012. Building on the successful introduction of online technologies to disaster response in Haiti, New York and New Jersey officials actively engaged participatory tools from the moment the storm was forecast to impact the area, through the storm's arrival, and throughout the aftermath. Nearly three years after the Haiti earthquake and located in a significantly wealthier region of the planet, Hurricane Sandy's participatory response benefitted from advances in communication technologies such as the popularity of Facebook and Twitter. Widespread use of GPS-enabled Smartphones in the area was also a key factor, as the dumbphones prominent in Haiti do not geocode messages. Internet communication technology was prominent in both official and volunteer responses to this disaster, including:

- The White House made a request to the global open source hacker group, TechChange, to develop apps that would help track evacuated seniors and map gas station closures (Hackpad, 2012).
- A man with no professional background in software development created a crisis map that became the city of Hoboken's official communication system post-Sandy (HobokenMap, 2013).
- The Office of the Mayor of New York City actively queried Google Analytics for search terms that led the public to city pages during the disaster aftermath and used top search terms to guide the Mayor's remarks in televised press conferences (Haot, 2013).
- The Twitter search string, or hashtag, "#OccupySandy" became a definitive community marker for the various streams of activity on Twitter that were

otherwise difficult to unify—and the success of the hashtag turned into a coherent community of informal disaster responders who are still active in impacted communities today (OccupySandy, 2013).

- The Federal Emergency Management Agency (FEMA) launched a Smartphone app to help disaster victims stay informed of important information.
- The Office of the Mayor of New York City estimated that their engagement of the public via social media platforms increased their reach tenfold (Haot, 2013).

In the aftermath of Hurricane Sandy, Google hosted a conference in its New York City offices aimed at exploring what worked best and what failures could be learned from the technological and social responses to disaster relief. There, as in Haiti in 2010, discussion focused most on the need to increase access to the maps and apps. Crisis maps continue to be designed primarily for a computer interface; however, Smartphones are quickly becoming the preferred way for many people to access the social web.

Implications for Professional Preparation

Healthy People 2020 detailed the importance of online and mobile tools for "enabling quick and informed action to health risks and public health emergencies" (U.S. Department of Health and Human Services, 2011a). This study indicated that emerging health promotion and health education professionals require fluencies in technological communication platforms. This can be achieved with university-level curriculum focused on mobile phone app creation, SMS platform trainings, and courses in quantitative research and analysis packages including R and other open source software.

Mobile phones are the most important platform for communication in the aftermath of a natural disaster, especially because they are easier to charge and tend to remain in close proximity to victims during urgent evacuations. New developments in this field can focus on better operating systems for low-bandwidth, more intuitive user interfaces for individuals who are new to mobile apps. Structural support needs for mobile phone users in disasters, such as charging stations and redundant cell phone towers, can also enhance communication.

Future Recommendations for Research

Natural language processing is a rapidly emerging field that offers the most promise for improving the functionality of SMS- and other social media-based communication platforms. Future research should focus on creating natural language processing protocols that make two-way communication possible. For example, Figure 8 in Chapter IV demonstrated an SMS communication that colloquially referred to a geographic location where a woman was in labor. A separate coder was contacted to geocode the location in latitude and longitude. Natural language processing could engage an automated communication protocol that would respond to the initial sender with a message that says, “It appears you are at x location, is that correct?” If, after several rounds of this interface, an exact location could not be pinpointed, a human geocode volunteer could be engaged. However, the overwhelming majority of cases could be geocoded in this fashion, reducing the number of humans needed to map SMS messages.

Conclusion

In this study, a qualitative analysis of the diffusion of a new technological paradigm—crisis mapping—into a traditional bureaucratic discipline of disaster response found that after initial resistance, direct collaboration between communities and participation by employees and volunteers in social media helped remove institutional barriers. Whereas the Haiti earthquake crisis mapping response required significant volunteer labor, computer search algorithms were equally effective at categorizing messages and, in some cases, outperformed the human coding effort. Finally, by analyzing the types of social networks created by the crisis mapping effort, it was shown that mobile phone-based disaster response efforts have the potential to overcome the resistance to formal means of support by providing an opportunity to create bridging relationships within closely bonded communities.

Health education professionals are increasingly involved in natural disaster preparedness and response. They are critical for building resiliency in communities in advance of disasters by increasing the capacity of the 90% lay response. New advances in technology-based communications make new strategies possible, but this depends on innovation and acceptance of new and emerging technologies.

The story of crisis mappers in Haiti in 2010 is something of a fable for large bureaucratic institutions that exist to assist the vulnerable public in extreme times. Four years before the Haiti earthquake, speaking to a community of TED innovators, Hans Rosling (2006) famously said, “The world is getting flatter faster in technology than in health and wealth so we should all be using technology to achieve our goals in health and wealth.” Yet, when a technological innovation emerged that could dramatically enhance

community engagement after a natural disaster, the majority of bureaucratic entities shunned it. The good news is that the shunning was brief. Social networks were combined, change agents were employed, and the innovation was adopted within a year of its emergence. New game-changing innovations will assuredly again rock bureaucratic entities. This study demonstrated the critical importance of speeding up their diffusion.

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APPENDIX A

Wordles

One available technology for rapid visual analysis of large volumes of text data is a software program called Wordle, which creates a word cloud that acquires a shape, color, and font scheme to display the embodied emotion and most frequently appearing words in a document. Wordles are created based on a complex algorithm for visually displaying a text via typography, context, and emotion (Viegas, Wattenberg, & Feinberg, 2012). While not typically employed as a stand-alone approach to analysis, the use of word clouds to visualize texts has been found to be a valuable aid in analysis when used in tandem with other analysis mechanisms (Weiwei et al., 2010).

Wordles automatically generated by the body of SMS messages sent after the earthquake are compared with the UN's PDNA rapid assessment, conducted during the same time period, in Figures A-1 and A-2. This visual algorithm generated clear differences in mood and communicated very different priorities in the assessment of a situation. While the PDNA prioritized physical reconstruction of dwellings, had the assessment been guided by the participatory crisis map, it might have prioritized food and water security over housing and infrastructure reconstruction. In retrospect, water insecurity encouraged the use of open water sources, which led to the world's most deadly current cholera epidemic (Piarroux et al., 2011).

Figure A-1. Wordle created from Ushahidi's database of SMS messages

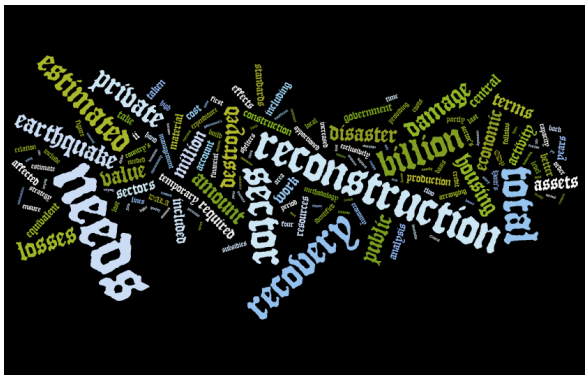

Figure A-2. Wordle created from the UN PDNA