

Mobile Medical Disaster Relief Technology:
Enhancing Communication, Medical Logistics,
Data Creation, and Crisis Mapping for
Vulnerable Communities

By

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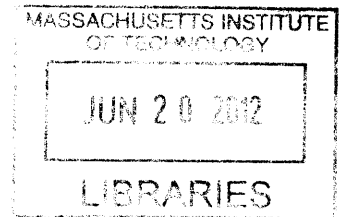
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ABSTRACT

This thesis explores the field of disaster relief and recovery, and the application of emerging technologies that are both used by, and use the data generated by communities affected by natural disaster. This thesis analyzes humanitarian disaster relief logistics conducted in Haiti following the devastation of the January 2010 earthquake, and melds this analysis with disaster relief technology design, thus applying a need-based approach to the creation of a new disaster relief technology – Mobile Medical Emergency Responders (MMER).

The first section of the thesis establishes a foundation for both the global and localized need for a telephony system such as the one I am designing – MMER. It does so by examining issues such as disaster relief coordination and information management challenges in Haiti, with the concurrent need for direct communication between volunteers and affected communities. It uncovers the challenges of disaster relief logistics and the medical supply chain, and the way in which MMER's crisis mapping component responds directly to these vulnerabilities. Low physician density and pitiful health care access is underscored, further supporting the need for the direct medical guidance and knowledge provided through MMER to its caller. Fundamentally, the global issue of illiteracy is stressed, in addition to the dearth of disaster relief technology to address this gap. This need is addressed by the unique position of MMER as a voice-enabled system.

After both the context and need for MMER are established, the specification of the technology that could respond to these challenges is created and presented in MMER's system design. The concept of MMER is critiqued and vetted by disaster relief professionals, its design further revised, and a site selection analysis is carried out through geospatial exclusion to determine which region is best suited for the launch and use of MMER. Finally, a usability pilot survey is assembled in order to obtain a deeper understanding of the regional and local cultural context in which MMER would be implemented, and to analyze the interviewees' current access and use of mobile phones and medical services.

A humanitarian disaster relief tool, MMER would be low (to no) cost for its immediate users. Catering to illiterate, disaster-affected communities, MMER would make it possible to unite affected communities and their self-reported needs directly to global volunteers and medical expertise, and to provide isolated communities in developing countries access to healthcare information through land-lines and mobile phones.

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PREFACE

This thesis explores the field of disaster relief and recovery, and the application of emerging technologies that are both used by, and use the data generated by communities affected by natural disaster. By examining both the problems and gaps presented in current disaster relief technology, I propose an alternative design for a disaster recovery system, one that adds to and enhances the capacity of disaster relief and the recovery of disaster-affected community in numerous ways. In the first section of the thesis I argue for the global and localized need for a telephony system such as the one I am designing - Mobile Medical Emergency Responders (MMER). In the second part of my thesis I provide the 'proof of concept' of MMER: I present its system architecture, in addition to interviews conducted with disaster relief specialists, a site selection within Haiti using Geographic Information System (GIS) criteria, a field test design, and pilot test survey proposal.

This thesis investigates Mobile Medical Emergency Responders (MMER), a telephony system that is catered to the needs and context of humanitarian assisted disaster relief efforts in developing countries. The ultimate goal of MMER is to mobilize thousands of medical experts around the world to provide medical advice remotely to disaster-affected populations. I examine how different types of technologies might be integrated to provide this system. The system design I present is modular in nature to adapt to future technological change, while the particular technologies proposed in the thesis are appropriate for and adapted to current needs. For example, I propose the integration of Interactive Voice Response (IVR) to achieve scale and sustainability, wherein the caller describes their symptoms to and through an Interactive Voice Response (IVR) system. The call is subsequently routed, with the support of IBM's Watson, to the appropriate medical specialist. I employ the Interactive Voice Response telephony system both as a means to decrease costs for routing and responding to the users' calls, and due to its ability to handle large call volumes. However, these technological selections should be understood as choices made within a fast-paced and ever-evolving environment of technological options (e.g., mobile phone upgrades, increased speed, data capacity, efficiency). Hence the technology selected for MMER is based upon current needs, access, and telephony capabilities in developing countries. Conversely, when MMER's system design is placed within a longer-term framework, the technology selected should be understood to be modular in nature, so as to allow MMER's design to be more adaptive to change, and to enhance the ease of MMER's capacity to be augmented over time.

Unlike other disaster-relief applications that rely heavily on MMS or SMS, the MMER system has the potential to open up aid and medical access to illiterate populations. This is due to the fact that MMER is voice-enabled, and furthermore allows any mobile or land line phone user to tap into MMER's resources. This key element – that of enabling illiterate populations to utilize and tap into the emerging field of disaster relief technology to access critical medical diagnostic advice – will prove central to the need for MMER and how it is uniquely positioned in this field.

At the back end, the MMER system produces a user-generated medical crisis map for disaster relief logistics and medical supply chain management purposes. This is executed by enabling its users to contribute high provenance and pedigree data regarding information such as their location, ailment, and medical need, which is subsequently captured in a database, aggregated with other such data, and converted into a crisis map.

Methodology

The first section of the thesis (Chapters One to Five) serves to identify gaps and problems within the field of disaster relief technology, and to review alternatives in response to these challenges. This portion of the thesis establishes a foundation for both the global and localized need for MMER. It does so by examining issues such as disaster relief coordination and information management challenges in Haiti, with the concurrent need for direct communication between volunteers and affected communities. It uncovers the challenges of disaster relief logistics and the medical supply chain, and the way in which MMER's crisis mapping component responds directly to this gap. Low physician density and pitiful health care access is underscored, further supporting the need for the direct medical guidance and knowledge provided through MMER to its caller. Fundamentally, the global issue of illiteracy is stressed, in addition to the dearth of disaster relief technology to address this gap. This need is responded to by the unique position of MMER as a voice-enabled system.

The second section of the thesis (commencing at Chapter Six) presents and develops the system design of Mobile Medical Emergency Responders (MMER) in relation to its user cycle, telephony components, technical dependencies, and potential limitations in field. Interviews conducted with leading humanitarian disaster relief experts in the fields of technology, communications, and community-based initiatives are reported, and their feedback for the MMER system is examined within the context of MMER's design. A site selection analysis is then carried out for Haiti through geospatial exclusion to determine which region is best suited for launching and using MMER. Due to the vital need for design feedback and usability analysis, I generate a user-centric survey for the selected region that would serve as a next step from the proof of concept, in the pilot stage of MMER. The goal of the survey is to provide an understanding of my users' needs, such as their access to health care, and familiarity with similar voice-enabled applications. In conclusion, I summarize my findings, and examine the pathway to MMER's implementation, providing a vision for future research and recommendations for next steps.

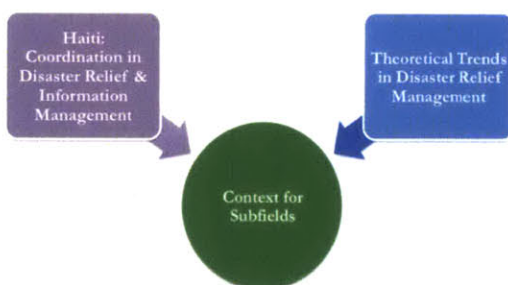


Figure 1: Contextualizing Sub-Fields

and exists within: (I) the use of mobile phones and the application of crisis communication in disaster relief, (II) emergency medicine and supply chain logistics, and (III) the emerging field of mobile health (mHealth). Finally Chapter Five (part IV, Figure 2) underscores the existing technology gap in the field of disaster relief. It serves to connect and conclude how each of the previous three sections set the stage for the need for MMER. Moreover, Chapter Five argues the

Thesis Outline

Chapter One presents two areas that will provide a foundational context to Mobile Medical Emergency Responders (MMER). The first is the type and form of disaster management and coordination that was conducted in Haiti - which includes the urban complexity and information management challenges of the relief efforts. The second provides the historical context of the disaster management field (see Figure 1). The latter will provide key definitions and models, and help locate the theoretical space that disaster relief technology and MMER occupy.

Chapters Two to Five (see Figure 2) explore the interconnected fields that MMER is influenced by

need for a technology – like MMER – that serves illiterate populations through a voice-enabled and voice-based system.

Chapter Six delves into the details of the voice-enabled emergency response system and outlines the system design of MMER, from the way in which the technology functions through to the way in which the user interacts with the system.

Chapter Seven presents feedback from leading humanitarian disaster relief professionals on the MMER concept, and seeks to integrate these critiques into MMER’s design and the project’s next steps.

This section is followed by a site selection analysis to identify the setting and region in which MMER would be most successful and of the most use in Haiti. Finally, a user-based survey is created for a future usability and pilot study. The survey seeks to capture users’ medical and cell phone access and usage through a mixture of multiple-choice and open-ended questions.

Having completed the empirical analysis, proof of concept, and design of MMER, Chapter Eight reviews the particulars of how the MMER requirements were configured, and looks ahead to provide a pathway to implementation.

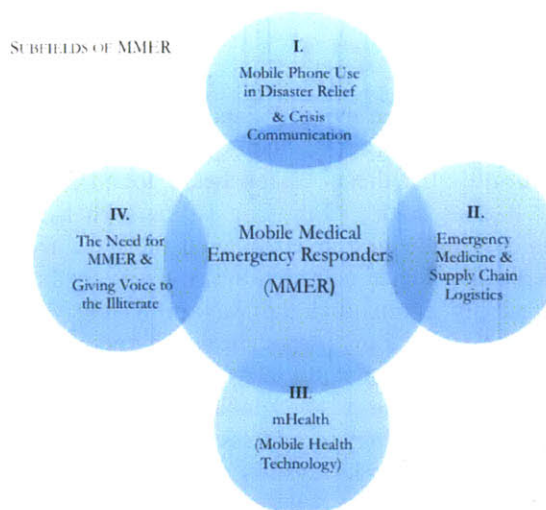


Figure 2: Sub-Fields of MMER

1. FOUNDATIONAL CONTEXT: DISASTER RELIEF EFFORTS IN HAITI AND DISASTER MANAGEMENT THEORY.

1.1 Haiti: Disaster Relief & Coordination

Decades of weak state apparatus and governance help explain—to a certain extent—the level of devastation as well as Haiti’s slow pace of recovery caused by the 7.0 M_w ¹ magnitude earthquake - with an epicenter 16 miles west of Haiti’s capital, Port-au-Prince - that hit Haiti on January 12, 2010 (ICVA, 2010). Prior to the 2010 earthquake, aid was delivered to the Haitian population through non-governmental organizations (NGO’s) who—in lieu of the government—had provided the Haitian population with essential services (Farmer, 2010), earning Haiti the nickname of the “Kingdom of NGOs”. One important consequence of providing aid primarily through NGOs was a failure to provide or strengthen the accountability or capacity of Haitian government institutions (Oxfam 2011 and Kristoff et al., 2010). Yet, different analysts provide mixed interpretations of the role and impact that international NGOs had played in Haiti. North American NGO’s, for example, claim that they had considerable experience with civil society, employed participatory approaches, and that their presence was one that was inclusive in that they worked alongside local NGO’s (InterAction, 2010). In contrast, other evaluators claim that international NGOs did not collaborate greatly with, or build the capacity of local NGO’s (Farmer 2010 and CARE 2005 & 2009). In this context, agencies did not enter a neutral-operating environment after the earthquake of January 2010 that hit Port-au-Prince and its surroundings, killing 220,000, injuring 300,000 and leaving 1.3 million homeless in its wake (Grunewald et al., 2010).

Post-earthquake, organizations were faced with a dilemma of either seeking collaboration and leadership from a fragile government, or conducting relief responses independently (with the latter sometimes yielding a quicker pace). The already-weakened Haitian government structure had suffered tremendous staff loss and was struggling to respond; it was therefore common for aid agencies to bypass local structures. Coordination with national authorities was minor at best; according to the inter-agency real-time evaluation report, few agencies informed or consulted communities either concerning what they - the agencies - were doing or why they were there

¹ M_w denotes the moment magnitude scale, or the size of the earthquake by the energy released. According to the USGS’ glossary of terms “The magnitude is based on the seismic moment of the earthquake, which is equal to the rigidity of the Earth multiplied by the average amount of slip on the fault and the size of the area that slipped” (<http://earthquake.usgs.gov/earthquakes/glossary.php#magnitude>)

(Grunewald, 2010). Yet again, the same historical consequence of NGO's lack of coordination with the government came back to the fore: the general lack of coordination with the Haitian government and national authorities could be said to have continued to undermine the role of national authorities and the state's capacity to act. Moreover, by failing systematically to involve and partner with affected communities in the humanitarian disaster relief response, community capacity could also be seen as being weakened, rather than strengthened or empowered in and through the international humanitarian disaster-relief process (Grunewald, 2010, p.5).

The United Nation's organizational "cluster system" made up of eleven groupings of NGOs, international organizations and UN agencies around a service provided during a humanitarian crisis (e.g., Education, Health, Emergency Shelter, Camp Coordination and Management, Logistics, and Emergency Telecommunications) did not aid in alleviating the issue of coordination.² The system buckled and failed to integrate, organize, and coordinate the hundreds of humanitarian actors who came rushing in to Haiti. In addition to information sharing and transparency being limited within the cluster system, there was also an absence of strategic vision and overall coherence of the response (IASC, 2010). UN cluster coordination meetings were held in English, ostracizing locals and making national staff inaccessible. Most frustrating was the weak leadership demonstrated among cluster leaders and those at the top of the UN system, delaying the potential for collaboration not only by weeks, but by five months (ICVA, 2010). Although Humanitarian-Military Coordination can be a sensitive and contentious area, especially for humanitarian aid workers who seek neutrality both in approach and image, Sir John Holmes (former under-secretary general for humanitarian responses at the UN) believes it is a challenge that must be overcome. The US military in Haiti was trying to identify a strong humanitarian-led coordination structure, yet it was extremely slow to materialize (IRIN, October 2010). Operational problems arose out of and in tandem to the breakdown of coordination. Needs assessments were duplicative and often partial; overall security and protection responses (especially to sexual and gender-based violence in camps) were inadequate; sanitation solutions were deficient; and transitional shelter was not provided at scale.

Urban Disaster Recovery

The path to disaster relief, recovery and resilience is further complicated by the urban locus of Haiti's disaster. The earthquake struck less than one mile off the coast of Port-au-Prince, Haiti's capital city; and according to the CIA Factbook approximately two million Haitians live in what

² For more information: <http://unmit.unmissions.org/Default.aspx?tabid=760>

is categorized as an ‘urban area’ (CIA Factbook, 2011). It is therefore important to analyze the mistakes made in Port-au-Prince in light of the complexity of urban structures and recovery.

There is consensus amongst development analysts that “the humanitarian system is largely unprepared for responding to urban disasters” (Ferris, 2010 and World Bank, 2010). Ferris (2010) briefly touches upon the difficulty of working in an urban, as opposed to rural environment, where the former “is a more complex undertaking for humanitarian actors than running refugee camps in rural areas” (Ferris, 2010.) Dimensions of urban complexity in disaster relief include the range of actors present, the pace, as well as the services, infrastructure, and sheer concentrations of people involved. In addition to these elements, other dimensions that require us to reframe the way in which urban, as opposed to rural disaster relief and recovery operates are issues such as housing (short term versus long-term and tradeoffs of each), commerce and trade, and the use and concentration of markets (where agencies work with local markets as opposed to competing unfairly with them).

As previously mentioned, working with and through municipalities, as well as partnering with pre-existing local providers and structures was limited in scope in the humanitarian relief efforts - with exceptions such as Tearfund’s work with local government representatives in Léogâne and Gressier (Clermont, 2011). This overarching trend of not partnering with state or existing community-based organizations did not assist in rebuilding local social or human capacity, a key to building Haiti’s future resilience to shocks. The presence of politics is also different when comparing rural and urban areas. Whereas rural regions are sometimes characterized as detached from or absent of government, urban areas are not. Although the Haitian government was weak(ened), state bodies such as the *Direction Nationale de L’Eau Potable et de l’Assainissement* (DINEPA) still played an important role in recovery. Agencies such as the British Red Cross, Age UK, and Oxfam worked with DINEPA in water provision and although these agencies might have made a trade-off of a slower direct delivery, the partnership and collaboration with DINEPA ultimately strengthened longer-term recovery (Clermont, 2011). According to a post-disaster survey data of 10,430 responses (interviewed between 3/14/2010 and 5/2/2010 and compiled by MIT’s Engineering and Systems Division Class ESD934) ‘finding a job’ was the responders’ number one priority (over housing and food).

Capacity building and training in urban centers takes on increased importance, not only in building resilience pre-disaster, but also in recovery. A good example of collaboration and putting

local individuals to work was the collaboration established by the British Red Cross with local associations in the neighborhood of Delmas 19 (located near the waterfront) to improve their environment by contributing their labor to clean drainage channels to decrease the chance of the region flooding (Clermont, 2011). Unfortunately there are few examples of such work, and the overwhelming assumption was made and acted upon that external rather than internal skills and resources were best. There were documented cases of local doctors and nurses being ignored in their own medical centers by international medical teams, transforming the relief effort into a skewed and primarily externally driven effort (Clermont, 2011).

Urban centers are engines of growth, and as such are both more (economically) vulnerable to shocks but also show great potential and promise for recovery. Cities are characterized by a concentration of skilled people and services but as mentioned, these were often overlooked in Haiti's relief and recovery operations with the perception that these types of skills and services were not available. Yet street markets were operating within days of the earthquake. Water vendors, for example could not compete with free water provided by external agencies, nor could Haitian-based private sector suppliers compete with free imported bulk goods from aid agencies. Despite the fact that there is an unavoidable issue of bottlenecks and delays when relying upon or partnering with local markets and in-country private sector importers, much more could have been done to analyze and make use of local procurement capacities in Port-au-Prince (Clermont, 2011). By partnering with and using the Haitian market place, private sector development and small and medium enterprises are supported, and benefits such as job creation, efficiency, tax revenues and capacity are strengthened and generated (Clermont, 2011).

Although not exclusively an issue of urban recovery, exit strategies were not clarified nor communicated among, within or outside of agencies. In contrast to a rural setting, the complex realities of urban recovery might have further complicated agencies' ability to set and measure success (Clermont, 2011). By establishing and communicating both the scope and scale of involvement, and by partnering with local organizations, international agencies would have been better equipped to measure and examine short-term as opposed to long-term goals. In addition, rather than have external agencies play out an elongated relief effort that created unhealthy dependence, the former could have used exit strategies to first focus on and build local capacity and to ultimately transition relief and recovery efforts to state and local agencies.

Summary

While the segment on Haiti's disaster relief coordination served to provide a glimpse into the errors committed with and through the internal management and coordination of humanitarian agencies (e.g. the collapse of the cluster system and weak leadership), the urban setting of Haiti's January 2010 earthquake provided a deeper dive into the urban complexity and context of the errors committed in relief and recovery efforts. Moreover, the history of meager integration between international and local NGOs as well as the regular circumvention of the state by international NGOs foreshadowed the ineffective coordination after the earthquake struck in January 2010. Weak coordination and communication between all actors involved (between affected communities, local and international agencies, and government) was further exacerbated by the failure of the cluster system to streamline efforts or to oversee the management of inter-agency coordination in a timely manner. Limited engagement with communities, and the noticeable absence of building upon existing human and social capital helped only to delay recovery and increase the affected communities' dependency upon external aid.

Information Management

Because of the major hurdles external humanitarian actors faced in information management, and communication within the cluster system, we turn our attention within, to the vital role of the affected community as a relief agent. According to the USAID's Office for Foreign Disaster Assistance's (OFDA) annual report, OFDA staff repeatedly stated that disaster-affected individuals, not the international community, are the first responders (OFDA, 2009). In the same vein, ALNAP's (Active Learning Network for Accountability and Performance in Humanitarian Action) head of research and development, Ben Ramalingam observed that the "majority of life-saving work in any disaster is done by the populations themselves... Agencies must give good information to communities so they can plan their own recovery from the start" (IRIN, January 2010). Therefore one of the key components to Haiti's recovery and its capacity to build resilience to future hazards and shocks is through the strengthening of its human and social capital. Agencies that were able to recognize, use, and build these forms of capital tended to engender quick steps towards recovery (Clermont et al., 2011).

Humanitarian organizations have reaffirmed a central lesson, now a tenet, after every large-scale disaster: that good communication and information management is critical to effective and

efficient humanitarian logistics and coordination (IFRC, 2000 & Harvard Humanitarian Initiative, HHI, 2010). Filling the information chasm -- collecting data and knowledge of the damage, distilling critical information out of chaos,³ -- is a critical need after a major disaster strikes (ICRAM, 2010).

From a disaster relief information management vantage point, the case of Haiti was groundbreaking. It was the first time that social media and mobile technology entered into the humanitarian disaster relief system at such an intense level and in such high volume (HHI, 2010). However, it is likewise important to note that according to the 2011 report 'Lessons from Haiti' generated by Communicating with Disaster Affected Communities (CDAC) (CDAC, 2011) that there are limitations in claiming Haiti's 'new media' experience a complete success story. The report underscores that in Haiti there was a lack of knowledge on how to integrate the new technologies into existing humanitarian aid structures and organizations, in addition to the absence of connections, common language, and operating procedures between international agencies, new communities of volunteer technologists, and large government.

Despite issues of limited inter-operability and limited coordination between technologists (and their emerging technology), and with disaster relief organizations, what is indisputable is that massive amounts of information were generated and mined from the disaster-affected community and global volunteers (HHI, 2010). The simultaneous explosion of communications between citizen and humanitarian aid workers and the showcasing of new media applications in Haiti was termed a "real world laboratory" (Nelson, 2011). Active information-seeking behavior from Haitian citizens (instead of being relegated to the role of recipients of one-way communication) through mobile phones, social media, and social-media driven radio-show programs increasingly became the norm rather than the exception. According to the CDAC report (2011) the most notable innovations to arise from Haiti were "the translation of crowdsourced data to actionable information; the use of SMS message broadcasting in a crisis; and crowdsourcing of open maps for humanitarian application." Such examples include Ushahidi⁴ or Digicel's '4636' program. Digicel, one of Haiti's leading telecom companies, launched free SMS texts in support of relief efforts, enabling users to send free messages to information centers regarding their emergency needs or to report missing persons, which in turn produced quasi real-time citizen-based reports.

³ The nature of communications needs differ at different stages of a disaster; likewise the contribution of mobile technology (and other forms of communication) varies correspondingly. (*The Role of Mobiles in Disasters and Emergencies*, 2005, GSM Association)

⁴ Ushahidi is a software platform that was created as a result of the contested 2007 Kenyan presidential election. It can be adapted and used for many purposes: tracking of elections, outbreaks of violence, and most markedly following Haiti's 2010 earthquake. According to its website (<http://www.ushahidi.com/>) it is "an open source project which allows users to crowdsource crisis information to be sent via mobile."

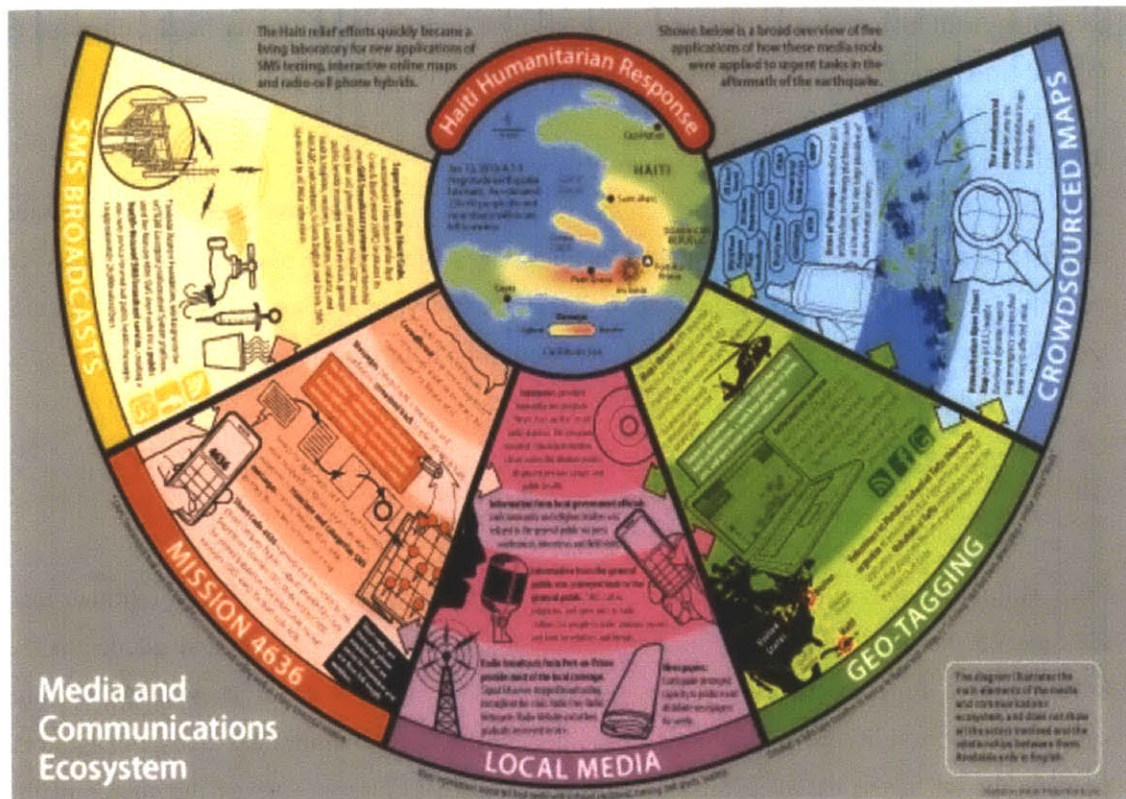


Figure 3: CDAC Report, 2011. Comms. Ecosystem in Haiti

In brief, the Haitian population did not play the role of silent (or silenced) recipient and beneficiary; through start-ups such as Digicel’s 4636 program, and Ushahidi, they had increased voice and visibility. Moreover, populations affected by natural disaster and the mobilized masses of global volunteers will only continue to grow exponentially in volume and in their potential for change and impact.

1.2 Theoretical Trends & Disaster Relief Management

To be able to situate the subfields that will be covered in the latter half of this paper, and to contextualize the application of and role technology (and hence MMER) plays within it, a brief theoretical history and overview of the three dominant trends in disaster management research will be given. The three theoretical branches of disaster management that will be covered will be: the US-based **functionalist** approach, the **social constructionism (or human adjustment)** perspective, and finally the interpretation that **modernity and technology are contributing risk** factors. Specifically, we will pause at Hewitt’s analysis of the dangers of modernity and

technology and his critique of the dominant technocratic approach of disaster management so as to be able to place the role of technology within an established theoretical branch⁵.

Major Theoretical Trends of Disaster Management Research

Over the last three decades there has been much dispute over both the characteristics that defined a disaster, and what made up (or should constitute) the subject matter of disaster relief research (Hewitt, 1983; White, 1994) According to Tierney's five-year national assessment of natural hazards research (Tierney, 2011), the most cited definition in the social sciences is that developed by Fritz – a disaster sociologist - who defined disaster as:

An event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented. (Fritz, p. 655, 1961)

Fritz' definition underscores the disaster event and its impact upon a social structure (rather than focusing on the underlying social or environmental origins of the disaster) and alludes to the influence of a **functionalist** or systems perspective to disaster research. A functionalist and systems-perspective is one of the classical approaches in the definition and study of disasters. Centered on an 'event based' approach, disasters are seen as discrete events; the source of the disaster is understood to be external rather than internal, and the interest and actions taken are focused upon practical matters in the immediate impact of the event, rather than the social origins of a disaster (Barton, 1969). Functionalism had, and continues to have a major influence on North American disaster research and studies. This is largely attributed to the fact that U.S. disaster research originated in World War II funding and war-related projects organized around case studies of disaster events – leading to an event-oriented and inductive research strategy (Tierney, 2001). Today, researchers continue to define situations as disasters according to the functionalist 'demand-capacity' model in which demands overwhelm the capacity of the affected community or region.

The **social constructionist** approach appears to be orthogonal to functionalism. Constructionists such as Stallings (1995), Drabek (1986) and Kreps (1984), focus on the social processes and activities that occur in and around disasters. Thus, for constructionists what is of import in understanding disasters are not the physical effects of what could or does occur, but rather the social construction and processes "through which groups promote claims about disasters and their

⁵ Although we cover three theoretical approaches, the field of disaster management can be simplified and reduced to two major divergent methodologies: that of a sociological versus a geographical hazards approach to natural disaster.

consequences.” (Tierney, 2001) However, while functionalism looks at disasters as discrete events, and sequesters nature from the analysis of societal adjustments and definitional processes, both the social constructivist and functionalist approach overlook the relationship (or impact) of man to nature and fail to create competing frameworks in which vulnerability is imbedded in, or arises from the affected community or society.

Both the social constructionist perspective and the functionalist approach were expanded upon and used as a foundation for social geographers who promoted the concept of **human incremental adjustment**. The 1970’s saw the rise of the Human Ecology or Natural Hazards research approach led by the social geographers Gilbert White and John Dewey (White, 1994). This perspective focuses upon the relationship of man to his environment, and the ecology of human choice. Vulnerability to hazards is understood to stem from the human use system, where humans occupy vulnerable or disaster-prone locations. In addition to cultural or behavioral adaptation, the natural hazards approach pushes for reduction activities that include the revision and implementation of land use zoning, building codes and disaster-resilient construction practices (Tierney, 2001). Hence vulnerability and risk is understood to be present due to choices individuals and communities make in inhabiting certain disaster-prone areas, rather than the source of risk emanating from the community or society itself. In summary, the human adjustment perspective of Human Ecology resonates with the constructionist perspective, while its behavioral science dimension fits more squarely within functionalism.

Technology & Risk

In contrast, European social theorists such as Beck and Lulhmann introduced a hazard-centered critique of modernity in which they argued that vulnerability is accentuated by, and inherent in, the social order of modernization and a technology-centered society. Beck contends that industrialized society has become a ‘risk society’ (Beck, 1992) introducing new risks such as chemical or nuclear threats, or making once calculable risks incalculable and uncontrollable. Lulhmann (1993) presses on and states that modern society has become riskier due to the reliance of its institutions on technology. Lulhmann stresses the inherent risk of technology: instead of decreasing risk, Lulhmann believes that technology enhances it, as in the case of technology used as a safety or control system for other technology. In support of Lulhmann’s argument, Tierney (2001) underscores that the disasters at Chernobyl, Bhopal and the Three Mile Island were not only failures of technology, but also failures of technology to regulate (technological) risk.

While this theoretical vein examines the macro-view of “self-inflicted failures of modernity” (Hewitt, 1997, p.3), it does not address the role technology has or could play in disaster relief or recovery efforts. Rather it is Hewitt’s (1983) technocratic critique that has the potential to more adequately address the role that technology plays in disaster recovery theory.

Hewitt mistrusts the technocratic approach of seismic and natural science practitioners, which he believes to be the prevailing and dominant view in hazards research. Defined as an approach that enables technical procedures to dominate over other fields, the technocratic view is presented as a sociocultural construct that can “easily miss” the sources of social influence over hazards (Hewitt, 1983). Hewitt claims that the technocratic approach - which he also refers to as the ‘natural science-technological fix’- is one that favors (e.g., through funding) fields such as physical science, technology and engineering. Therefore emphasis is placed on areas such as: monitoring and understanding geophysical processes, physical planning to contain the hazard according to geophysical patterns, and emergency management plans developed through geophysical analyses. This focus results in what Hewitt believes to be an approach which quarantines the disaster in thought and practice in a space outside of ‘everyday responsibility’ (Hewitt, 1983). Finally, Hewitt interprets the dominant technocratic view through a Weberian lens – that the technocratic view is an expression of the way institutions route their resources into a particular style of work and practice (Hewitt, 1983).

In response to this one-sided critique of technocratic approaches and the risk of technology, is the emergence of promising and life-saving technologies in the preparation, coordination, response and recovery stages of disaster management (for a complete overview of technology innovations in disaster management see ‘New Technologies, 2009’). These technologies gather data and information from numerous sources, and are not only accessible to humanitarian aid workers and research branches, but to the affected communities themselves. For example, with respect to disaster relief preparation and coordination, the Global Alert and Coordination System⁶ (GDACS) from the European Commission’s Joint Research Center synthesizes existing disaster information management systems. GDACS not only sends real-time alerts on natural disasters but also integrates news from over one thousand news feeds, sets up an online discussion forum for disaster responders, and bases its mapping system through the incorporation of post-disaster satellite imagery (New Technologies, 2009). Moreover, Hewitt emphasizes that technology overlooks the social dimensions of disasters in addition to issues of social inequality. However,

⁶ <http://www.gdacs.org>.

Hewitt's analysis does not include current communications and community-centered technologies that support recovery. An example of technology that can be used by responders and the affected community alike during the response and recovery-phase of a disaster is Frontline SMS⁷. Frontline SMS uses a free software platform, and is essentially a flexible and scalable communications hub that allows users to send text messages to groups of people through their mobile phones or computers. It allows for a two-way communication between groups of individuals, or a central hub and a group. It can therefore be used for a variety of needs such as emergency alerts (catered by region, or camps) or to conduct public surveys. Finally, an example of the use of technology post-disaster that counters Hewitt's blanket statement and fear regarding technology in the context of disaster management, are those technologies that aid recovery and economic growth such as mobile phone applications like Konbit⁸ in Haiti or Souktel's⁹ 'JobMatch' that connect individuals to job opportunities through text messaging. With respect to MMER, it fits within the recovery phase to promote a two-way communication system between the affected individual seeking medical advice and a medical practitioner, providing the caller with both guidance and medical advice.

Unlike Hewitt's rejection of Weberian dominance, these technologies give voice and the ability to mobilize, organize and in some cases gain access to employment for victims of the disaster. Given that these technology innovations are still emerging and represent a nascent yet fast-growing field within disaster management, they have yet to gain a theoretical or conceptual label. It is time to rediscover and re-write a critical literature and theory on the role technology plays in disaster relief and in enhancing human communication in crisis contexts. This is not to say that technology is without its own complexities and drawbacks, but as illustrated with current and concrete examples, it has shown that as a tool of recovery placed in the hands of affected communities and relief agents, it holds great promise. We are in an era of engagement with technology and a new critique of these emerging social and mobile technologies must be established.

Having briefly reviewed key theoretical perspectives to disaster management in the past, we turn to the present, where we find the current disaster management field to be multidisciplinary in nature, incorporating functionalist and social science perspectives, while emphasizing and expanding upon the concept of 'vulnerability' (Wisner, 2001).

⁷ <http://www.frontlinesms.com>.

⁸ <http://www.konbitforhaiti.org/>

⁹ <http://www.souktel.org>.

This chapter will close with a contemporary view of disaster management, so as to understand how vulnerability and risk is conceptualized currently. Furthermore we will be introduced to the four main stages -or segments- that comprises current disaster management strategies through the disaster management cycle. However, any discussion regarding disaster relief management must also be met with the definition of key concepts within the disaster management field: the interplay between risk, hazard and vulnerability.

Current Perspectives: Risk, Hazard & Vulnerability

The goal of disaster relief research and management is minimizing and managing risk and reducing the impact of a natural disaster event. Within the disaster management discourse, disaster risk is described as a function of hazard impact and vulnerability (and sometimes capacity). The most commonly applied pseudo-equation to model disaster risk is:

$$\textit{Risk} = \textit{Hazard} * \textit{Vulnerability}. \text{ (Wisner et al., 2004)}$$

Disaster management thus focuses on reducing the impact of a disaster event by decreasing vulnerability and increasing resilience or capacity. According to Wisner, a disaster occurs “when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external aid.” (Wisner et al., 2004). In both Fritz and Wisner’s definition, the idea that the affected society or community is overwhelmed and unable to cope independently with the changes induced by the hazard event remains, however while Fritz focuses on the ‘isolation’ of the event, Wisner emphasizes the embedded (and likely systemic or longer-term) role that vulnerability plays in the creation and impact of a disaster.

The term ‘risk’ refers to the impact (or potential impact) of the natural hazard in which the degree of vulnerability of the community is amplified by the hazard impact. Wisner approaches vulnerability through a socio-economic and political lens, and defines vulnerability as the capacity of an individual or group to anticipate, cope and recover from the impact of a natural hazard (Wisner et al., 2004). Vulnerability has been analyzed and identified by social scientists throughout the disaster management cycle (see Figure 5) and includes non-structural and structural components (e.g., structural conditions, socio-economic vulnerability, or hazard risk perception). One of the most established and widely used models that capture this concept and the views of social scientists is the ‘Pressure and Release’ (PAR) model (see Figure 4).



Figure 5: Disaster Management Cycle (Based on Tierney, 2001 & National Governors Association, 1979)

that improve the resistance of the building to physical impacts) to hazard exposure. Preparedness refers to capacity-building activities - which can be applied to the level of households, organizational entities or emergency preparedness units - that contribute to enhancing readiness in disaster response and recovery. The actions taken during the emergency response phase serve to respond to the immediate needs of the disaster-affected population, and to prevent additional loss by addressing ongoing threats. Activities in the response phase include evacuation, search and

rescue, the provision of emergency medical care, food and shelter. Finally, post-disaster recovery includes all processes that help repair, rebuild and restore the affected community, its properties, public infrastructure and its governmental services and operations.

As addressed earlier, each of the stages in the disaster management cycle can be assigned to a different technology usage or innovation. As will be illustrated in Chapter 2, the nature of communication needs and hence technologies differ at various stages of disaster. Specifically, the use of mobile phones in disaster relief will be expanded upon, in addition to the role they play in crisis communication.

2. MOBILE PHONE USE AND CRISIS COMMUNICATION

2.1 Mobile Phones and Disaster Relief

The great advances in communications technology (the number of new technologies, the spread, range and mobility of functions available) has had a tremendous effect on both mobile phone penetration and the use of social media and networking sites, crowdsourcing websites, and the general way in which information is exchanged and delivered (ICRAM, 2010). For example, Facebook saw a 153% increase in unique visitors from June 2007 to June 2008 and an additional surge of 157% (of 208 million visitors) in June 2009 (Schonfeld, 2009). Dramatic communication advances provide a potential and opportunity for humanitarian agencies to effectively communicate with communities affected by disasters and allow these individuals and communities to communicate with each other and with the external world (ICRAM, 2010). These improved communications systems not only help individuals prepare for disaster, but can also improve the response and recovery. However three challenges remain and have yet to be realized in the disaster relief communications sector:

1. With unregulated information flow there is a need for accuracy and an authentication of information (the issue of hoaxers in communication, or the example of "Twitter in Tehran" in which the re-tweets were inaccurate and misleading).
2. Social context within which the communication tool is used – information will only be used if it is trusted.
3. The flow of information must be two-way – from the outside world to communities affected by disaster and from the humanitarian organizations seeking to help the members of the communities. (ICRAM, 2010)

Moreover, the mobile divide is narrowing. According to the International Telecommunications Union (ITU) by the end of 2008 subscriptions topped 4 billion, or 61 mobile phones for every 100 individuals (ITU, 2009). The growth of the use of mobile phones “has been one of the most remarkable features in the last decade” (ICRAM, p.5, 2010).

2.2 The Use and Role of Information in Disaster Response

Similar to the stages of the disaster management cycle, (mitigation, preparedness, response and recovery) are the generalized phases of communication and communication needs in the use of mobile phones according to Coyle (2005): from early warnings, disaster impact, immediate aftermath through to recovery and rebuilding. According to Coyle’s research, there are various extents (albeit generalized) to which people need to communicate according to the unfolding

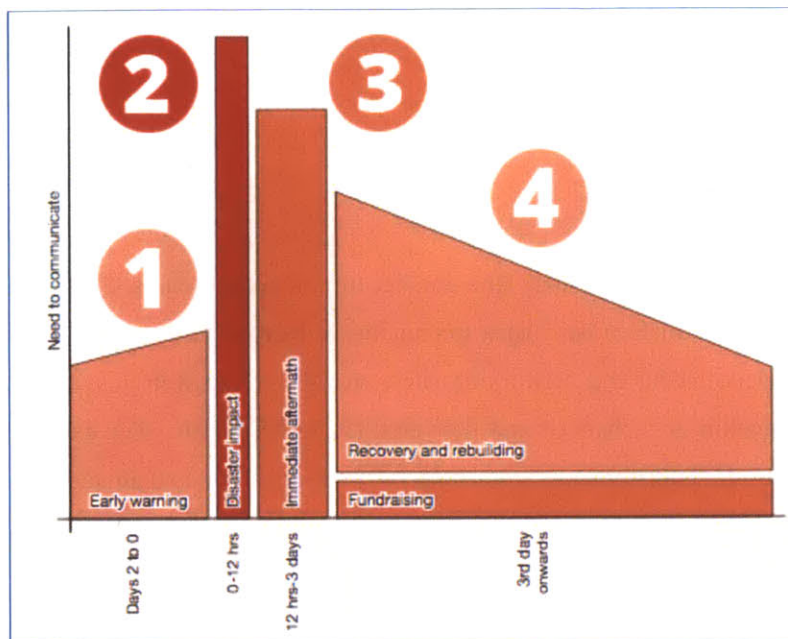


Figure 6: Communication needs at different phases of disaster. Adopted from Coyle, 2005

disaster (Figure 6 and 7).

As illustrated in Figure 6, communication needs and types can be clustered into four time periods. First are early warning systems set a few days, or even hours prior to the disaster impact. This form of mobile communication

is based primarily on one-way forms of

communication and broadcasts (e.g., public information campaigns) to maximize reach in preparation for the impact. The second grouping is that established and activated upon impact (with a range of 0-12 hours after impact). The technologies used during this phase are often satellite-based resilient emergency communications (see Figure 7 for specific examples); concurrently it is in this phase that all forms of communications are likely to be severely backlogged and impaired. The communication need swiftly shifts away from information campaigns (from stage one) toward life-saving emergency responses. As mobile networks begin to recover and satellite connection start to become available to relief workers in stage three or the 'immediate aftermath' phase (12 hours to 3 days after impact) decentralized two-way forms of communication are most prevalent and needed for the purposes of rapid recovery, the ability to locate family and friends, and for exchanges of news and timely updates (Coyle, 2005). The fourth and final stage – that of recovery and rebuilding – (which starts as of the third day post-impact), is the continued widespread dependence of affected communities, agencies and relief workers upon mobile phones for dispersed two-way communication in order to gather and exchange information for co-ordination and recovery.

Given its unique role in allowing for a decentralized flow of communication, the use of mobile phones before, during or after a natural disaster, likewise correspond to the communication needs at each stage. Coyle, (2005) breaks this down into the aforementioned communication need

categories, and groups the formats needed at each phase (Figure 7).

In brief, while early warning requires more of a one-way form of communication (of one to many), the reconstruction phase – the phase within which MMER functions – demands a two-way exchange of information, where mobiles provide a unique advantage over other forms of information channels. This advantage is due not only to the fact that mobiles can disperse and disseminate information informally and quickly, but also because they can provide and transmit the specific needs and demands of affected communities to the outside world. Specifically, MMER not only aids in the decentralization of medical information from medical expert to caller -and vice versa- it also has the potential to capture the information provided by the caller to ultimately provide the right resources to the right individuals, in the right locations through the generation of crisis maps. This advantage is critical; MMER’s potential to provide the right resources to the right place will be covered in greater detail in Chapter Three, in the analysis of medical supply chain management and logistics.

Timeline:	Early Warning	Disaster Impact	Immediate aftermath	Recovery
Communications needs	Broadcast to as many vulnerable people as possible; timely, one-way information	Emergency response – emphasis on life-saving; intra-operable, resilient emergency communications. Public demand for news of friends/family	Person-to-person contact, for swift exchange of news and developments; rapid recovery of 2-way communications amongst those affected and family, friends	Information exchange and co-ordination; dispersed 2-way communication for as many of those affected as possible
Best forms of communication	Many, to maximise reach: broadcast technologies, maybe supplemented by web, backing up prior public information campaigns	Satellite most resilient, short term, if emergency services have access to it. All forms of communications available to public likely to be impaired	Mobile, as network recovers (especially for developing countries). Satellite for relief workers, if available.	Mobile (especially for developing countries)
Distinctive mobile contribution?	NO: One amongst many	OFTEN: Inter-operable for use by different emergency services (although may be damaged in extreme circumstances). Congestion management required to balance competing requirements. SMS more effective	YES: Widespread means of decentralised, 2-way communication. Network recovery often after 1-2 days even when damage sustained	YES: Widespread means of decentralised, 2-way communication of needs. Very important in developing countries with little fixed-line alternative.

Figure 7: Communication Needs by Disaster Phase. From Coyle, 2005

The Role of Télécoms Sans Frontières and the Speed of Mobile Network Repair

Mobile networks are a critical part of the infrastructure that must be repaired and restored as quickly as possible by the government and operators involved post-disaster. Unlike other means of communication, such as fixed-line connections, the recovery time (and ease) of repairing mobile networks compared to fixed wireless base stations is much faster. Moreover, new mobile networks can be set up relatively quickly by emergency response teams in which there were no existing mobile networks prior through the installation of temporary networks (Coyle, 2005). The speed and ease of restoration and set-up of cellular networks provides yet another strong advantage for the use of mobile phones post-disaster.

More specifically, in developing countries in which mobile phone penetration and use has proven to be center-stage in communications infrastructure, organizations such as Télécoms Sans Frontières (TSF) are vital in the international disaster relief response effort. Since 1998 TSF has been a central emergency communications support for almost every humanitarian response to natural disaster (ICRAM, 2010). This vital role is further illustrated in TSF's status with respect to the United Nations and other key humanitarian agencies. It became the first NGO partner for the United Nation's Office for Coordinated Humanitarian Affairs and the United Nations Children's Fund in 2006. It is a partner of the European Commission's humanitarian aid department and works alongside the United Nations Disaster Assessment and Coordination team in early needs assessments post-disaster. TSF has three bases: in France, Thailand and Nicaragua, and can normally reach an emergency area in 24 hours, but can take up to 48 hours to deploy (TSF, 2012).

In summary, according to the findings of the GSM Association report, *The Role of Mobiles in Disasters and Emergencies*, (Coyle, 2005) which assessed the use and impact of mobile phones in large-scale disasters, the use of mobile phones in disaster management during the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, and in the January and February 2010 disasters that hit Haiti and Chile respectively, was revealed to be critical. The UN Foundation and Vodafone Foundation's report (New Technologies, 2009) highlighted through a series of case studies the effectiveness of mobile phone technologies in disaster alert systems, preparedness, response, and recovery. Moreover, the range of applications of mobile phones post-disaster was impressive. The mobile phone was not only used as a critical (and often times sole) communication tool, but was

also leveraged and used as a major fundraising, data collection, and disease surveillance tool. The latter is an example of ‘mHealth’, or a mobile health technology applied in disaster relief – a term and subject that will be expanded upon in Chapter Four. For example, a mobile phone disease surveillance study examined the effectiveness of mobile phones after the 2008 Sichuan earthquake in China, in which mobile phones were distributed to 495 local health agencies. Due to high reporting by the agencies, the outcome of this study was the identification of 38 infectious diseases. (Yang, et al., 2009)

2.3 Crisis Communication

It is important to stress that mobile phones are a tool for communication and consequently of crisis communication during and after the onset of a natural disaster. Therefore, the process and social dimensions of communication need to be addressed, alongside the technical dimensions. According to Mileti & Sorenson (1990) crisis communication is a four-stage process that involves *hearing, understanding, believing, confirming* and *responding*. Yet Mileti and Sorenson present a rather linear and culturally void progression that is more likely to be present in non-crisis situations, as opposed to crisis situations in which the communication and interpretive process is fragmented, augmented, attenuated or short-circuited. The social amplification of risk framework (SARF) created by Clark University and Decision Research academics is an integrative theoretical framework that captures both risk perception and risk communication, and serves to describe “the various dynamic social pressures underlying risk perception and response” (The Social Amplification of Risk, 2003, p.13) This framework points to the impact of social, institutional, cultural and psychological processes that either heighten or diminish both individual and social perceptions of risk.

The hypothesis and starting point of the model is that the disaster or ‘risk event’ (that include either actual or hypothesized incidents) could be made “largely irrelevant or localized in their impact unless human beings observe and communicate them to others” (Social Amplification of Risk, 2003, p.13). Rather than simply the experience of physical harm, it is the *communication process* (that can be portrayed through various images, signs and symbols), and the subsequent *interpretations of risk* (that interact with a range of cultural, social, psychological and institutional processes) that lie at the heart of the social amplification of risk framework. These stages or transformations of communication and interpretation either amplify or attenuate perceptions of risk and its manageability for groups and individuals. For example, ‘individual stations of amplification’ (i.e., the dynamics and individual processing of risk) are influenced by prior

attitudes, blame, risk heuristics, and trust in addition to whether the individual is a member of a social or cultural group that “codetermine the social processing of risk” (Social Amplification, 2003). Moreover, the amplification or diminution of risk perception in these social units or ‘social stations of amplification’ are in turn influenced by culture, institutional structures, and rules or role expectations pertaining to that group and individual.

More specifically, it is the decoding process that determines the receiver’s selection of critical information (Renn, et al., 1992). According to Renn, et al., (1992) the process of an individual’s perception of information includes the decoding of signals, where the individual deciphers the meaning of the signals in their environment (media or other) in addition to picking up cues to ascribe credibility to the information or source of information being provided. Next, the receiver draws inferences based on these signals, such as judging the intention and seriousness of the information and its sources, followed by the evaluation of the message (its importance, persuasiveness, and effect on the receiver’s personal life). Once the message is evaluated, the individual forms specific beliefs, or rationalizes their belief system based on the subject of the message and its alignment with their previously held beliefs (e.g., shifting beliefs about the subject of the message, or reinterpreting the belief to minimize cognitive dissonance). The final step is forming the intention to take corresponding action. (Renn, et al., 1992)

In the case of MMER, not only must a caller or user of the system understand and decode the message and information being imparted by the health practitioner, but they must also infer and evaluate the importance of the medical advice being provided. Given that MMER is a two-way rather than a one-way form of communication the decoding and evaluative stages are supported and ameliorated due to the fact that a dialogue between caller and medical practitioner can occur, in which the caller can pose clarifying questions. Furthermore, due to the fact that the individual is initiating the call and making a conscious decision to use MMER, and that the medical information and guidance provided is catered to the caller’s expressed needs, the evaluation of the message - and the rating of the importance and pertinence of the information provided for the caller - is further enhanced. However, during the decoding process when individuals ‘decipher the message’ and assign or attribute credibility to the subject and source of the information what matters is not just the clarity of the message, but the source of the provision of the message, the reputation of the source (or provider), and the accuracy of past messages. Hence, the level of professionalism and the type of information provided by MMER responders will be of utmost import for the perception and application of the message, and how that information is utilized and

acted upon by the caller. Therefore if MMER were to be imbedded and institutionalized within an existing organization (such as the IFRC, or the government's Ministry of Health) maintaining and enhancing the reputation of both parties in the aftermath of the disaster event would be critical.

According to Marincioni's (2007) study of ninety-seven US and Italian emergency management agencies' use and implementation of IT in their communication systems, one of the most important determinants of effectiveness of the technology was the social and cultural adaptation of the technology to its end user or target community, as well as its ability to garner feedback from its end-user. Due to the complex cultural, institutional, and social dimensions mentioned in the framework above, and because human behavior is dependent on "demographic, cultural, economic and psychological factors" (Rodriquez et al., 2007), a field-based survey based on MMER's services will need to be carried out in Haiti to gather feedback from a sample of potential future MMER users (see Chapter Seven for details).

Crisis Communication in Haiti

On the case of crisis communication in Haiti, Wall (2011) eloquently states, "while methods may be highly technical, communication as a process is deeply rooted in local culture." Using examples such as *Noula* a Creole-based live broadcasting Haitian radio station that utilized Facebook, phone-ins (rather than SMS-based communication) and on-the-ground reporting as a means to reunify lost families and friends post-disaster, Wall underscores the fact that for a communication system to deliver it must "engage the population and their technical capacity as equal partners" (Wall, 2011). It was also noted by *Noula* staff that there were basic errors (e.g., duplication or typing errors) in the UN data's list of camps because *Noula* staff "knew the places." (Wall, 2011) Such examples point to the fact that residents and survivors have tremendous knowledge of and persistent access to local information on the ground.

An interesting example provided by Wall (2011) in Haiti's disaster relief communications was the creation of an Information Line by the International Federation for the Red Cross' (IFRC). This Information Line provided advice on cholera and the hurricane response, receiving over 130,000 calls during the cholera epidemic and around 400,000 regarding and during the hurricane season (Wall, 2011). In addition, according to an interview conducted with Dr. Nigel Snoad - Google's Director of Disaster Management Technology - (June 2011, New York) in a survey collecting feedback from Haitians on NGO services provided, the IFRC's information line received one of the highest satisfaction ratings by Haitians affected by the disaster. Three key

points emerge from Wall's research: that communities and end-users must be active participants in the communication process, that affected end-users and community members likely have the most valuable and detailed on-the-ground information, and that the IFRC's information phone line was revealed to be one of the most used and highly ranked services by its users.

When applying this to MMER we see that MMER is a cross between a medical help and information line, and moreover that the information provided by the caller is utilized: it is captured and a crisis map that indicates the medical need or ailment reported is generated. This in turn provides humanitarian organizations and disaster relief agencies with user-generated data that can help organizations better serve the individuals and their communities by supplying and providing them with the targeted medical supplies reported, for that given location.

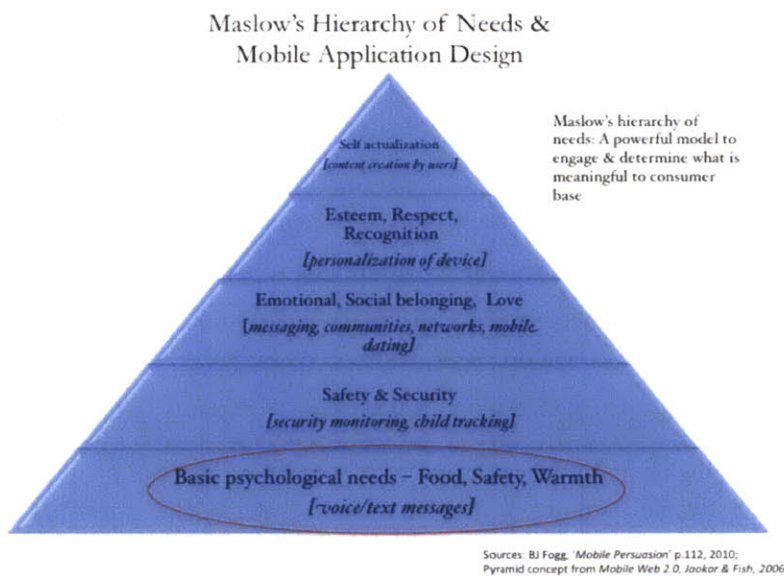


Figure 8: Mobile Design based on Maslow's Hierarchy

meaningful to the consumer base and user (Fogg, 2010). Moreover we see that MMER fits into the first foundational tier of basic needs: in this case medical needs, health and safety.

Finally, when applying the concept of Maslow's hierarchy of needs to different types of mobile application designs (see Figure 8) we appreciate that a design system based on need indicates - especially in the case of the most foundational needs - what will take hold and be most

3. EMERGENCY MEDICINE & LOGISTICS

In order to understand the role that health care support, and medical emergency management plays in disaster relief and recovery efforts, it is essential to provide a definition and overview of the process of disaster relief logistics with respect to the medical supply chain. First, I establish the context of health threats post-disaster and the correlation between disaster and disease (see Figure 9). To do this, a snapshot of the disaster relief medical supply chain through the roles of the assessment, distribution, and selection of medical goods. Finally, I conclude with the challenges and obstacles faced in medical logistics due to the introduction of counterfeit medical goods and inaccurate assessments. These challenges will thus establish the foundation and justification for MMER’s crisis mapping application, which could help to ease medical logistic strains post-disaster by decreasing inefficiencies in the assessment of medical supply needs.

Table 1.1 Short-term effects of major disasters

Effect	Earthquakes	Windstorms (without flooding)	Tsunamis and sudden floods	Slow-onset floods	Landslides	Volcanoes and mudslides
Deaths ^a	Many	Few	Many	Few	Many	Many
Severe injuries requiring extensive treatment	Many	Moderate	Few	Few	Few	Few
Increased risk of communicable diseases	This is a potential hazard after any significant natural disaster. The potential increases in close correlation with overcrowding and the degradation of the sanitation situation.					
Damage to health facilities	Severe (structure and equipment)	Severe	Severe, but localized	Severe (equipment only)	Severe, but localized	Severe (structure and equipment)
Damage to water supply systems	Severe	Minor	Severe	Minor	Severe but localized	Severe
Lack of food	Infrequent (generally caused by economic or logistical factors)		Common	Common	Infrequent	Infrequent
Large population displacements	Infrequent (tend to occur in urban areas that have suffered severe damage)		Common (generally limited)			

^a Including potential lethal effects in the absence of prevention measures.

Figure 9: Health Effects Post-Disaster. From WHO, 2003

3.1 General Post-Disaster Medical Needs

The pressure placed on the already weakened Republic’s logistical and organizational capacity, further enhanced the chaotic context of the disaster-relief efforts conducted in Haiti. I maintain that logistical stress is generally felt with more intensity in the health sector, where shortages of supplies or faults in the flow of goods have fatal ramifications. As illustrated in the case of Haiti, the actors involved in the environment of humanitarian relief range from military forces, donor

agencies, international non-governmental organizations to the national (and local) government. In addition to the complications of collaborating and coordinating with such disparate actors, as indicated in Haiti’s coordination crisis, is the issue that humanitarian personnel lack the training in logistics, stock-control procedures and medical supply chain management (Boulet-Desbareau, 2011 & Pan American Health Organization - PAHO, 2001).

There is a general correlation between the type of disaster impact and health threats that ensue (see Figure 9). Injuries tend to occur at the time and place of impact, while communicable diseases can strike at different times with variable intensity due to lack of hygiene or overcrowded conditions (PAHO, 2001). Hence, epidemics are not often caused by the natural disaster itself, but rather due to medium- or long-term conditions: through population displacements (most often towards urban areas), degraded living conditions, lack of basic sanitary conditions, or environmental change. Specifically, the most frequent cause of increased morbidity is fecal contamination of drinking water and food. According to the Pan American Health Organization (PAHO) the risk of epidemic outbreaks is thus “proportional to the density and displacement of the population” (PAHO, 2001).

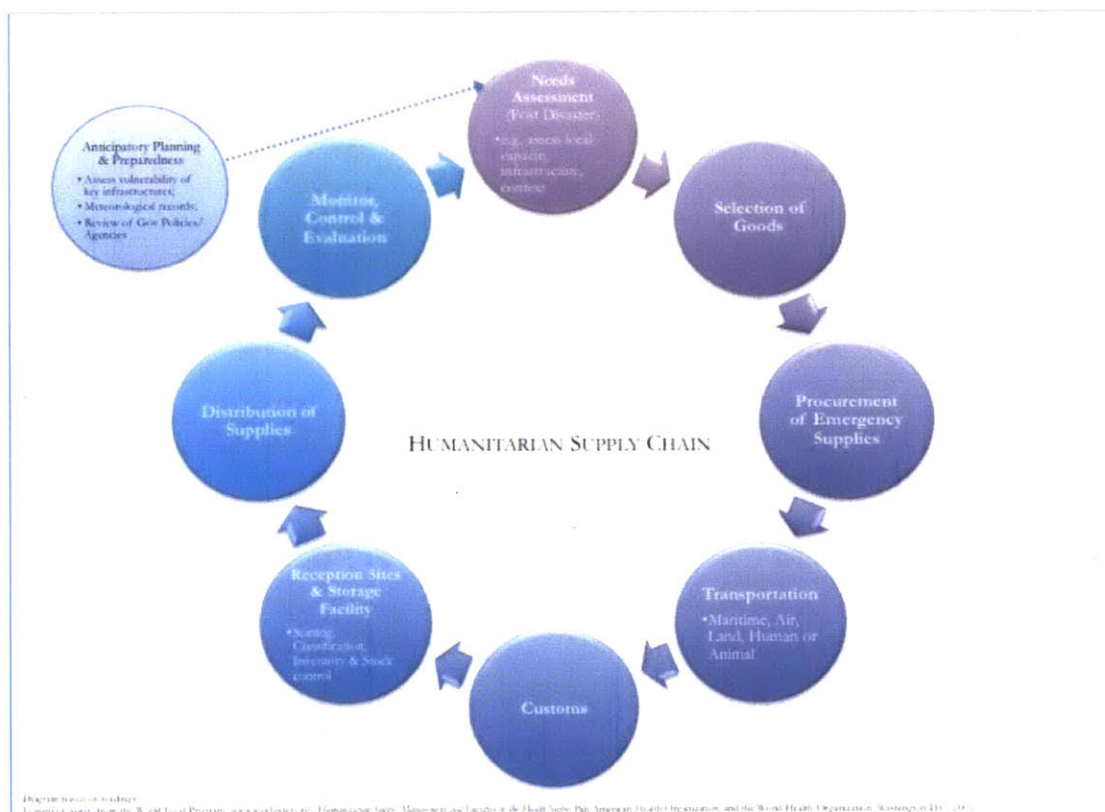


Figure 10: Simplified Humanitarian Supply Cycle (Based on PAHO & WHO, 2001)

3.2 Medical Supply Chain Logistics

Logistics is commonly understood in the humanitarian field to be both a physical (material) flow of goods as well as an informational flow from raw good through to the point of delivery. Logistics thus consists of the end-to-end process of supply, management of materials or goods, and their distribution. According to Nizushima and Thomas (2005, p.60) humanitarian logistics is the “process of planning, implementing, and controlling the efficient, cost-effective flow and storage of goods and materials as well as related information, from the point of origin to the point of consumption for the purpose of meeting the end beneficiary’s requirements.”

Unlike commercial supply chains, the humanitarian relief logistics and supply chain system has a sudden and often large demand of unknown quantities and types of supply in an unpredictable geographic location. The financial constraints, short lead-time, heavy media scrutiny, high stakes impact, and assortment of actors involved – in addition to the likely breakdown of key infrastructure – further adds to the complexity of humanitarian logistics. Although the humanitarian supply cycle diagram (Figure 10) suggests a linear and sequential process, in reality the supply-cycle components are often carried out simultaneously due to complex overlapping and inter-dependent relationships. However, for the sake of analysis and of understanding the import of each step, and how each thread is reliant upon the next, the supply chain is presented in its simplified form (Figure 10). The four distinct components of the emergency medical supply chain I will explain are: (1) anticipatory planning, (2) needs assessment, (3) selection of medical goods, and (4) distribution of supplies.

Anticipatory Planning: Despite, or rather due to the unpredictability of the type and amount of supplies needed, or the exact location of a natural disaster event, it is essential to do anticipatory planning, complete with stipulations of roles, responsibilities, and procedures for implementation. This key step is, or should be, the first within the humanitarian supply-chain management process (see Figure 10). The preparatory stage consists of the creation and maintenance of a national and/or regional emergency plan that, according to PAHO (2001) contains three critical planning activities. First, is an assessment of the vulnerability of key infrastructure, e.g., water-supply systems, hospitals, national transport infrastructure and highways – with alternative actions to be taken if these were to collapse (PAHO, 2001). Second, is an up-to-date stock analysis of the location, means (transportation, ports, distribution centers) of distribution, and sources of key supplies such as drugs or medical provisions. The third major component of the preparatory logistics phase is the review and dissemination (and training) of government policies, plans, and

preparations so that other international agencies and NGO’s are aware of these, and can easily coordinate relief efforts based upon these plans.

Needs Assessment: A key element in emergency logistics post-disaster is an ongoing capacity assessment to assess the extent of impact, as well as local response and logistical capacity on hand. This phase defines the level of response, identifies and allocates resources, and isolates the most affected regions (Log Cluster, 2012). It is a circular and repetitive process that involves monitoring and review, as the needs of affected communities change over time. Failure to assess the needs and impact of a disaster accurately leads to “inadequate assistance, poor utilization of resources and a poorly structured response” (Log Cluster, 2012).

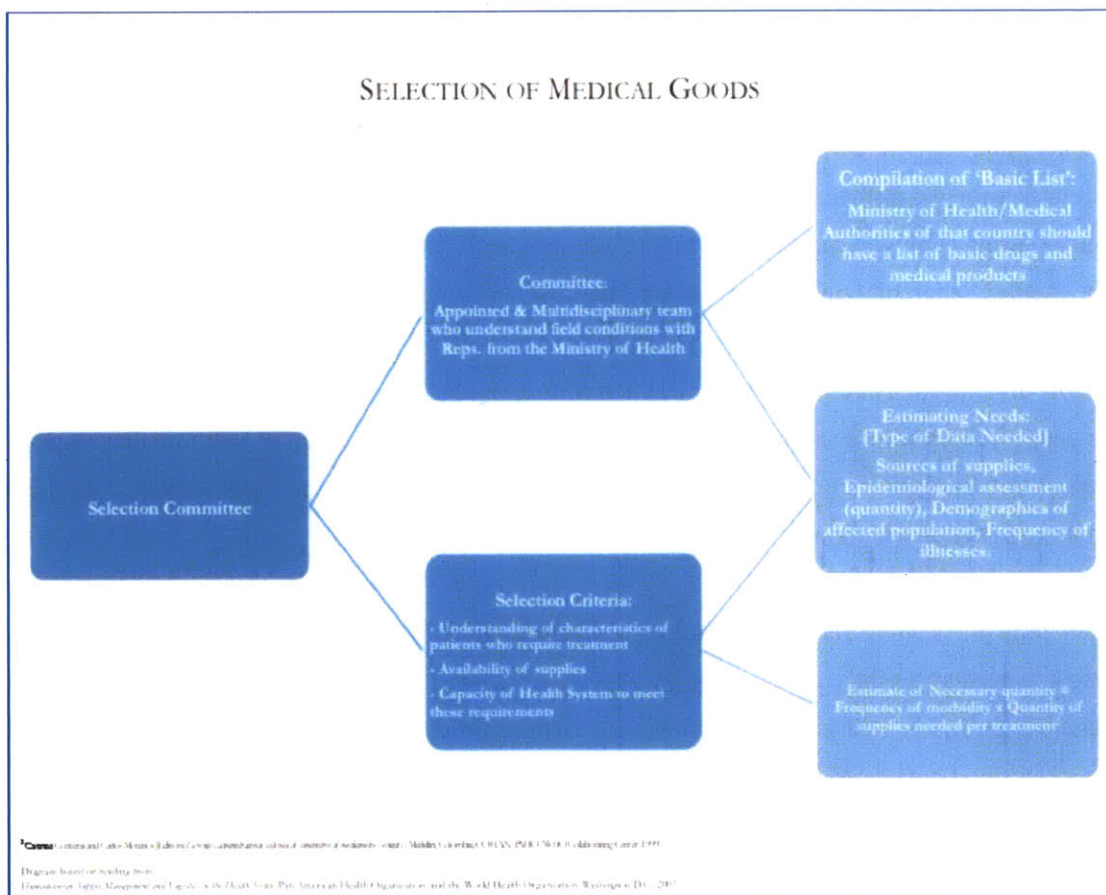


Figure 11: Process - Selection of Medical Goods

Selection: As illustrated in Figure 11, the selection of medical supplies is ideally carried out by a body of experts that makes up a ‘selection committee’ (PAHO, 2001). However, the selection of medical supplies by this appointed and diverse medical team should first be based upon a list of existing drugs and medical products compiled by the affected country’s Ministry of Health or

other authorities. Moreover, the committee should also gather data such as: epidemiological assessments, an analysis of the frequency of illnesses, demographic data, and an understanding of the availability of supplies and capacity of the existing/local health system.

Distribution: As show in Figure 12, there are two main forms of distribution systems: indirect and direct (PAHO, 2001). The former allows for greater control over the goods (and donations) and requires a strong understanding of the affected population (e.g., customs, conditions, and needs), in addition to the social and physical environment. In the direct form of distribution, there is an obvious need for experienced and knowledgeable logistical, administrative, and infrastructural ability. In the case of an organization that does not have the operational and logistical ability to handle direct distribution, indirect distribution is adopted. This involves the selection of a local and trusted counterpart who has deep on-the-ground knowledge, who ensures that the distribution follows agreed-upon principles and standards, and has the ability to monitor, document, and control the supplies in the field (PAHO, 2001).

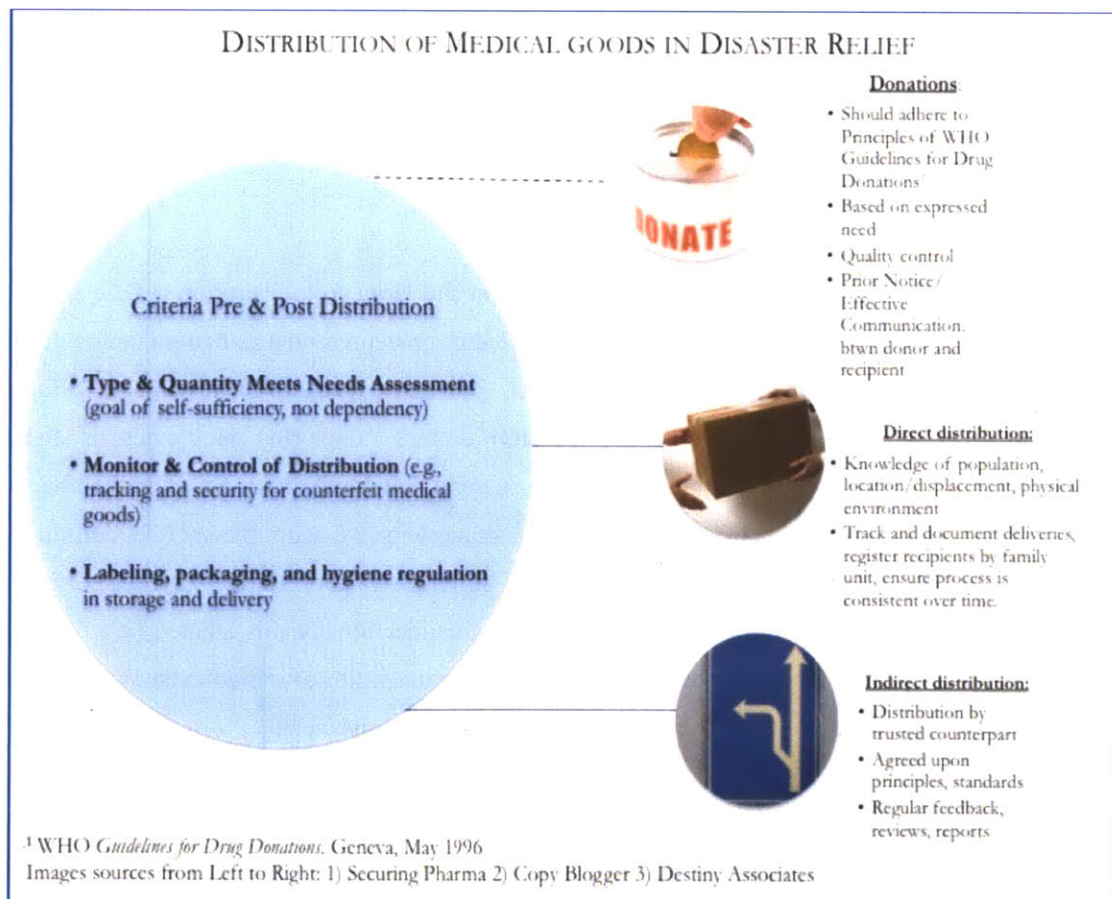


Figure 12: Process of Medical Distribution

The distribution of medical goods should be guided by humanitarian law and core humanitarian principles (e.g., impartiality, neutrality, and independence) in addition to abiding by the SPHERE guidelines¹⁰: an international standard of humanitarian disaster relief that establishes a practical framework for accountability which sets minimum standards, definitions, and measurable indicators of levels of assistance with respect to water, food, health care, and shelter. Therefore not only should distribution be equitable, monitored, and controlled, but it should also be proportionate to the needs of the affected community. Moreover, the security, protection, labeling, and proper storage of medical supplies are of paramount importance due to the potential for the introduction of counterfeit goods, the mis-appropriation, misuse, or de-activation (e.g., through temperature changes or expiration dates) of the medicines or drugs in question.

3.3 Medical Supply-Chain Challenges

Two major issues are often overlooked in terms of medicines: the introduction of counterfeits into the supply chain, and the lack of medical perspective or “de-medicalization” of humanitarian efforts. This is in addition to the complications of ensuring a dynamic, secure, and rapid supply chain flow among regions and various actors, of estimating the right quantity and type of drug to be delivered at the right time and place, alongside the challenge of correct storage and transportation.

According to the definition established by the US Food and Drug Administration (FDA, Section 201), counterfeit drugs are those that are falsely labeled or misrepresented as being manufactured or distributed by a legitimate drug manufacturer, processor, packer, or distributor (FDA). However, the World Health Organization (WHO) defines counterfeit medicines as those “deliberately and fraudulently mislabeled” (WHO, Counterfeit Medicines). So as to be able to draw the distinction between substandard drugs and counterfeits, we adopt the WHO’s definition. We define substandard drugs to be those that may suffer from poor storage or transportation along the supply chain and are rendered impotent, are unintentionally mis-labeled (e.g., due to mistakes in poor production), or contain incorrect ratios or quantities of ingredients (Bate, 2008). In contrast, we define counterfeits to be drugs that are willfully mislabeled.

Likely a low estimate given unknown and undetected amounts, Mackey (2011) assesses that in 2010 alone counterfeit drugs made up *at least* \$75 billion in global medicine market sales. Others suggest that on average 25% of the drug supply in the developing world is counterfeit

¹⁰ The Sphere Project. Humanitarian Charter and Minimum Standards in Disaster Response, 2004. (<http://www.sphereproject.org/>)

(Representative Buyer, 2007). Bates (2008) points to the “high-reward, low-risk” element of this illegal activity compounded by a lack of consumer awareness as a reason for its burgeoning growth. Moreover, the spectrum of drugs affected by counterfeits ranges all the way from lifestyle to lifesaving medicines. Such contamination of the global drug supply chain is also present during times of non-crisis. Specifically, the introduction of counterfeit goods leads to antimicrobial resistance (e.g., in the case of malaria and tuberculosis) and death (Mackey, 2011). What is essential to note is that the prevalence of counterfeits along with their sale and usage varies by location, and that developing countries and patient populations that lack access to medical supplies are the most at-risk to the purchase and use of such medicines (Bates, 2008 & Mackey, 2011). The disproportionate impact on the poor in developing countries is further heightened due to weak import and quality-control regulations (Bates, 2008) in addition to a lack of infrastructure and technical expertise to test or regulate such activity (Mackey, 2011).

In times of crisis, the complexity and multitude of actors involved only exacerbate the situation, by which counterfeiters can more easily “insert themselves [in the supply chain] claiming that they are wholesalers...where other legitimate wholesalers may trade unwittingly with counterfeiters passing as wholesalers” (Bates, 2008).

Finally, according to Pierre Boulet-Desbureau, Director of the Logistics Department of Médecins Sans Frontières, the logistical complexity of disaster relief induces a de-medicalisation of humanitarian action (Boulet-Desbureau, 2011). According to Boulet-Desbureau “the aid provided today during humanitarian crises is progressively less and less medical,” moreover medical constraints from procurement to distribution are not readily understood or taken into consideration (Boulet-Desbureau, Conference Presentation, 2011). Even those organizations that do specialize in the medical field are finding it increasingly difficult to guarantee the quality and control of pharmaceutical goods along the supply chain. Boulet-Desbureau also points to strict import restrictions set by developing countries as an additional obstacle in impeding humanitarian medical responses. For example, it is almost impossible for Médecins Sans Frontières to import medical goods to 25 to 30% of countries in which it operates. While these import restrictions might protect the financial interests of local or national pharmaceutical production, the quality control is “rarely aligned to the WHO’s international standards” (Boulet-Desbureau, 2011).

3.4 MMER: a Crisis Mapping Tool

In response to the central tenet noted above – that the medical supply chain information chasm in disaster relief needs to be filled – I plan on building a data management system within MMER that would crowd source the data provided by its callers, and in turn generate a crisis map with ‘hot spot’ regions. This data management system would capture the caller’s responses to MMER’s automated routing queries regarding their location, medical ailment and basic profile (such as age and gender). The caller’s profile and response to the IVR routing questions would be then automatically transferred to the medical responder, and if the caller approved it¹¹, could also be used as a data point in the crisis map. The map would display the location and ailments being reported by callers and could inform entities such as the ministry of health, clinics, pharmaceutical companies or NGOs of:

- (a) Trends in infirmities or diseases (or potential outbreaks) reported by the callers,
- (b) The need for certain medical supplies or goods in specific regions, hence enabling the supply-chain and delivery of pharmaceutical goods to increasingly cater to the needs of disaster-affected communities.

A major issue in ‘bottom-up’ crowd-sourced information (and hence crowd-based mapping) is the provenance and pedigree of the data being submitted: for example in the misleading Twitter feeds re-Tweeted in the Iranian post-election protests in mid-2009, or ‘chain’ text messages instigating ethnic violence in Kenya’s December 2007 elections (New Technologies, 2009). In the case of Twitter, it is hard to track and identify the Twitter user’s identity, and to verify the information provided in a users ‘tweet’. With respect to the 2009 Iranian post-election Twitter case, Twitter amplified and over-represented the voices of a young and affluent minority of Iranians, whose message was then re-tweeted by users based in the United States (New Technologies, 2009).

As Ushahidi’s new program ‘Swift River’ underscores, in the case of crowd-sourced mapping, there is a real need to filter, cross-check and validate all sources of information (e.g., SMS, uploaded photographs, etc.) to filter out inaccurate or deliberately misleading information. The role and importance of social networking tools in reporting information during, or after a disaster when mainstream media is lagging (or is limited in scope or censored by the host government) is undeniable. However, no matter how fast, widespread and innovative a social media technology

¹¹ The caller would be aware of this functionality and could opt out of his/her information being recorded beyond the duration of the call through a menu choice. Even if the caller opts out, the system could record the medical incident at coarser resolution to protect the caller’s privacy while not distorting spatial analysis and frequency stats.

or tool may be, if the crowd-sourced information is not validated in real-time, speed and access, the primary advantages of this given technology are nullified.

MMER's callers would generate a user-driven crisis map in which the provenance and pedigree of the input data was known and of high quality. There is a direct incentive for the caller to provide accurate information regarding their identity, location and ailment given that they will be more accurately diagnosed, guided and aided by the medical responder they are calling. As concluded in the joint paper on *New Technologies in Emergencies and Conflict* (2009, p.37) "it is the people concerned who themselves have the most detailed and immediate information needed for humanitarian agencies to deliver an effective response." In addition, MMER callers have already made a conscious decision to call and receive medical guidance and help, unlike a social media user who contributes to a general crisis map, website or Twitter feed for a broad range of reasons.

Summary

This chapter covered key medical processes in humanitarian assisted disaster relief. Having briefly established the relationship between epidemics and disaster impacts, I showed that health risks peak in the aftermath of a disaster through population displacement, overcrowding or through the collapse of sanitation systems and infrastructure. I then covered the essential role, vulnerability, and risk of disaster-relief logistics and medical supply chains were then covered. I highlighted the distinct medical preparations and considerations needed to accommodate the supply chain through the phases of anticipatory planning, needs assessment, selection, and distribution of goods. In addition, I examined additional challenges to the medical supply chain: that of the injection and presence of counterfeit medical goods, in addition to import restrictions and the "de-medicalization of humanitarian action." These point to a critical need not only to control and monitor medical goods throughout the supply chain through to their point of delivery, but as we highlighted in the supply-chain discussion of "needs assessment" and "selection," also to obtain an accurate and continuous stream of data to assess need over time. To conclude, I illustrated how MMER's data management system and crisis mapping technique could utilize high provenance and pedigreed data from its callers to report medical trends, or highlight hot spots for treatment and attention. Finally, the crisis mapping component could provide a dynamic report on medical supply chain needs to disaster relief agencies so that the medical goods provided could more directly reflect and respond to the self-reported needs of the disaster affected communities.

4. MOBILE TECHNOLOGIES FOR HEALTH & ESTABLISHING THE NEED FOR MMER

This Chapter seeks to present and define the nascent field of mobile health (or mHealth) and the subsequent role and potential impact MMER – itself a mobile health application - can play within the health care system of low- and middle-income countries. We will then examine the application of mHealth in health surveillance, and the importance and dominance of voice-based mHealth initiatives over those that are text-based or electronic. With respect to MMER, health burdens, access to health services, and mobile phone penetration will be mapped both globally and in Haiti to reflect and illustrate the potential need for the system. Finally, the potential and impact of a mobile-based service like MMER to reach marginalized populations that are otherwise isolated from accessing health systems will be established.

4.1 Defining mHealth in mobile telecommunications

The definition of mHealth – or mobile health – is broadly understood to be the use of mobile telecommunication for the improvement of health services and information within public health and health service delivery systems (Stephanian, 2003). mHealth capitalizes on the mobile phone’s core utility of both voice and SMS, but also includes mobile technologies such as smartphones or PDA’s, with GSM/GPRS/3G or WiFi capability. More specifically, mHealth is a subset of eHealth (or electronic health), which uses information and communication technology (ICT) – such as satellite communications, computers or mobile phones – to provide health services and information. Since the definition of mHealth was established in 2003, the field has “gained significant momentum through the unanticipated spread of mobile telecommunications infrastructure and uptake of handsets and services throughout low- and middle-income countries (LMIC’s)” (Earth Institute, 2010).

Within the broader health systems framework, the opportunity for mHealth lies in the improvement of health system ‘enablers’, defined as having the ability to ensure effective use of health system ‘inputs’ such as financing, research and development, or service delivery (Dalberg, 2010). Three health system ‘enablers’ were identified by an InfoDev study in which mHealth could play a valuable role: first, in the improvement of information management in health care systems (e.g., data collection mechanisms), second in the delivery of health care (e.g., through the mapping of health diseases or threats, knowledge sharing, and diagnosis) and third, through the improvement of communication (e.g. health promotion, and information flows) (Chetley, 2006).

Another way that mHealth could have impact within the healthcare system is in the creation of supply chain management tracking tools that include user-based incentives to help track the goods at the point of delivery. As discussed in Chapter 3, supply chain management is critical because of unreliable supply chains and the frequent lack of access to life-saving treatments. This can result from short-term shortages experienced during regular (non-disaster) periods in LMIC's, and particularly post-disaster, when supply chains break down and counterfeits are increasingly introduced.

4.2 Policy Debates over mHealth

The domain within which MMER operates is two-fold: first, it exists within the broad field of disaster relief and recovery technology, and second, it touches upon and is related to the sector of mobile health. Having established the definition of mHealth and the pervasive penetration of mobile phones in LMIC's, we now turn to a more macro-perspective on the current state of research, literature and potential limitations of mHealth in improving health outcomes in developing countries.

mHealth has been labeled a “leap frog technology” for developing countries, especially in regions in which there are established mobile networks but weak healthcare infrastructure (Krohn & Metcalf, Chapter 1, 2012). According to Fortney et al. (2011) twenty-first century healthcare access goes beyond traditional indicators of access towards those of geographic, financial, cultural, and digital access due to the fact that most mHealth technologies promote an encounter-less utilization, a form of patient and provider communication that lies outside of the scope of traditional face-to-face clinical encounters. Concurrently there is an ongoing paradigm shift away from a hospital-centric health care system to one that is patient-centric; one that provides a decentralized distributed system where healthcare resources such as process, placement and people are redistributed (Krohn & Metcalf, 2012, Chapter 6). The emerging model is thus one in which the fit between the patient and the healthcare services determines and dominates service provision and dissemination (Fortney et al., 2011).

Not only does mHealth have the potential to reduce geographic and temporal access for isolated or low-resource users, evidence suggests that the presence of the ‘digital-divide’ along the socio-economic ladder is less acute in mobile phones when compared to other communication technologies, such as the Internet. (Kaplan, 2006; Forestier, 2002)

Resource-poor environments do not imply a major barrier to the use of mobile phones (Kaplan, 2006). As a healthcare intervention, mobile phones appear to have a low threshold of access (Geser, H. 2004). Moreover, mobile phones are less expensive to introduce and to install over large areas as compared to fixed land lines (Feldmann, 2003; Vodafone Policy Paper, 2005).

Nevertheless, major policy debates loom large over mHealth for developing countries and more generally, a questioning of the value of communications technology in improving development outcomes. According to Nelson (2006) there are three strands of policy perspectives or debates around the value of information technology in developing countries (see Figure 13). The first is the 'quick fix', where communications (phone, internet, computer, etc.) are understood as a

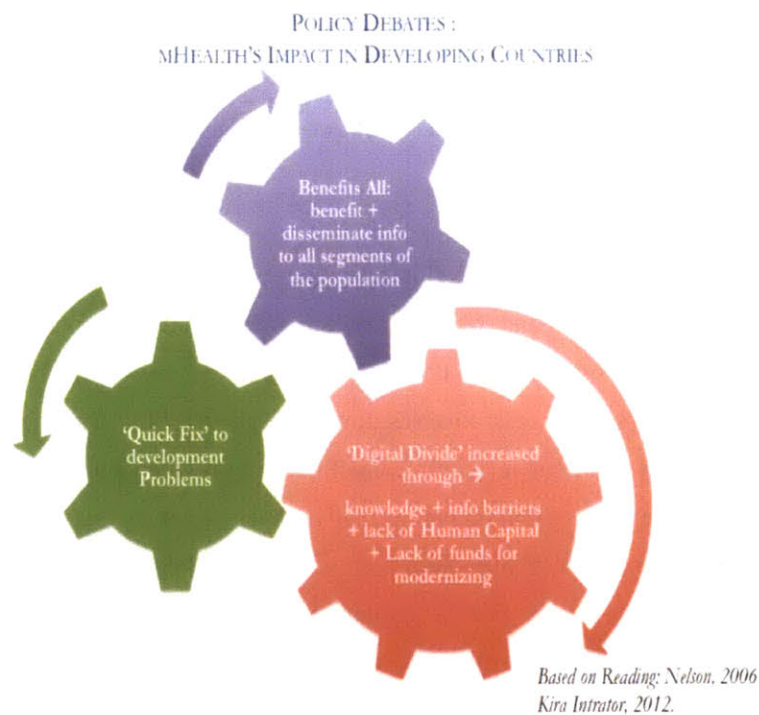


Figure 13: Policy Debates over the Impact of mHealth

superficial response to address and solve development challenges, which should instead be addressed by crosscutting and comprehensive policies across sectors (see Figure 13). The second perspective builds upon the concept of the 'digital divide' where communications policy is seen as "increasing social gradients" due to elements such as knowledge and information barriers, lack of financial support for modernization, and the absence of human capital for making such changes (Nelson, 2006; Kundu, 2004). Finally, the third perspective is that communications technology will benefit all segments of the population; that it will open both opportunities to women and low-income citizens, and help disseminate information more broadly. Proponents of this perspective often point to case studies conducted in Africa and the Arab states in which the poor have been able to access technology through innovative means such as public facilities or mobile phone sharing (Donner, 2008; Hammond, 2001; Nelson, 2006).

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Further clouding these debates is the fact that evidence can be found that both refutes and supports the viewpoint that mHealth is an effective healthcare intervention in developing countries (Kaplan, 2006). A predicament in the field of mHealth is the significant gap that exists in mHealth research in developing countries. Issues flagged are the lack of shared outcome measurements in mHealth evaluations, the small number of controlled studies or randomized clinical trials, the dearth of literature on mobile phones as a health intervention in chronic conditions in developing countries, and limited evidence on overall cost-effectiveness of mHealth interventions (whether in telemedicine or in studies of enhancing adherence to medicine) (Kaplan, 2006).

Despite the pressing and undeniable need for additional evaluative, standardized and high quality studies to be conducted in developing countries, the concept of accessing health information, data and diagnosis through cell phones in LMIC's (low and middle-income countries) exhibits tremendous potential as a healthcare intervention (Kaplan, 2006).

4.3 Adoption of mHealth in LMIC's

According to the International Telecommunication Union, there are over 5 billion wireless subscribers worldwide, with over 70% of these residing in low and middle-income countries, dwarfing fixed internet deployment and landline access. Mobile network penetration alongside the growth and innovation of the mobile phone market in producing increasingly powerful handsets and cheaper data transmission, transforming the way in which information and health services are accessed and managed (mHealth, WHO, 2011). The mHealth phenomenon can be largely attributed to the explosion of wireless capacity and services in developing countries; where mobile subscriptions in LMIC's numbered under 200 million in 2000, at the beginning of 2009 subscriptions grew to a staggering 300 million (The Economist, 2009) and still show signs of rapid expansion in many countries in Africa, as well as in India, China and Brazil (Dalberg, 2010). Today, mobile phones are the technology device with the highest penetration in the developing world.

Moreover, according to a survey conducted by the World Health Organization (WHO), the most frequently reported types of mHealth applications used in Member States were health call centers (59%), emergency toll-free telephone services (55%), the management of disasters and emergencies (54%) and mobile telemedicine (49%), with two thirds of all mHealth programs still

in the pilot or informal stage (mHealth, WHO, 2011). In Member States in the low-income group the most frequently reported type of mHealth applications were health surveillance initiatives and health call center activity (mHealth, WHO, 2011).

With respect to the use of mHealth in LMIC's, health surveillance and disease tracking was emphasized as having great potential. Two cases that were underscored in the WHO report on mHealth was the use of Innovative Support to Emergencies Diseases and Disasters' (InSTEDD) mobile phone data collection software in Thailand to record incidents of communicable diseases. The 2003 outbreak of SARS in Cambodia revealed the limitations of the country's surveillance system; Cambodia thus implemented the Cam e-WARN system that monitors disease outbreaks via SMS and phone calls. The way in which the system operates is that provincial offices send the data to the national office where it is then analyzed. When the number of disease cases inputted by surveillance officers exceeds a predetermined threshold, a trigger is sent to the national database flagging the issue and indicating a province or district. In response a team is sent to investigate and take action. The result of Cam e-WARN was the Health Ministry's ability to control the spread of disease, and to monitor rural district areas where Internet services are still inaccessible and unavailable.

What is important to note is that advances in mHealth have resulted in innovations and the increase in data collection and surveillance. Traditional studies compare pen and paper methods of surveillance and data collection with mobile technologies (mHealth, WHO, 2011). However a study conducted by Patnaik, Brunskill, and Thies went further and compared which type of mobile functionality (electronic, SMS or voice) was the most accurate during data collection. The study found that the voice collection method had the least errors, followed by electronic forms, and SMS (Patnaik et al., 2009). In addition, the adoption of mHealth appears to follow a pattern, in which it seems to be more easily adapted and "incorporated into processes and services which traditionally use voice communication" (mHealth, WHO, 2011, p. 76).

4.4 Global Health Need & the Potential Impact of MMER

The first step to understanding the potential impact MMER could have in low- and middle-income countries (LMIC's) is to examine the health burdens and systems in place at a country-level. As illustrated in the MMER need-based map (Figure 14), there is both a shortage of health service providers or physician density, especially in areas of high disability-adjusted life year

(DALY) rates. The DALY rate is a measure of health that combines morbidity and mortality. It quantifies the global burden of disease by country by incorporating an estimate of the years of life lost (or premature mortality) with years lived with disabilities, thus measuring “health gaps as opposed to health expectancies” (WHO, 2003). With respect to low physician density levels, human resource shortages in the health sector of underserved regions and countries are a major obstacle to a patient’s access to specialized care or even treatment. Mobile technologies, such as MMER, are a means of circumventing such obstacles by connecting patients to health-care providers or community health workers in both urban and rural areas.

However LMIC’s not only face significant health burdens of infectious diseases, they also face the ‘dual challenge’ of non-communicable diseases (see Figure 14). Furthermore, beyond the national health burden is that of reaching urban and rural populations who face significant, but unique challenges (see Figure 15, Dalberg, 2010).

MMER has the means to reach marginalized populations that are otherwise isolated (either geographically or economically) from health systems, by providing increased access to information and services, regardless of the individual’s social status, location or income. In cases where individuals do not have their own mobile phone subscription it is common for individuals to rent mobile phones locally or share among friends or family. GrameenPhone’s initiative with the telemedicine firm TRCL, Ltd. to create a ‘Healthline’ consultation service is a potent demonstration of the power of mobile-based health care applications. Healthline enables Bangladeshis to call doctors at a very modest charge, and since November 2006 Health Line has received more than 3.5 million calls (Ivatury, 2009). Furthermore, a randomized survey found that over 70% of users had no access to a health care provider within a 5-mile radius (Ivatury, 2009). Mobile-based applications such as ‘Healthline’ help bridge the physical and economic gap in health service delivery and support to serve low-income and isolated patients.

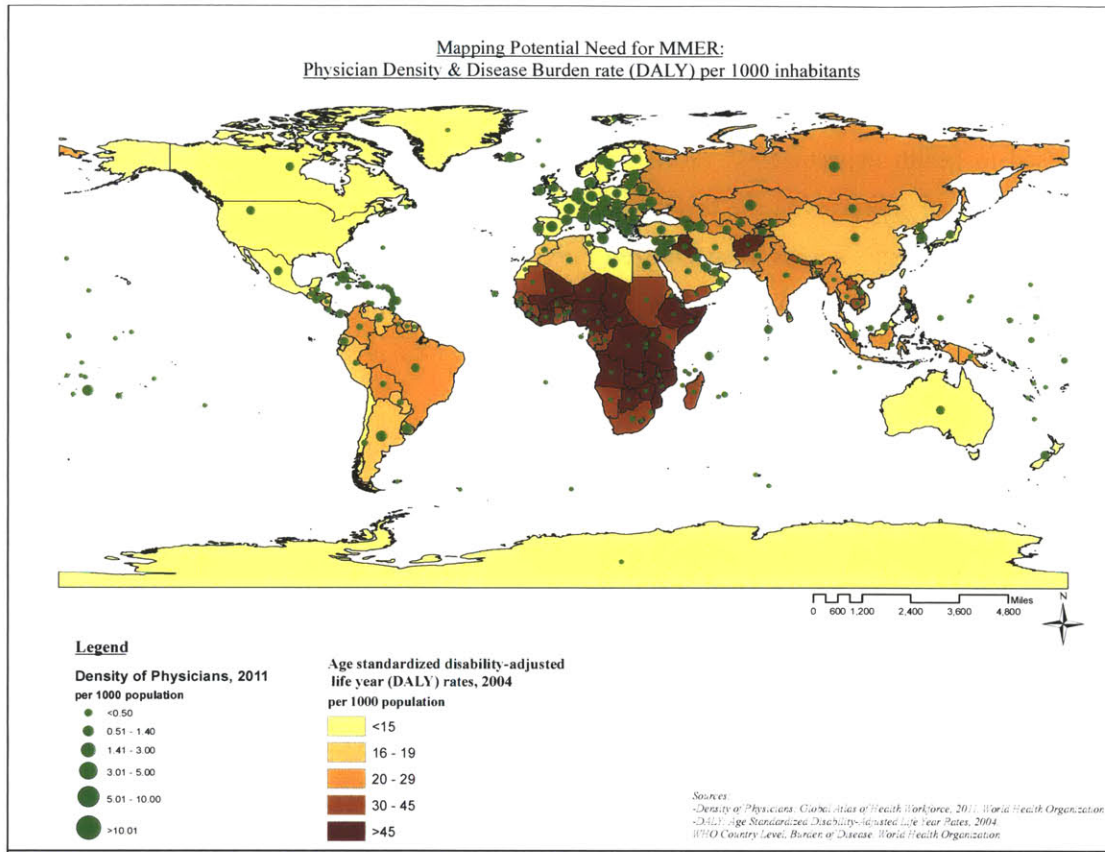


Figure 14: Global Map of Health Burden & Need for MMR measured by DALY rates and Physician Density

Rural population health challenges	Urban population health challenges
<ul style="list-style-type: none"> Low health care worker density, which particularly limits pre-natal and maternal care and results in large distances from specialty services Lack of supporting health care infrastructure, ranging from viable roads necessary for distribution of products, to internet networks that transmit data, to electricity that could support a cold chain, to clinics Limited efficiencies from scale due to large distances and widely distributed populations Vulnerability to climatic crises, civil strife, violence and displacement Poorly balanced diet leading to malnutrition Cultural barriers around use of modern medicine, particularly for women's access to health care 	<ul style="list-style-type: none"> Inequitable distribution of health care resources, such that the poor lack access to affordable health services Inadequate sanitation and refuse collection as well as overcrowding conditions contribute to easy spread of communicable diseases Unhealthy lifestyles, such as consumption of cheap and convenient high fat high sugar diets, yet low in essential nutrients, and sedentary behavior, smoking, and the harmful use of alcohol and other substances

Source: WHO; Vital Wave Consulting, mHealth in the Global South - Landscape Analysis, 2008

Figure 15: Urban vs. Rural Chart for mHealth. From Dalberg, 2010

4.5 Health & Mobile Penetration: Establishing the need for MMR in Haiti

We have thus found that surveillance data collection through mobiles and call centers are areas of nascent growth in mHealth for LMIC's, and that voice-based data collection thus far yields the

most accurate data. Hence the role of MMER as a targeted information and health call-center, and secondarily as a data collection surveillance system that utilizes bi-directional communication (as opposed to a communication system based on one-way messaging of health content) through the collection of data based on voice communication, appears promising.

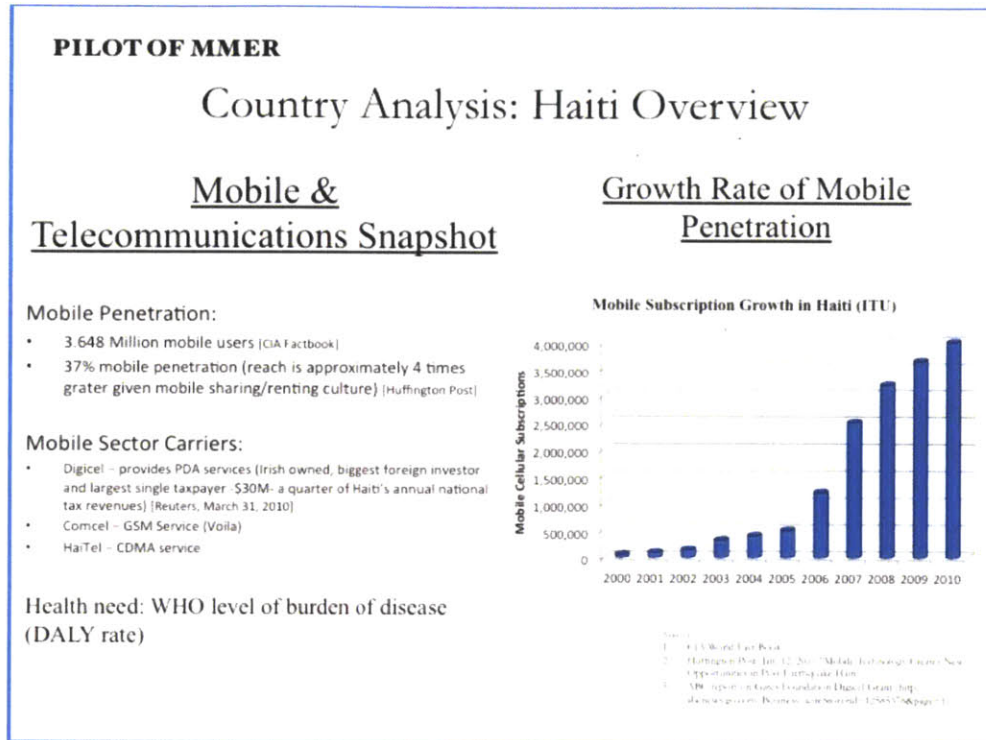


Figure 16: Mobile Penetration & MMER Readiness in Haiti

As indicated in the baseline country analysis for Haiti (Figure 16) we note the high penetration of mobile phone use, and the continued and recent growth of mobile subscriptions. When combined with information from the map in Figure 17 we see that Haiti has an extremely low density of physicians (a ratio of less than 0.50 physicians 10000 inhabitants) combined with one of the highest DALY rate scores. From a policy perspective, Haiti has yet to implement a unit in their Ministry of Health responsible for the implementation of technology policy (see Figure 17). In the long term, it is necessary that mHealth initiatives be integrated into and built upon the existing health system and be accompanied more generally by public awareness campaigns and guidelines for use.

From a healthcare perspective, in Haiti there is limited access to basic social services such as water and health care, and one in five children dies of a preventable disease before the age of five

(UN OCHA, Report 2010). Even prior to the 2010 earthquake, the major causes of child mortality were “diarrheal diseases, acute respiratory infections, and malnutrition” (Pan American Health Organization, Report on Haiti, 1998). With respect to well-being and health, Haiti ranks 158th out of 187 countries in the United Nations Human Development Index (2011), an index that broadly calculates ‘well-being’ and provides a “composite measure of three basic dimensions of human development: health, education and income” (Human Development Index, 2011). With deficient sanitation systems, poor nutrition, and inadequate health services, almost half of overall deaths were attributed to respiratory infections, meningitis, diarrheal diseases (including cholera and typhoid) and HIV/AIDS (CNN Health, 2010).

Moreover, the Haiti HIV/AIDS epidemic is one of the most extreme in the Caribbean with an estimated rate of adult HIV infection (aged 15-49) of 1.9% (UNICEF Statistics, 2010). Before the earthquake an estimated 120,000 people were living with the virus, which included 12,000 children (UNAIDS, 2010). Since the earthquake, in addition to the outbreak of cholera, it has been widely reported that transactional sex, sexual exploitation and sexual violence have increased greatly (AlertNet, 2012), likely further exposing Haitian populations to HIV/AIDS.

Furthermore, a mobile-based rather than an electronic or internet-based health care service option was selected due to the accessibility and penetration of mobile phones over the Internet (see Figure 17). Mobile phone health access would reign over electronic access to health care in Haiti not only due to current census numbers that reveal that there were 40 mobile phones per 100 individuals, compared to only 8 internet users per 100 individuals in Haiti in 2010 (UNICEF Statistics, 2010) but also due to the fact that in times of crisis organizations such as Telecoms Sans Frontières allow for a rapid response and restoration of mobile cell towers, as compared to internet satellites and connections.

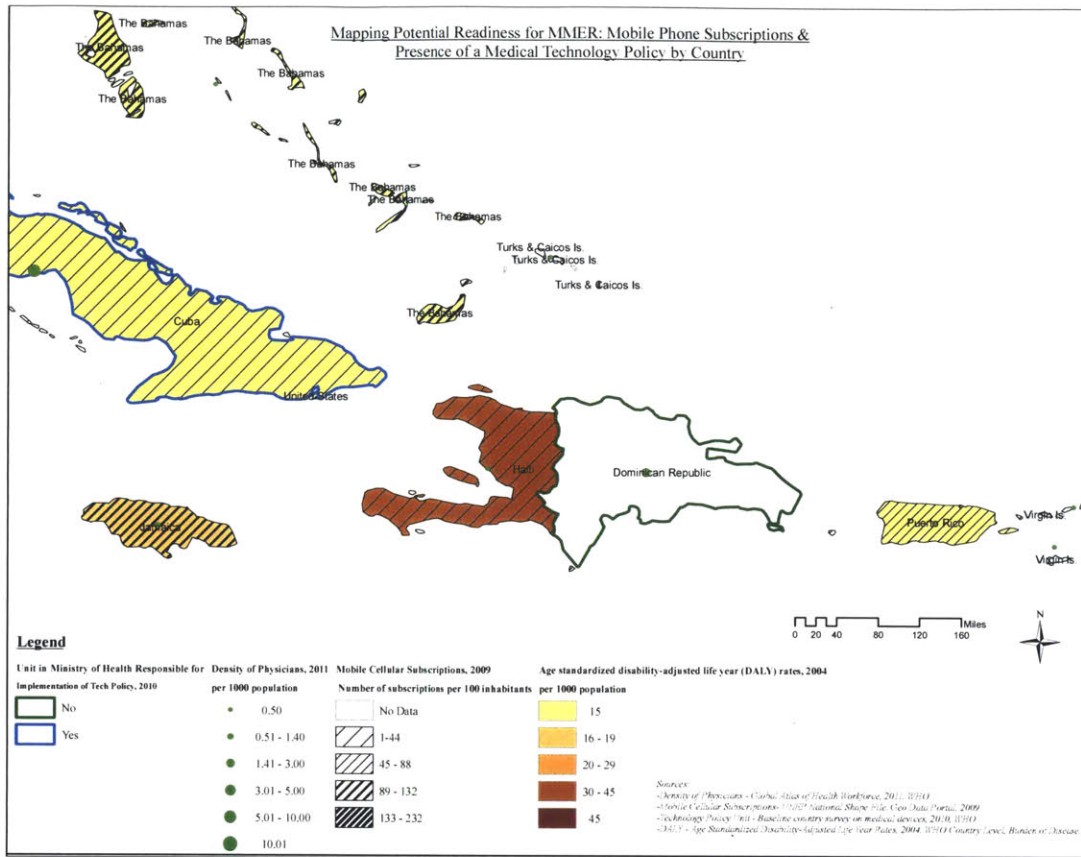


Figure 17: Map of Haiti, MMER Readiness & Need

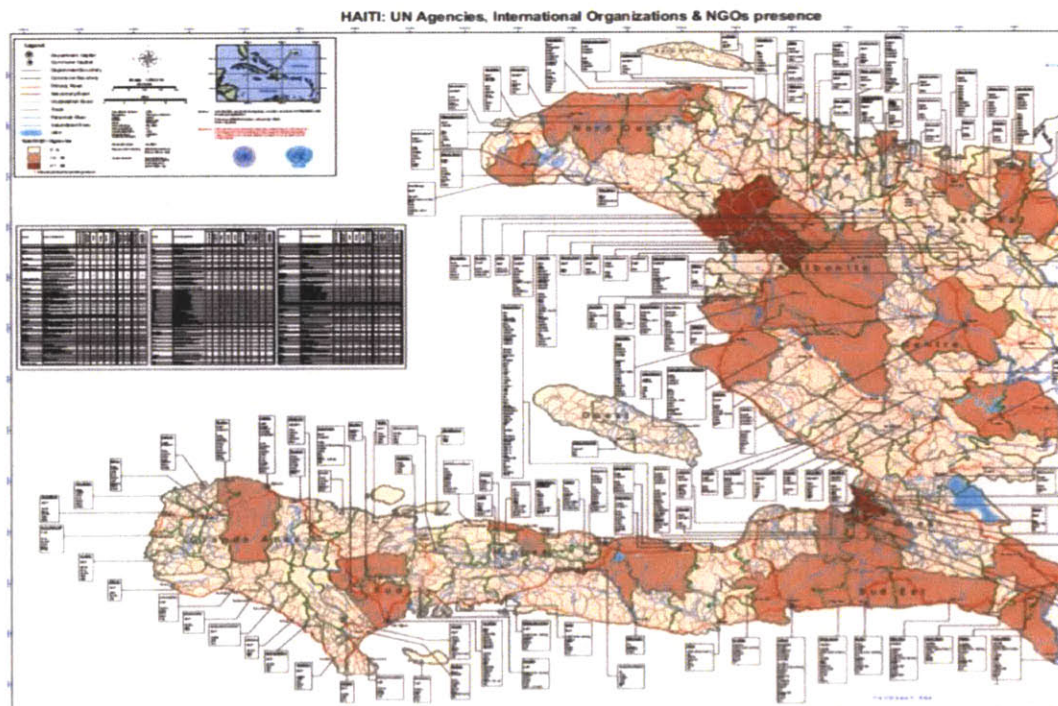
In summary, MMER would allow disaster-affected communities in both urban and rural regions to access and communicate across vast geographic distances with medical specialists and health care providers around the world. Moreover, MMER could play a role in leveling out the social gradient in health, where inequities result from social conditions among socially disadvantaged populations, creating a need for health systems to be more responsive to population needs (Marmot, 2007). In the short term, financial support to help improve the use and access to health services for the poor is critical. However the key issue is the reduction of financial barriers to such services (Marmot, 2007): MMER could help reduce such financial obstacles, while providing virtually any individual with a mobile phone with information and medical expertise in real-time.

5. ESTABLISHING THE NEED FOR MMER

The first segment of this chapter will revisit and restate the arguments for the need for MMER, which include issues such as the ability of MMER to skip the ‘middleman’ within the chaos of disaster relief coordination, the prevalence of mobile phone use post-disaster, and the forms of communication and information needed in disaster recovery captured within the two-way flow of information when utilizing MMER. The second part of this chapter builds upon the first, and introduces the widespread issue of illiteracy with respect to disaster recovery and relief technologies, both on the global scale, and within Haiti. It further illustrates how a system like MMER can meet this need by being voice-enabled.

5.1 Problem Identification & the Subsequent Need for MMER

As outlined in Chapter One, the failure of the U.N. cluster system to integrate, and the lack of coordination in the humanitarian response in Haiti occurred for a multitude of reasons, but was clearly exacerbated by the sheer number of NGO’s, INGO’s, agencies and faith-based organizations that inundated Haiti. As illustrated in Figure 18, there were over ten thousand



profit organizations. In addition to Haiti being inundated with thousands of external agencies was the chaos of coordination that ensued. What is needed is a structure that skips these ‘middlemen’ to enable disaster-affected individuals to connect directly with health care professionals; MMER enables the caller to voice their direct need, and to have these medical questions answered and addressed by a medical professional. Moreover, what was unique about the case of Haiti post-disaster, and in the consequent use of disaster relief technologies was the emergence and explosion in volume of highly skilled and mobilized global volunteers and the disaster-affected communities. Uniting these two emerging groups – the high impact global volunteers and the affected communities – is the central nexus at the core of Mobile Medical Emergency Responders.

Chapter Two highlighted that low and middle-income countries (LMIC’s, as defined and categorized by the World Health Organization) are currently using mobile phones post-disaster as a vital communication and life-saving tool, and that increased mobile penetration is only enhancing this trend. It was noted that mobile networks (with organizations such as TSF) were one of the quickest infrastructures to be restored post-disaster. Finally, Coyle’s analysis of the type of mobile application or communication needed during reconstruction (as opposed to an early warning system which warrants a one-way system) was that of a two-way exchange of information. MMER utilizes bi-directional communication - a criteria for disaster relief technology also underscored by New Technologies (2009) - and establishes a two-way flow of information that recognizes and capitalizes on the fact that affected communities are a primary source of knowledge and information for sound recovery. Thus the three elements covered in Chapter Two are also central to MMER’s foundation: the use of mobile phones post-disaster, rapid cellular network recovery, and a need for a two-way exchange of information during the disaster recovery phase.

Chapter Three exposed the vulnerability of humanitarian medical supply chains, as evidenced by issues such as the pervasive lack of training of disaster relief workers in logistics and the presence and insertion of counterfeit goods into the medical supply chain. Compounding the vulnerability of a post-disaster medical supply chain is the need not only to track, store and secure such goods throughout the chain, but also to gather more accurate real-time consumer driven data to assess need. MMER’s medical crisis map could help flag medical trends or areas of high need, and could also provide a high provenance and high pedigree need-analysis for supply chain management to pharmaceutical companies and humanitarian organizations requiring such data.

Chapter Four established that mobile health (mHealth), and the subsequent potential for a service like MMER, is a rapidly growing and much needed service, enabling health care knowledge to reach marginalized populations in developing countries. Moreover, the most frequently reported and utilized mHealth applications in LMIC's were health surveillance initiatives and health call centers (mHealth, WHO, 2011) both of which are key elements of MMER's structure. In addition, studies revealed that voice-based data collection yielded more accurate data (Patnaik et al., 2009) in comparison to collecting the information via SMS or electronic-based entries from users. MMER capitalizes on this finding, as it too collects its data for both its medical practitioners, and crisis mapping services, via voice.

5.2 Giving 'Voice' to the Illiterate

At first glance, the use of disaster relief technology like Ushahidi or FrontlineSMS - a two-way mass messaging system appears to have exploded the growth of new communication channels, crowdsourcing and information infrastructures within and for communities affected by disaster. However, not all communities benefited from these new technologies due to the fact that MMS and SMS-based disaster relief technology exclude illiterate individuals from first-hand access, use, and ability to leverage this technology to warn, prepare, inform or influence their life-critical decisions or movements.

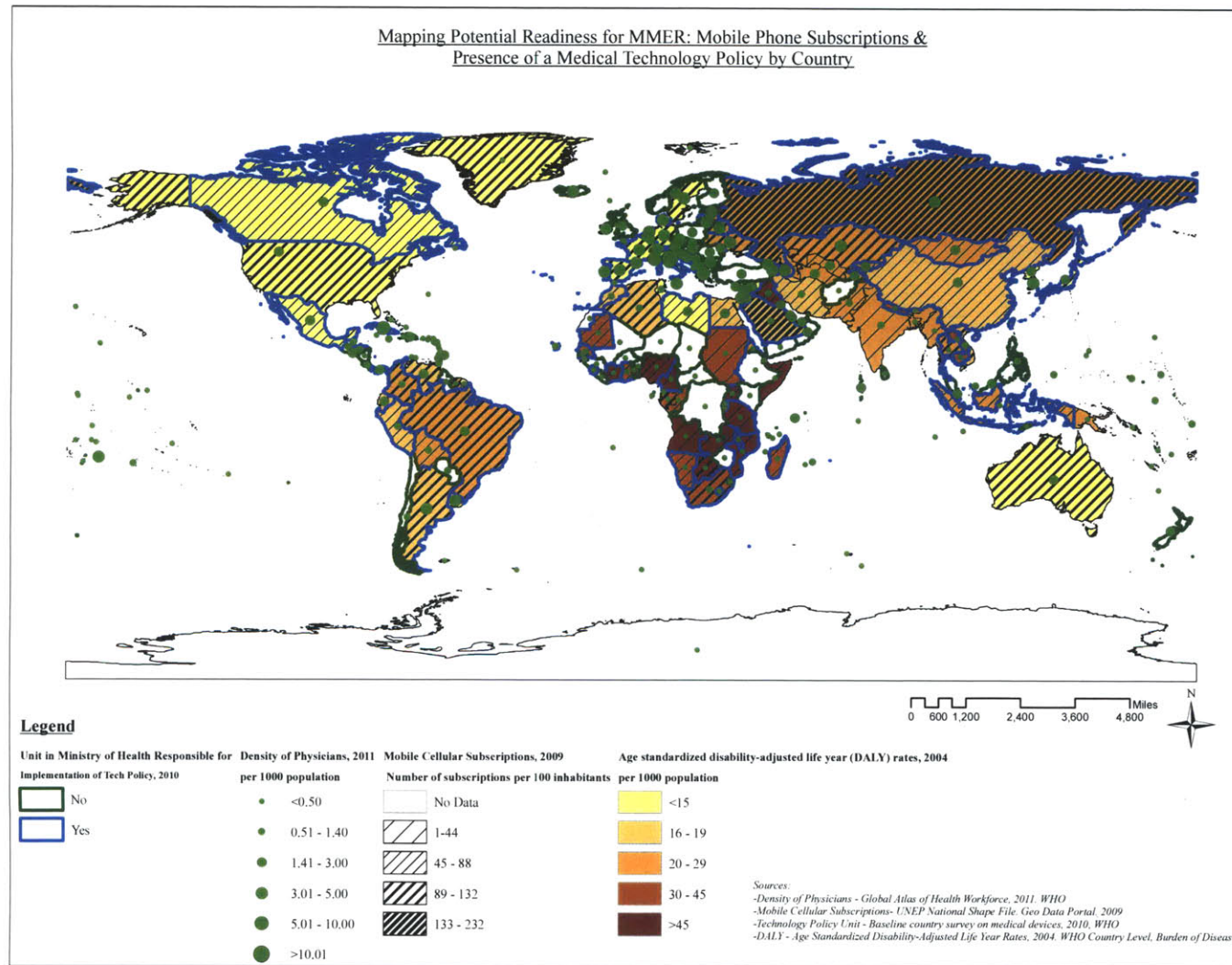


Figure 19: World Map of Readiness & Need for MMR generated by Mobile Phone Subscriptions, Burden of Disease (DALY Rates), Physician Density, and Medical Technology Policies by Country.

We have now established a need for MMR's system through the lack of physician density and high DALY rates in addition to the readiness of the market through the impressive growth of mobile penetration in developing countries (Figure 19). To the list of both established need and readiness for a system like MMR, we can now add the dimension of illiteracy.

Global adult illiteracy levels (Figure 20) compounds both the need and the demand for a voice-based disaster relief system. Not only does MMER open the market to illiterate populations (and visually impaired individuals), but also due to its universal accessibility the user does not need to be trained in a new visual interface, nor do they need to pay additional costs associated with maintaining the visual component or data delivery of the device. Finally, MMER's IVR system would reduce the cost for the user, and provide the service of handling large call volumes, and if callers sought similar sets or forms of information it would also allow access to this data 24 hours a day (Mallik, 2003).

MMER: Access for Illiterate Populations

MMER is a means to reach marginalized populations affected by natural disaster that are otherwise isolated (either geographically or economically) from health systems, by providing increased access to information and services, regardless of the individual's social status, location or income. MMER is not an emergency call center, or a 911-equivalent: it addresses the requirements of the recovery and reconstruction phase(s) of a disaster response. Hence, the medical needs it will be responding to and address would likely be more chronic in nature, and it would focus on the dissemination and exchange of medical information rather than an immediate emergency-response or direct service follow-up¹².

The central tenet of MMER, both as a mobile health application and a disaster relief technology, is the ability to serve and cater to illiterate populations. In contrast with well-executed and established literacy-dependent MMS and SMS-based disaster relief technology (e.g., Frontline SMS or Usahidi) MMER focuses on voice-response and voice-activated questions and responses. In this manner, when mapping possible regions for MMER deployment, high-illiteracy zones will be taken into account. At the front-end MMER caters to illiterate populations through a voice-driven infrastructure using an Interactive Voice Response system (IVR), supported by IBM's Watson healthcare application to further strengthen and increase the robustness and quality of call-routing, and at the back-end with the response of a medical practitioner to the users queries and call.

¹² Despite the fact that MMER and its outreach marketing messages (see System Design, Chapter Six) are catered to non-emergency and medical needs, there is a possibility of individuals calling the system for non-medical reasons or needs. For this reason, the welcoming IVR menu option (See Figure 23) helps transfer out these types of calls to other agencies, or restates and informs the caller of MMER's capacity and use.

Addressing a Global Issue

As illustrated in the map below,¹³ illiteracy is a global issue; in countries such as Guinea, Benin, Burkina Faso, Mali, Niger and Afghanistan adult literacy rates are below 30%, and in countries such as Bangladesh, Bhutan and Nepal total adult literacy rates range between 52.8% and 56.5%. We can thus see the potential application of MMER to regions in which illiteracy, cell phone access and low access to physician treatment and information reign.

The two maps below (Figure 20 and 21) illustrate the need and potential for MMER's global application using illiteracy and disaster risk as driving factors and indicators. The first map presents global adult literacy rates – indicating countries within which MMER could have the greatest impact and be of maximal use to illiterate individuals. The second map provides a

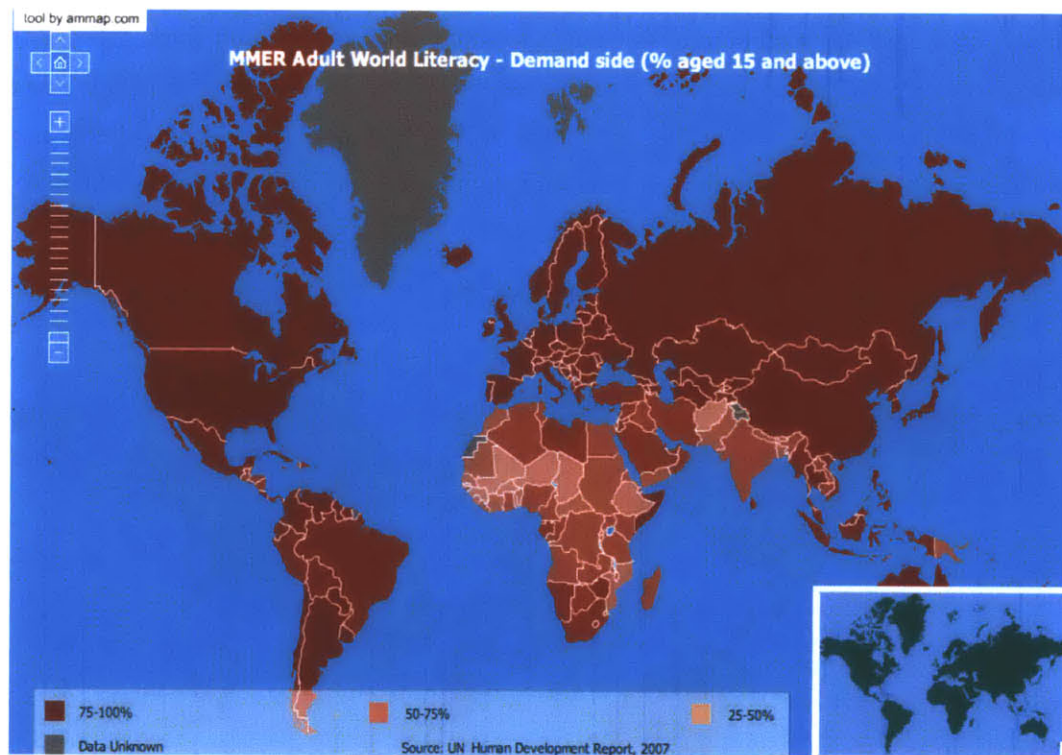


Figure 20: World Map of Adult Literacy – Mapping MMER's Need Globally

general snapshot of global hazard exposure and natural disaster risk by country, generated by the United Nations International Strategy for Disaster Reduction's Global Assessment Report on Disaster Risk Reduction (GAR, 2011). By comparing the maps we see countries in which MMER might be of use – to respond to and focus in on disaster-prone regions and populations that would

¹³ An interactive version can be accessed here: <http://www.mit.edu/~intrator/kira/ammap.html>

otherwise be overlooked by (if even present) literature-based disaster relief technologies.

The ‘Multi Risk Class’ global disaster risk indicator (see Figure 21) is based on mortality risk analyses. The indicator was generated by compiling geographic and physical information on specific hazard events such as cyclones, earthquakes, floods, and landslides in addition to the footprint and impact of these (GAR, 2009, Chapter 2). . One limitation of the mortality or multi risk class indicator in Figure 21 is the fact that drought is not represented, which thus underestimates mortality risk for countries in some regions, especially in Africa (GAR, 2009, Chapter 2). The mortality risk indicator is an average of absolute (average deaths per year) and relative risk (killed per million per year) by country. The classification system was then compiled into a mortality risk class or index with the minimum of zero expressing unknown exposure, three indicating a medium-low classification of mortality risk, a classification of seven flagging a high mortality risk, and the maximum classification of nine signaling a ‘major’ mortality risk (see Figure 21). For each impact area, the exposure was computed as the number of people and the value of economic assets within that area; disaster risk in Figure 21 is thus defined as the “probability that a hazard event of a give magnitude will occur, the number of exposed people or the value of exposed assets, and the level of vulnerability” (GAR, 2009, Chapter 2, p.20).

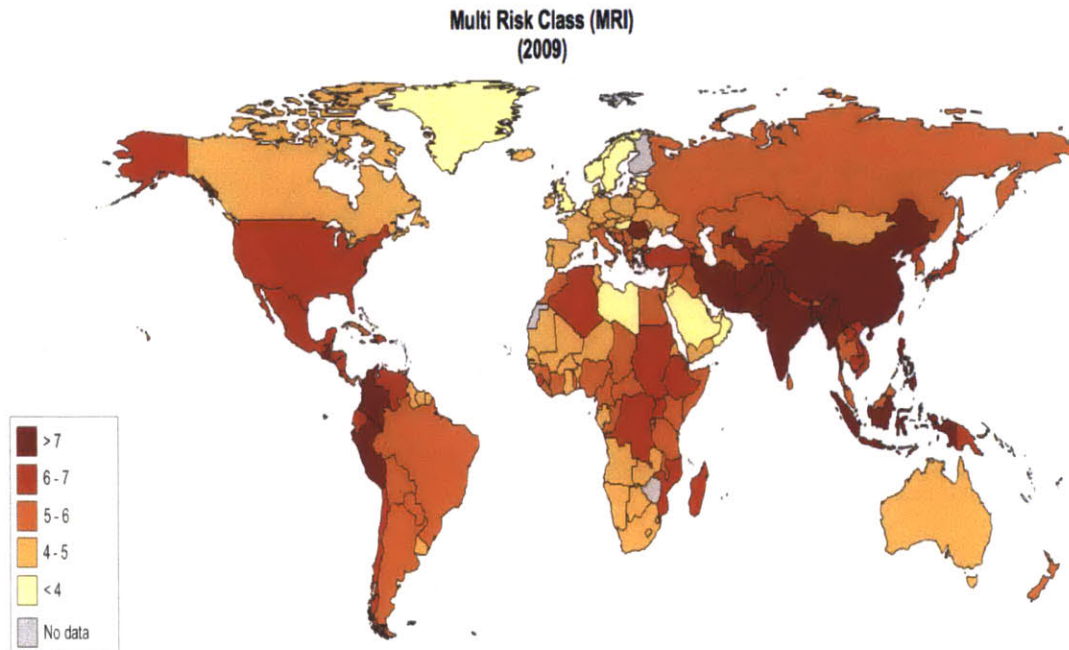


Figure 21: Global Assessment Report on Disaster Reduction, 2011. Risk Indicator: Multiple Mortality Risk Class. (UN ISRDR, preventionweb.net)

MMER: Illiteracy in Haiti

When applying these two elements –illiteracy and persistent risk and vulnerability to natural disasters - we find Haiti ranking high in both. In addition to Haiti’s health burdens, Haiti’s adult literacy level – defined as those aged fifteen and over – barely reaches 50%. Moreover, Haiti’s overall adult literacy rate according to Haiti’s national census is extremely gendered (IHSI - Institut Haïtien de Statistique et d’Informatique, 2003) with an extremely low rate of literacy in both Creole and French at 48.6% for women, and 60.1% for men, further isolating Haitians – especially women– from public health campaigns, information, access and potentially direct care. In addition, two major literacy trends were identified in the 2003 Haitian National Census report (IHSI, 2003). Literacy was particularly low in rural regions of Haiti with an overall rural literacy rate of 38.6%, and inter-generational progress in literacy is evident with youth aged 15-29 displaying the highest rates of literacy at 75.4%, compared to those aged 60 and older with a literacy rate of only 18.1% (IHSI, 2003). We can thus start to conjecture that rural populations in older age-brackets are likely to be illiterate, less likely to be able to use SMS or MMS-based disaster relief technology, and that therefore a product such as MMER would be of a strong value add.

Haiti, Vulnerability & Continued Disaster Risk

In its synthesis report, the IPCC Working Group I (IPCC, 2007) highlighted four main dimensions of climate change relevant to cities. First, heat waves will increase in frequency in most regions. Second, heavy precipitation and flooding will also affect most areas; current data suggests that a significant increase in flooding is already taking place in many regions (World Bank, 2009). Third, drought will increase in scope (with severe impacts on multiple sectors such as health, food production and energy supply). Fourth, there will likely be an increase in the intensity of tropical cyclones and extreme high sea level rise. With respect to this fourth impact, the IPCC report further states that evidence suggests “substantial increases in intensity and duration [of tropical storm and hurricanes] since the 1970s. In the extratropics, variations in tracks and intensity of storms reflect variations in major features of the atmospheric circulation, such as the North Atlantic Oscillation” (IPCC, 2007, FAQ 3.3)

In light of the climate change impacts listed above, Haiti faces and will continue to face an increasing frequency and magnitude of extreme climactic events. The main natural hazards in the Caribbean are meteorological - including floods, droughts, landslides and tropical cyclones. Haiti

lies within the hurricane belt and its horseshoe shape makes for a particularly long coastline, increasing Haiti's vulnerability to flooding (UNDP, 2001). The likelihood of landslide occurrence is also high due to the fact that Haiti is located on the mountainous section of the Hispaniola island; two-thirds of the country lives on slopes that exceed 20 per cent grade. Haiti's severe deforestation further exacerbates the country's vulnerability to landslides, with less than 2 per cent of Haiti's 1970 forest-cover remaining, (Picariello, 1997) further aggravated by a 3.4 per cent change in annual deforestation (UNDP, 2001). During the rainy season (July to October) Haiti's rivers overflow, increasing the risk to floods and landslides. The social and economic impact of climate change and natural hazards will only further serve to reduce Haiti's resilience and ability to respond to future disasters; as underscored in the Tearfund report: "Climate change alters not only physical hazards but also vulnerability" (Tearfund, 2009).

In summary, Haiti faces one of the highest relative risks to disaster in the world (UNDP, 2005). Vulnerability can be generally understood as existing at two levels: the external dimension-- the shocks and stresses to which individuals are subject to, and the internal dimension--the social capacity of individuals, households and communities to adjust to damage and loss in the face of climate change and natural hazard impacts (World Bank, p.6, 2010). In addition, climate change is linked closely to assets – the more assets individuals have and the more diverse their assets, the less vulnerable they are, and vice versa (World Bank, 2010). Hence from an individual asset base and from a community asset perspective (i.e., financial or productive assets) poor populations are at the highest risk in the event of natural disasters. Thus Haiti's unfavorable ranking is not only due to increased natural hazard occurrence, climate change impacts, and acute environmental degradation, but it is also driven by social and internal factors (e.g., assets or institutions) in which human vulnerability plays a central role.

Summary

This section argued the need for MMER as a healthcare intervention system that allows illiterate individuals to communicate directly with healthcare professionals. The need for MMER was underscored by revisiting previous chapters and the gaps in existing disaster relief technology that the former had revealed. The examination of issues such as the lack of access to health care (e.g., physician density), impressive mobile phone penetration and mobile phone usage in LMIC's, compounded by the issue of global illiteracy and regional disaster risk and vulnerability, further helped support and form the type of service and ultimately the system design of MMER. The gaps MMER fills range from: its ability to unite affected communities and their self-reported

needs directly to global volunteers and medical experts, providing crisis maps and medical supply assessments, through to providing isolated communities in developing countries access to healthcare information through mobile cell phones. Having established the existing gaps and need for a system like MMER, we now turn directly to MMER to clarify its system design and function.

6. MMER SYSTEM DESIGN

6.1 System Overview

The vision I have for MMER is to develop a telephony system that works on landline and/or any type of mobile phone to be used post-disaster during the ‘reconstruction’ phase (a month or so after the event occurs). MMER will likely have two types of interfaces: Web and Mobile phone. The main part of the project concerns the use of mobile phone or landline telephones for calling an easy to remember and cheap/free phone number (much like a 311 system and number). A Web interface is used by medical specialists (the ‘responders’) so that they can access the information provided by the caller in the initial phase of the call (e.g., type of ailment, pain, age, location of caller).

6.2 Core Mechanics & Purpose

MMER will be utilized and deployed during the reconstruction and recovery phase of a humanitarian response (rather than upon immediate impact) to assist two types of users: primarily the population affected by the natural disaster, and secondarily humanitarian aid workers who need additional medical advice to guide their assistance in camps or in the field with affected communities. MMER saves time and lives by prioritizing and sorting calls and cases, while mobilizing medical specialists to engage in high-impact public service at any time of day and location (since calls could be routed to the volunteers' home numbers at times that are most convenient to them).

Interactive Voice Response (IVR) as of yet has never been applied to or used in medical disaster relief technology. On the front-end, the MMER IVR system will request the caller's (a disaster victim or aid worker's) basic profile information, and through a series of questions (created against a corpus of medical knowledge and based upon interactive responses given at each step) will gather the caller's symptoms. Using analytics the call is then prioritized and routed to a doctor specialized in the treatment or ailment pre-identified by the caller.

As highlighted in the CDAC 2011 report on ‘Lessons from Haiti’ a major challenge presented by the generation and proliferation of new technologies was their integration into existing humanitarian aid structures and organizations. Similar to the break-down and lack of stream-lined coordination between the 10,000 international organizations and agencies in Haiti (UCF, NSF

Map of UN Agencies, Figure 18, 2011) disaster relief technologies were not built to inter-operate with one another. Thus the inevitable problem of these technologies not being able to ‘talk’ with one another and producing a lot of independent information ‘noise’ is simultaneously created. Moreover, due to these obstacles the potential for these same technologies to have a short-shelf life between disaster episodes is heightened. The technological capacity I therefore wish to use is one that streamlines the software and increases the quality assurance and quality control of the IVR digital triage. An additional general technological parameter needed is one that employs a voice input to an Artificial Intelligence engine with a health care diagnostic tool. Moreover, the technology in question needs to be in a form that is modular enough, and nearing readiness (i.e., is available as a service) so as to fit into the MMER framework. Currently, the technology that fits these parameters is IBM’s Watson, which is further being applied to the healthcare industry.

IBM’s Watson is a “...computing system that rivals a human’s ability to evaluate a hypothesis, learn from additional evidence and confidently respond to complex questions posed in natural language with speed and accuracy.” (IBM Software, Solutions for Healthcare, 2012). In the context of healthcare, IBM’s Watson can apply and combine predictive root cause analysis (using built-in medical terminology) with natural language processing. Moreover, IBM’s Watson also has the potential to generate a standardization technique for digital triage that would introduce a superior level of quality assurance. Unlike current disaster relief technologies that would have to be updated or replaced by newer and faster technologies, by integrating Watson at the front end of MMER, one could isolate and update the software as IBM’s Watson continues to be developed and updated over time.

[6.3 The MMER User Cycle](#)

The user cycle diagram illustrates the simplified user cycle: the user’s decision-making points, interaction with and use of MMER. The user is a member of the affected community - an information-seeking literate or illiterate individual who wishes to gain access to basic health care information or an initial diagnosis. It would serve the individual who otherwise lack access to such information; for example due to geographical isolation, the destruction of surrounding health clinics during the disaster, a lack of transportation to a given center or facility, or the general absence of physicians or nurses on hand to respond to the users medical queries. A second type of user would be an individual who had previously sought or received initial treatment in field hospitals in the aftermath of the disaster, but currently needs follow-up treatment, guidance and

advice (such as caring for a surgery or wound) due either to the fact that the field hospital is no longer present, or can no longer take on patients. A third category of user could be an individual suffering from a chronic disease (such as HIV/AIDS) or one who needs more long-term care and information over an extended period of time (e.g. pregnant women).

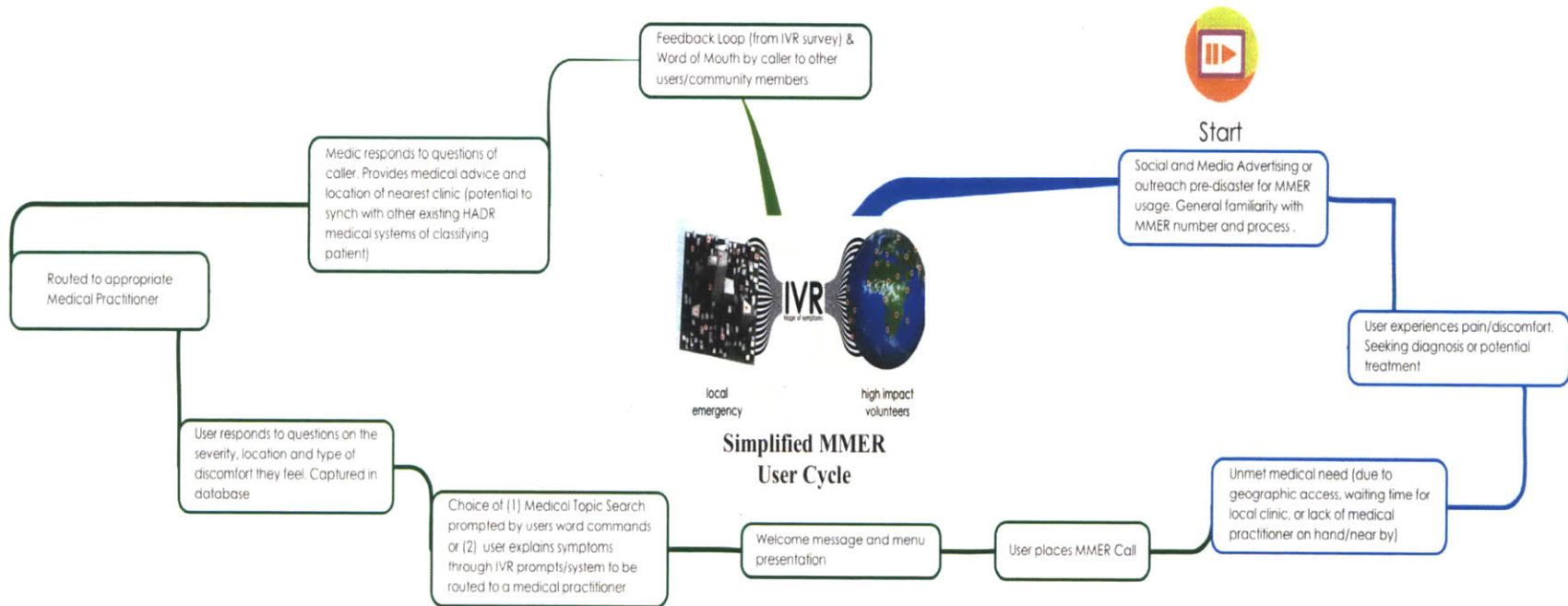


Figure 22: MMER's User Cycle

The MMER User Cycle: Outreach

As depicted in the first (or 'start') step, the user is informed of MMER through social media outreach or pre-disaster usage. Familiarity with MMER (or at minimum the IVR system) prior to the disaster is essential. Dr. Nigel Snoad, a leading disaster relief technologist and Director of Google's Disaster Relief Technology division, states that "what will win are systems that people already know how to use" and that "in an emergency people fall back on the tools that they use everyday" (Snoad, July 2011, interview). Thus introducing a new technology and interface at the time of, or in the wake of a disaster event would likely add to the 'noise' and chaos of the situation, catering to individuals who are more able to adapt quickly to new technology, rather than more technically and geographically isolated individuals whom MMER wishes to target and reach.

One of the first outreach mechanisms MMER would utilize in Haiti would be the radio: in talk shows or with examples by the host who would walk through the system to illustrate how MMER functions. According to the ‘Lessons from Haiti’ CDAC report (2011) one of the main findings was that “although much of the attention has been paid to new media technologies, radio was the most effective tool for serving the needs of the public. The first media priority in Haiti was to restore radio service (as it was in the tsunami and other recent crises).”

OUTREACH METHODS

- Radio broadcasting (CDAC, 2011)
- User trained at a clinic in the use of MMER
- Institutionalized within an established organization (Jacobo Quintanilla, interview, August 2011)

A second point of contact for individuals with longer-term needs (e.g., pregnancy or individuals with diabetes,

hypertension or HIV/AIDS) would be for the user to be introduced to MMER at their local clinic. During their first check up; they would be given the phone number, and a quick course and information session on how it functions and when to call (concept from brainstorming with Meredith McLaughlin, interview March 2012). A point stressed by Jacobo Quintanilla of Internews (interview, August 8 2011) was that of institutionalizing and integrating MMER within the folds of an established agency or international nonprofit organization so that the technology could be rolled out with a bundle of other direct service provisions and an existing disaster relief effort. Therefore the final outreach method would be to integrate MMER within an existing organization’s call center structure, like the International Red Cross’ popular 311-type call center (refer to Chapter 2.3 for details on IRC’s call center system).

Moreover, what is essential to note is that the key new systems proposed in the MMER infrastructure are not the front-end technologies used directly by the caller, wherein a basic mobile phone to call into MMER’s voice-enabled system. Rather the focus and the innovation of the system lie in the use and combination of MMER’s backend components. The backend modules capitalize on call center technology (such as IVR), AI engines (i.e, IBM’s Watson), and crisis management systems (such as crisis mapping and medical logistic needs). Below is a summary table of the main user cycle steps -- outlined in the use case user cycle in Figure 23 -- with the associated modular technology selected for MMER’s current system design, which will be further expanded and elucidated upon in this Chapter.

USER STEP/TYPE	USER INTERACTION/ USER TYPE	TECHNOLOGY USED
Outreach or Marketing prior to call	User type: <ul style="list-style-type: none"> Affected community members/ those with medical needs Local medical practitioners, health care workers, humanitarian workers 	<ul style="list-style-type: none"> Radio broadcasts Clinic training to outgoing patients. Public service announcements in key areas (camps, temporary settlements).
MMER's number is dialed; call is placed	User utilizes landline or cell phone	<ul style="list-style-type: none"> IVR menu (Tropo) system activated. Location of call is determined to help select language/dialect to use and process with IVR/MMER system.
Menu options announced	User listens and responds to prompts, undertakes menu selection. <ul style="list-style-type: none"> Caller first selects 'medical problem' on first menu, then on secondary menu routed to 'back-end' IBM Watson system for secondary screening, as needed. Second menu selection: option for medical information. Voice-enabled search. Other: non-medical needs are transferred out. 	<ul style="list-style-type: none"> Language recognition software (for both the pre-recorded IVR questions and for processing the given responses). Voice enabled IVR 'key word' search function (Tropo).
Menu choices made <ul style="list-style-type: none"> (a) First menu: automated, Second menu: differentiated decision-making (e.g., medical need, follow-up call, other assistance). Final step: speaking to Medical specialist, as needed. (b) Locate nearest clinic (c) Medical Topical Search (d) Other (i.e., transfer call out if non-medical issue) 	User selects preferred service in menu of selections through voice response (or touch tone if desired)	<ul style="list-style-type: none"> (a) IVR Routing, using AI system to triage effectively and efficiently utilize (and protect scarce supply of skilled staff). Caller info stored in database. Crisis map generated from data. (b) Clinic location determined using Ushahidi platform or automated weekly calls that collect updated resource info. from clinics using IVR/Tropo system. (c) IVR pre-programmed voice-based search function. Pre-recorded public messages in language needed. (Tropo) (d) IVR transfers out call. Automated message.

User Interaction

The first technical task is initiated when the call is placed to ascertain what language capability is needed. The backend of MMER thus knows where the call is originating from, and activates a pre-recorded welcome message in that given language/dialect. Moreover, MMER would also have language recognition capability so that the IVR system could also identify and further adapt the dialect of MMER to the dialect or language of the caller. With respect to the user interaction with MMER, the user would first receive a welcome message (see Figure 22, for user cycle) that would provide an overview of the service (i.e., that MMER responds to medical queries); how MMER functions (that the user will need to respond to a few question prior to being transferred to a medical practitioner) and finally manage and set user expectations. This third point is essential as one of the biggest risks faced by social media or related disaster relief tools that “crowd-sources information for humanitarian needs assessments” is that of raising user expectations and not meeting these expectations, as information provided by the user and captured by the system or organization is interpreted as an “implied or perceived promise of help” (Norheim-Hagtun & Meir, 2010, p.87).

A quick overview of the last four main steps of MMER is as follows.

- First, a selection by the caller of a medical topic search with a pre-recorded message, a request to locate the nearest clinic, or the chance to speak to a medical practitioner is made (see Figure 23 for a detailed use case analysis and breakdown of options other than direct advice and information from a medical practitioner).
- Second, if the caller chooses to speak with a practitioner it triggers a series of interactive voice response questions (such as location, age, gender, location/severity of pain or discomfort) that the caller answers (see diagram ‘Proof of Concept’, Figure 23 for IVR structure and a more detailed breakdown of the questions posed and decision tree cycle). With the support of IBM’s Watson, these responses would help route the call to the appropriate volunteer; while the answers and information provided by the caller would be captured and streamlined into a database for the medical practitioner to have on hand and further expand upon when speaking directly to the patient.
- Third, the medical volunteer has the caller’s responses on-hand, responds to their queries and informs them – if needed – of the nearest clinic. Finally, once the call is complete between the caller and the medical responder, the user has the choice to respond to a brief satisfaction survey to ensure that the voice, opinion and needs of the users are captured and utilized to further improve MMER’s design, structure, and ability to serve its primary client – the affected community.

Below is a use case scenario of an individual needing assistance with amputation and wound care.

POST AMPUTATION INFECTION OF WOUNDS/LIMBS

Background Information: Limb Loss Statistics in Haiti (post-earthquake)¹

POST EARTHQUAKE

- Estimates of 2000 to 3000 people with limb loss
- Majority are women and children
- Majority are below the knee amputations
- Numbers will grow over the next months to year due to poor infection treatment from trauma

Use Case Scenario: Amputation

A caller with a recent amputation is experiencing moderate pain from leg amputation that has not fully healed. They decide to call MMER to find information on how to care for the wound, but are hesitant to speak with a specialist. From the main menu they choose 1 by saying "specialist". When asked what their current level of pain is they say (or press) the number 3 button on their phone. The system then asks them where their pain is located and they reply "recent amputation". The IVR system picks up the word "amputation" and the caller is redirected to the question path for amputations. The caller answer "yes" to the question, "Did you have surgery within the last two years?"; and "below the hips" to the question "Where was your surgery located - was it above or below your hips?". Finally when asked "Do you have a large wound that is healing and dry, or an open wound that is still moist?" they reply "open wound".

The caller is then transferred to a medical practitioner/specialist in the field of amputation and wound treatment.

(NB: This use case scenario is based on existing coded MMER system programmed by Kira Intrator & Luke Read at the University of Central Florida's METIL Lab under Dr. Metcalf)

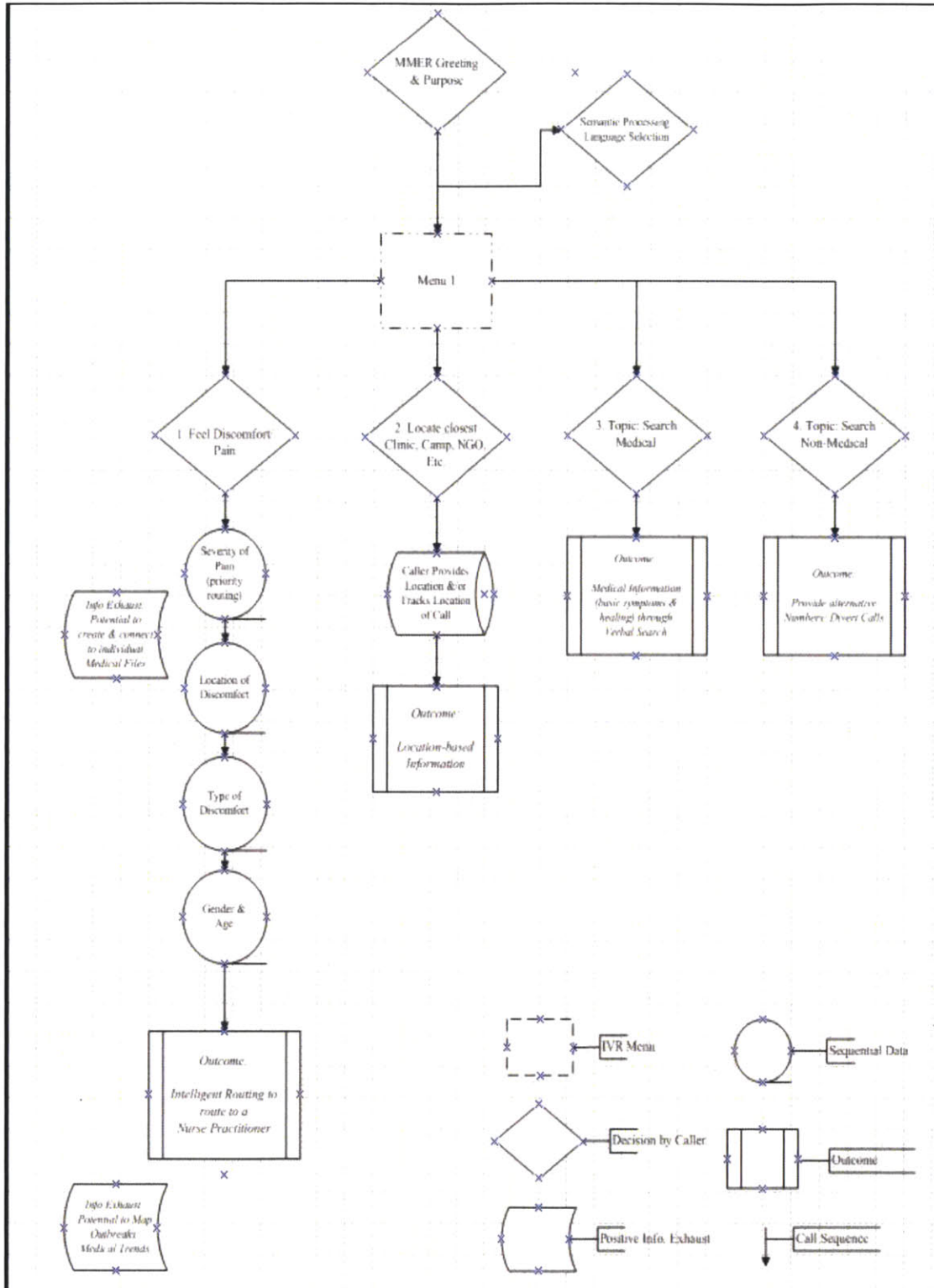


Figure 23: Draft 'Proof of Concept' IVR structure

Alternative Options

As illustrated in Figure 23, the alternate options (Numbers 2-4) provided in the menu options of MMER go beyond providing live patient to provider communication and advice. The alternative options in the menu options are: locating the closest, clinic, camp, or specified NGO (option 2 in Figure 23), a topic medical search (option 3 in Figure 23), and a non-medical topic search or query (option 4). With respect to the location of the nearest clinic or camp (option 2), the caller would provide their location and an automated response would provide them with the information of the closest service they were requesting. Given that MMER is activated and maintained during the recovery phase, information on service-providing clinics would likely be more established and mapped by organizations such as Ushahidi and the United Nations. This information would then be coded into MMER to provide callers with a verbal response. The general medical topic search would be voice-activated and would tap into a pre-recorded library of standardized messages that would conform to the humanitarian medical norms (e.g., by the World Health Organization or the United Nations). The final alternate option - a non-medical query or topic search - would inform the caller that MMER is a medically focused service and is unable to provide them with the information they are requesting (and potentially provide the caller with the name or number of another service, depending on the context/country).

Output - Crisis Mapping

A final output of MMER would be the production of user-generated, high provenance crisis maps. The data would be extracted from the database and patient logs created during the course of the call. More specifically, the information would be obtained from the responses the callers would provide to the IVR portion of their call (age, gender, location and general ailment/medical need). Major disaster relief agencies, international organizations, pharmaceutical organizations, or national governments could pay an annual fee and subscribe to the MMER mapping program. These agencies or organizations could then directly utilize MMER's maps, or sweep MMER's database (with the information rendered anonymous for the privacy of the user) to extract information to help make their medical supply chain increasingly reflective of reported need, or to inform the Ministry of Health and national government of the location, amount and type of medical need during the recovery phase. The subscription fee and crisis maps would in turn allow for these key actors to help offset the costs of the MMER system for the primary user - the disaster affected community.

6.4 Assumptions and Dependencies

One of the most fundamental technical needs of MMER is an IVR system. IVR is a telephony system that allows callers to interact with a computer using voice (speech recognition) or a telephone keypad or touch-tone. A caller's query can be responded to by following the IVR dialogue. The system is pervasive and in its simplest form can be found in small

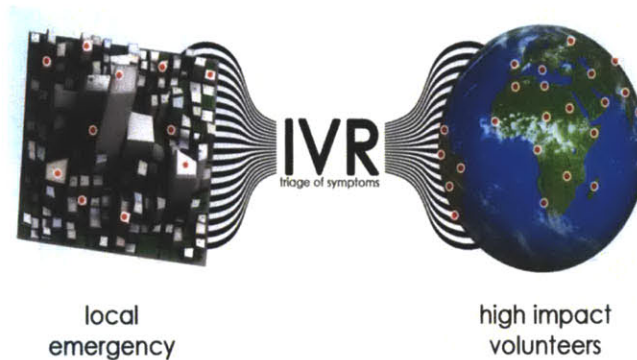


Figure 24: The IVR System is central to MMER's structure

businesses with automated attendant responses, where the caller is automatically transferred to an extension without the need for a live operator or receptionist. IVR is also used in credit card companies or banks to help direct the caller to the correct service representative, to provide the caller with up-to-date information about their account, or to offer them with a pre-recorded message that addresses their query. IVR technology is often deployed to help manage large call volumes, and to decrease up-front costs for the company (as the inquiries can be responded to without the need of incurring the cost of a live agent, who can instead be freed to deal with more complex interactions). In addition IVR systems enable users to obtain data relatively anonymously (e.g. clinics use IVR to allow callers to gain access to test results anonymously). The IVR system can also be used to collect information via survey form, in which the user is prompted to respond to answer questions either verbally or by punching the numbers in a touch-tone phone. The system selected for MMER (and hence the system that MMER is dependent upon) is the Interactive Voice Response system 'Tropo'.

MMER & IVR System Architecture

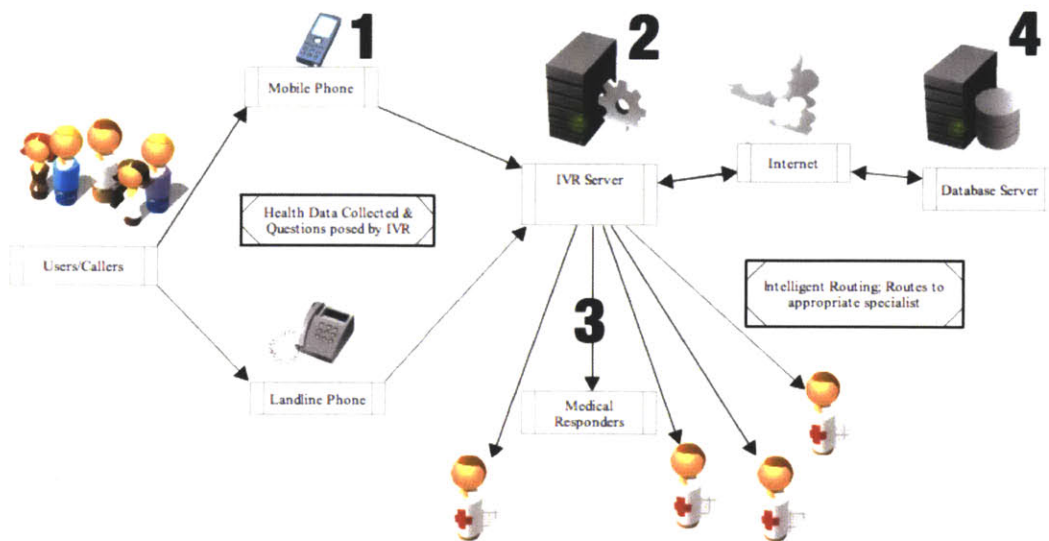


Figure 25: MMER IVR Architecture

In the case of MMER, as illustrated in the Figure 25, the IVR system architecture allows the user to call using either a mobile phone or a landline (step 1). This call is connected to and received by the IVR platform (step 2), which is essentially a server and operating system hardware on which the IVR system runs. The server recognizes spoken input (voice recognition), which it then translates into text to speech (TTS) information as an output. This output is then transferred and conveyed to the MMER responder through a database (step 3). The IVR application (in the case of MMER it is 'Tropo') then controls and responds to the calls on the IVR platform, gathering information and transferring the calls to the MMER responders (step 3). Finally, there is a need for a programmable interface that adheres to the application program interface standards, and that exchanges information among modules to facilitate the connection, or chaining, of backend services. The technology that currently responds to this need is an XML/PHP backend server that includes a database that captures the information received, storing it and transferring it to the medical responders to provide them with a basic patient profile (step 4).

Selection of IVR Application

I chose to use Tropo (see Figure 26: architectural stacks comparing Tropo to two alternative leading IVR systems – Asterisk and Tellme Networks) because Tropo has an in-built speech

recognition program in twenty-four languages and a hardware transparency layer which allows the developer to focus on the program itself. In addition, Tropo was easier to learn, navigate, program and code, therefore reducing development time. During development it was also simpler to install and execute MMER from an independent server.

Similar to the other programs in the architectural stack comparison, Tropo is based on Voice Over Internet Protocol (VoIP) – or in layman’s terms – a phone service over the internet. Voice Over Internet Protocol lowers costs¹⁴, as it is much cheaper than traditional phone services, which could be held in monopolies or be in the hands of government entities. For VoIP to work, analog¹⁵ phone signals need to be turned into digital signals over the internet. VoIP can work in regions with broadband or those that have internet access or digital telephone towers, and functions with more recent digital cell towers such as the digital and data transport enabling Global System for Mobile Communications standard (GSM) rather than the omnipresent original old copper wire public switched telephone network (PSTN) system, which only carries analog voice data, and is unable to carry digital data. The limitation of Tropo is that although it supports Session Initiation Protocol trunking (SIP), which creates a single conduit for voice and data (blending connections of voice and data into a single line), eliminating the need for separate media for each mode (Waxer, VoIP News), Tropo’s SIP system doesn’t always function properly, as evidenced by problems such as Trans-Atlantic echo.

Therefore, to enable Tropo to be more robust and have a back-up to its SIP support, part of the mapping analysis in Chapter 7 includes the identification of regions that have VoIP and internet access capacity to further strengthen and enable Tropo’s system to have further reach and resilience, and to ensure ‘species diversification’; that there is more than one type of hardware, or provider on hand upon which the MMER system can depend.

¹⁴ Familiar examples of VoIP to VoIP connections is Skype which enables users to essentially do international calls for free (or a sunk cost given internet service charges).

¹⁵ Everything we hear, including human speech is in analog form.

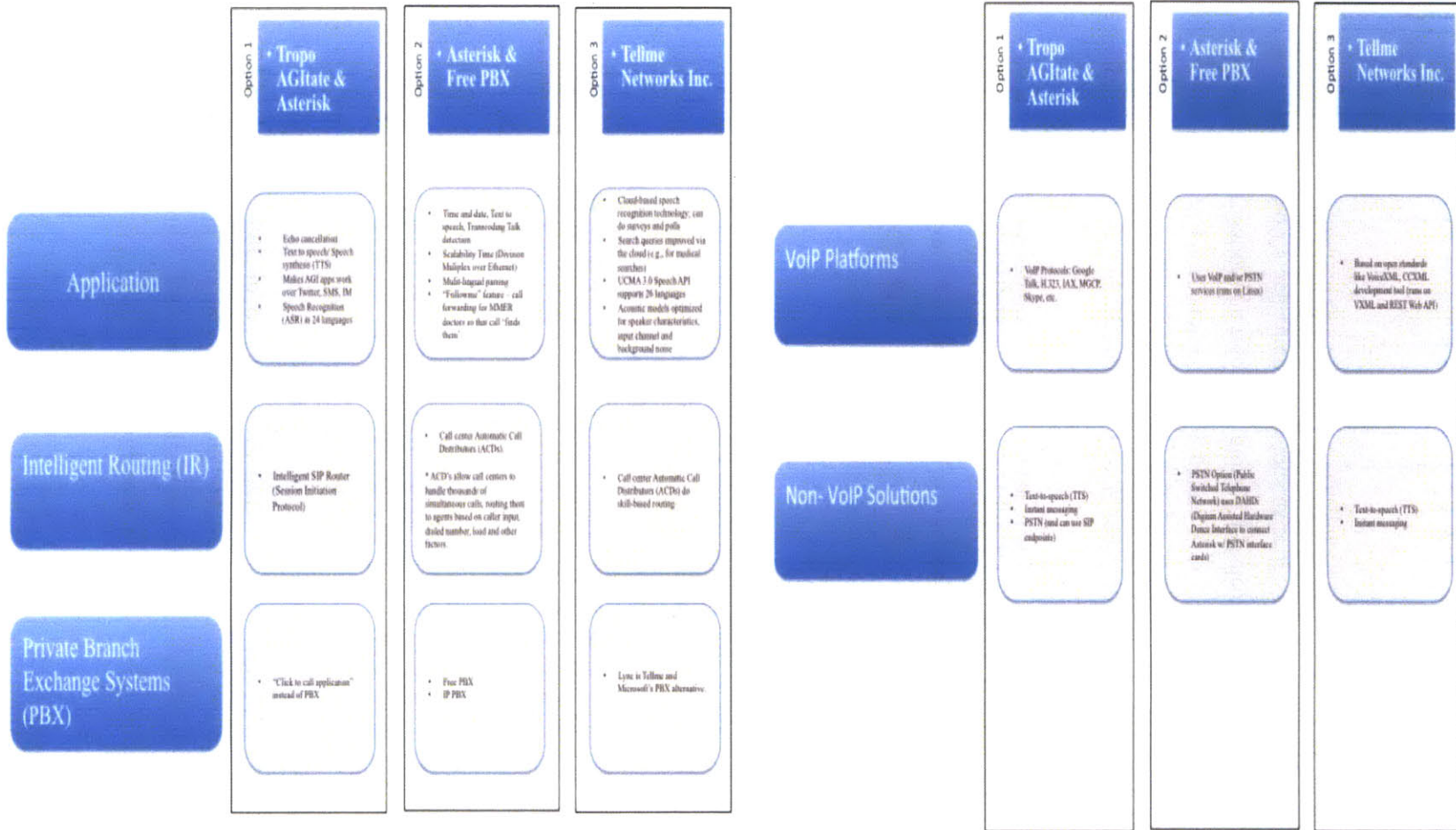


Figure 26: Architectural Stacks comparing IVR Systems

Technical Constraints

The technical limitations of Tropo is two-fold. Tropo is ideal as a proof of concept system and to undertake usability studies. However it is constrained by its lack of scalability and robustness to handle thousands of calls (Dr. Steve Chan, interview, March 2012). Second, when compared to Asterisk, Tropo has more limitations in its ability to connect to the legacy network and omnipresent public switched telephone network (PSTN) system, whereas Asterisk does so with more resilience and robustness (Dr. Steve Chan, interview, March 2012). Asterisk's modular and open source architecture (or 'development platform' approach in which the architect can create his/her own voice communication server) allows it to interoperate more readily with standards-based telephony equipment.

Another potential constraint is the ubiquity of mobile phones and the speed of change from analog to digital, GSM, and 3G to 4G. Therefore, MMER is structured in a modular fashion; in other words general parameters and technological needs are outlined and the corresponding current technologies are selected. However, the technologies selected (e.g., Tropo, having MMER be voice-enabled, the absence of photo/video diagnosis) are due to current infrastructure, costs, cell phone tower capabilities in developing countries, and needs, rather than in anticipation of future mobile phone penetration, increased access to bandwidth and data, decreased cell phone costs, and increasingly sophisticated cell phone models. Thus the limitation of the current system design is that the technology selected could be dated in five to ten years, but its advantage is its modular nature. Thus there is a distinction made between general parameters and functional needs (such as the need for a routing system that handles large call volumes at low cost) and the specific current technologies employed (like the IVR system 'Tropo').

A final technical constraint would be that access to mobile cell phone towers may be limited or restricted due to damage post-disaster (even during reconstruction). However, as previously stated, at that time cell phone towers/mobile phone lines would be running prior to landlines. Given post-disaster limitations on resources, money, and electricity the user would likely need to make calculated trade-off's and careful decisions as to if - or when - they use MMER, as the system would tap into their cell phone battery and phone credit.

Next Steps

Having established the structure, core purpose and mechanics of MMER, in addition to elucidating the user cycle and the technical dependencies of the MMER system, we are prepared to receive feedback from disaster relief and technology professionals on the concept and implementation of the telephony system. Furthermore, we will layout the structure of MMER's pilot test and hone in on and conduct a site selection analysis of where MMER could function, be used, and have its value maximized in Haiti.

7. EXPERT INTERVIEWS, SITE SELECTION & SURVEY DESIGN

Interviews were carried out with four expert humanitarian disaster relief professionals, each of whom brought to the fore a different set of experiences, skills, and perspectives. The goal of the interviews was to get grounding and feedback from experts with deep field experience in disaster relief and recovery in the implementation and use of humanitarian technologies, and to obtain critical feedback on the MMER concept.

The second segment of this chapter (as of section 7.2) moves from the vetting of MMER and the insights provided through the expert interviews, to the design and construction of a pilot study that consists of a GIS-grounded site selection analysis and a usability survey design. The interviews, combined with the plan and structure of the pilot study, provide a framework for the third and final stage of research for MMER: pilot/usability studies, scalability analysis, and technological testing that in sum will allow for MMER to be implemented, and for its impact to be realized.

7.1 Interviews

Background Information on Expert Interviews

My first interviewee is **Jennifer Chan** (August, 2011), an author of Harvard Humanitarian Initiative and UNOCHA's joint report on *Disaster Relief 2.0: The Future of Information Sharing* (2011). In this report Ms. Chan focuses on the use of humanitarian technologies in the aftermath of Haiti's disaster; in addition Ms. Chan served as a medical practitioner in one of the largest rehabilitation field hospitals in Haiti post-disaster (in January and March 2010). She thus brought to bear both direct humanitarian medical aid experience and a technological understanding of the relief efforts. Ms. Chan knew how to use open source disaster relief technology (which she carried out for Ushahidi) for evaluation, in addition to her research focus on the interface between volunteer and technical communities with humanitarian agencies.

The second interviewee is **Nigel Snoad**, who has a unique background in both disaster relief technology creation and dissemination, having worked in Microsoft in crisis communication development, and as current Director of Google's disaster relief technology unit. Dr. Snoad has more than a decade of field experience in disaster recovery as the Information Management

Strategy Advisor of the United Nation's Office for Coordinated Humanitarian Affairs, and as the head of the United Nations Joint Logistics Center mission to Indonesia during the 2004-2005 Tsunami response.

Third is **Jacobo Quintanilla**, the Humanitarian Director for Internews, who not only has vast experience dealing with disaster recovery communications within Haiti, but also provides a nuanced understanding of crisis communication, and the power of, and need for, the voices of locals to be heard through local media.

Finally there is **Jemilah Mahmood**, the former Chief of the Humanitarian Response Branch of the United Nations Population Fund (UNFPA), who oversaw the agencies' emergency preparedness in addition to humanitarian and recovery responses in both complex and natural disasters. Ms. Mahmood brings a unique community-centered approach, through which she promotes capacity building as a critical component for continued community preparedness and resilience in the face of natural disasters.

Medical Feedback and Implementation of MMER - Jennifer Chan

The main themes that emerged from the interview with Jennifer Chan were: first, the dynamics and changes of clinical capacity on the ground and the technology used within this field, and second, feedback on the implementation of MMER. With respect to the first, Ms. Chan highlighted that measuring the feasibility of a clinical activity on the ground was not simply a clinical matter, but also involved logistics. For example, one of the major obstacles and issues Ms. Chan raised was the dynamics of knowing the existing abilities of medical clinics on the ground (so as to properly transfer patients, and to accurately suggest clinics to patients for follow-up treatment). She explained that the capacity, services, and resources of clinics in Haiti, with respect to medications, human resources, and structural ability, changed weekly. There was no reliable way to know or to understand "what the actual resources (in the clinics) were because they were so dynamic" (Jennifer Chan, Interview, August 2011).

With respect to the use of disaster relief technology, Ms. Chan stated that the technology that she utilized the most and thought worked the best, (especially in her position as patient transfer coordinator, among other jobs) was the Open Street Map application. The reason she thought it functioned well in the field was because "it was simple, and easy to find". Simplicity thus reigned over "high resolution satellite imagery (which) would have had no use...it would just have been noise...knowing that there was a bush in a certain location would not have been that useful"

(Chan, Interview, 2011). Ms. Chan thus stresses that the usability, simplicity and applicability of the disaster relief technology was of the highest import, above those with higher resolution or more sophisticated technology (i.e., crowd sourced data over satellite imagery for map rendering). As a health provider, clinician and manager of operations at her field hospital, Ms. Chan was also sensitive to the issues of interoperability and profusion of technology. Ms. Chan highlighted this issue as a real challenge: “what I noticed was that many people were creating many technologies all at once (e.g., patient tracking systems)”. However it wasn’t for lack of quality of the concept or idea, but rather the lack of interoperability and integration that was an obstacle – “there were amazing ideas but they were not coordinated together; all of a sudden things were cropping up left and right... They were just causing plumes of information from which it was challenging to cull or to make decisions from.” (Chan, Interview, 2011)

Feedback on the MMER System

Ms. Chan suggests that the types of cases or needs that MMER patients would have during the recovery phase of disaster relief would be for on-going physical therapy or consideration for the removal of external fixators (i.e., post-amputation guidance and care). More specifically, Chan stated that the best types of case studies or pilot tests – which coincidentally were coded into the MMER prototype – were cases for cholera, diarrhea, and help with follow-up amputation care. Other types of case studies that Chan suggested testing for were child malnutrition, lower respiratory tract infection (she noted that she often sees pneumonia cases in post-disaster crisis situations), and obstetrics care. More specifically, in the case of obstetrics care Chan saw cases of “impending labor and post partum hemorrhage”. In cases such as these Chan stresses that what is of import is “matching resources with the request”. Thus Chan recommends that these calls and first stage diagnoses also be coordinated with hospitals, clinics, and resources on the ground. For example Chan describes that “if there is a child with diarrhea who is not alert or interactive” the system could match the caller and find “an existing clinic that most matches the resources needed for the patient, like the pediatric hospital St. Damiens, in Haiti.” This harks back to Chan’s original suggestion – that MMER could provide critical medical information, referrals, and suggestions, but it also could potentially provide and match the caller with the ever-changing and dynamic resources and clinics present on the ground.

An element that was both vital in her experience as clinician and in her feedback of MMER was that of setting expectations for the patient, or in the case of MMER, the caller. She highlighted that setting the caller’s expectations is essential, as a “lack of clarity leads to...unexpected effects,

whether it is a lack of response or a lack of information provided...it inevitably leads to frustration.” Therefore Chan suggests that both the messaging within the call and the campaigning for MMER set expectations of “what can and cannot be done with the tool at hand.” She further states that in her experience “this [method] has had positive results”. As outlined in the system design of MMER, both the messaging within the user cycle when the call is activated, and the outreach and marketing of MMER clarifies MMER’s role and sets the user’s expectations to what type of information (rather than a final diagnosis) the call can provide.

Finally, in order to optimize MMER’s infrastructure and the results it would provide, Chan suggests training the volunteer clinician responders in Disaster Relief operations. Chan highlighted that the best type of physicians MMER could host were those who, in addition to having an MD, would have field experience and/or a Masters in Public Health. Moreover “providing trainings (in disaster relief operations) would really maximize the volunteer medical community,” by giving them an awareness of “other realities, not only in developing portions of the world, but in general humanitarian disaster relief settings.”

In summary, Chan was very supportive of MMER and stated that it has “great potential” and that “I definitely see potential for how MMER could be integrated” into post-disaster recovery operations. With respect to future work and testing of MMER, Chan mentioned that “one of the things that I found very helpful in other types (of disaster relief technologies) – for example the work I did for Ushahidi across sectors – is exactly what you are doing: writing a proof of concept, doing pilots, then examining the non-technical side of how these things work.” The pilot survey presented in the latter part of this chapter, serves this purpose: it will examine the user base, their needs, and provide feedback on the MMER service. Furthermore, to merge “human communication systems with technology” Chan underscores that “what is remarkable is finding out what can or cannot be done earlier on, and that is what you are doing – talking to other groups, seeing what has worked, what has not” (Chan, Interview, 2011).

Overview

Ms. Chan provided medical perspectives and ground truths for MMER. As illustrated in Figure 27 (see branch section under ‘Jennifer Chan’) she discussed the need to set callers’ expectations, and the need for MMER’s volunteer responders to be trained in disaster relief operations. The remaining three interviews helped bring to light key themes (see Figure 27), specifically around the use of humanitarian technologies and MMER. These themes can be categorized as follows:

disaster relief trends and challenges (Dr. Snoch), the role of technology in a disaster relief setting (Quintanilla), and community involvement (Mahmood) (see Figure 27).

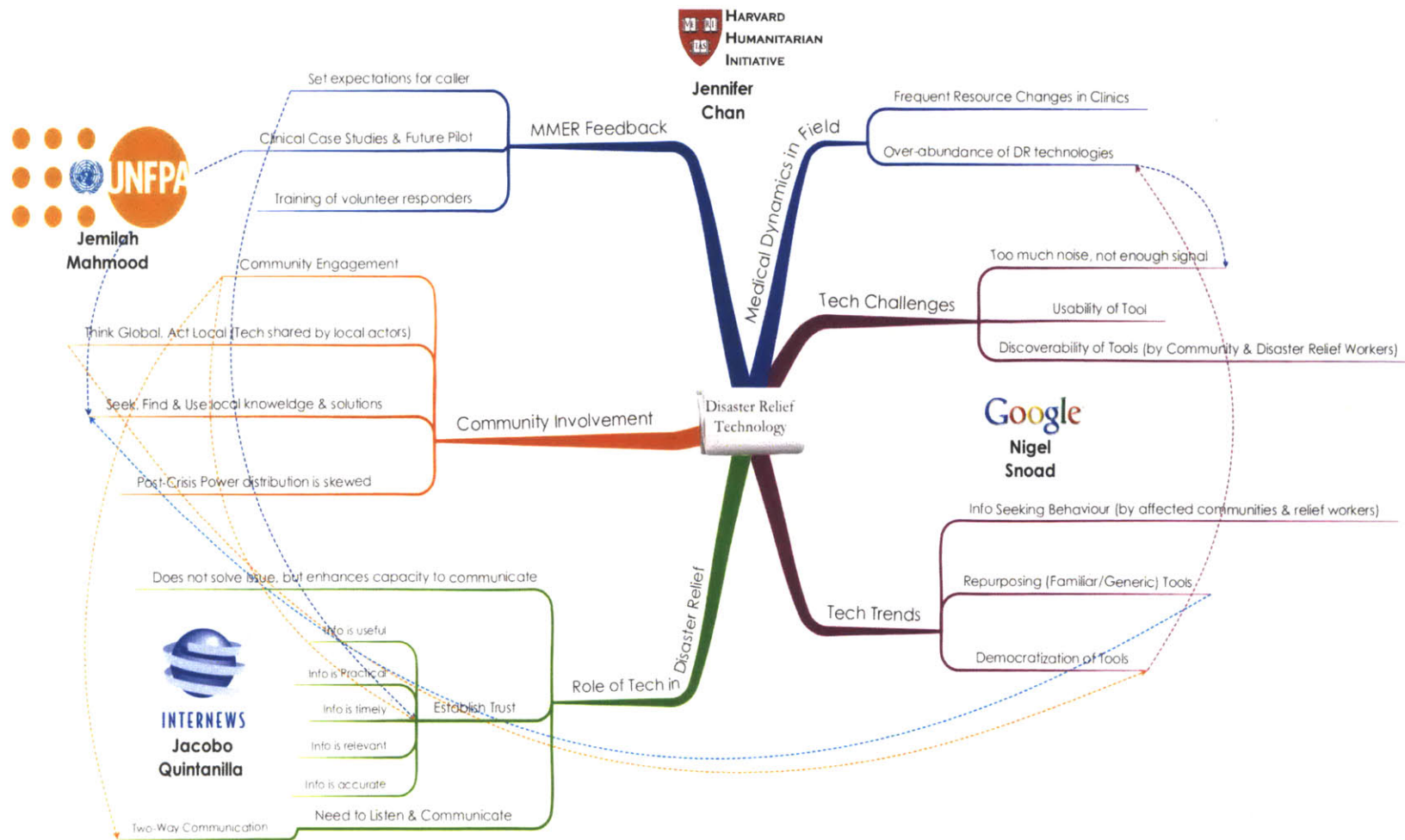


Figure 27: Summary of Interviews with Disaster Relief Expert

Disaster Relief Technology Trends - Nigel Snoad

In an interview conducted on July 2011 with Dr. Nigel Snoad, he stated that one of the most interesting trends was the “democratization of tools”, in which you get non-professionals setting up and making use of sophisticated tools quite quickly. One such example was a Haitian businessman setting up *Noula*, and the formation of community-based crisis maps with accurate depictions of camp settlements that integrated and used simple spreadsheets, maps, and social networking tools like Facebook (Wall, 2011). One of the foundational issues Dr. Snoad underscored was how to make disaster relief technology both *usable* and *discoverable* (see Figure 27) so that individuals like the small businessman in Haiti could make use of, and leverage that same technology in a creative and impactful manner. In the generation of new humanitarian aid technology, Dr. Nigel Snoad states that usability is massively under-thought with respect to design, and that there is a general absence of user feedback and usability studies in the dissemination of new tools, thus limiting their use and adoption (Nigel Snoad, Interview, July 2011).

Conversely, there exists the issue of discoverability for humanitarian aid workers and professionals who seek to ‘discover’ the information and tools that are being generated by the affected communities and citizens on the ground. Thus the system of discoverability is not simply one in which affected communities seek to find what is being generated by disaster relief agencies (i.e., a top-down approach) but is also a problematic that exists from the ‘bottom-up’ where technologists and relief workers seek and try to find what innovations and information creation are happening on the ground. Hence Haitian citizens started to have technological avenues for the amplification of their voice and expression, through both the democratization of technology and through the repurposing of existing tools. Yet a complicating factor was that of “too much noise, and not enough signal” – in other words that there was an overload of information with neither a filter for prioritization, nor a framework for controlling the quality, type, and often the source of incoming in-field information. Moreover, this unfiltered information overload was compounded by the fact that “there is still very little standardization of disaster relief tools” (Snoad, Interview, July 2011) so that the stream of information being generated was not only of varying quality, but also of varying format and type.

According to Snoad, another truism of disaster relief technology applications is that “in an emergency people fall back on the tools that they use everyday.” Thus *repurposing* existing tools

becomes key, rather than the false assumption that “if you build it, your users will come.” (Snoad, July 2011, interview). Hence Dr. Snoad believes that what ultimately ‘wins’ or will be utilized in emergency and disaster relief responses are generic systems that individuals already know how to use. With respect to repurposing in the case of MMER, Snoad believes that the success of call centers utilized by the Red Cross for camp operations and displaced populations in Haiti, could be translated into the success and the launch of MMER (as a medical type of call center and information management system). Snoad underscores that in his experience the Red Cross call center in Haiti “worked extremely well”, as did those he witnessed in Sri Lanka a few years prior - “We keep doing these call centers (where communities affected by disaster can call in and pose general questions to the agency), and it keeps being very successful. But we keep being terrified to do it – of exposing ourselves to criticism. It was shown to be very valuable to the communities it served, to serving them and their queries. I still don’t understand why it is not a standard operation in relief efforts” (Snoad, Interview, July 2011)

In line with Ms. Chan’s suggestion, Dr. Snoad suggests that the next steps for future work and testing of MMER would be to prove that there is a value gain for the users (e.g., shortening wait time in clinics, increasing the accuracy of diagnoses, providing life-enhancing and life-saving information). In addition, Dr. Snoad suggests both field-testing and showing that MMER can work both culturally and technologically in field. The first of these is covered by the usability survey, which analyzes responders’ familiarity with the IVR service and their access to health services (see Section 7.3). The second dimension – a technological proof of concept – would be carried out through a technological trial of MMER’s robustness in field. In other words, the trial would primarily test MMER’s ability to handle and route significant call volumes, utilizing medical cases described by Dr.Chan, in the field.

The Role of Communication Post-Disaster - Jacobo Quintanillo

Jacobo Quintanillo is the Humanitarian Director of Internews, whose mission is to “empower local media worldwide to give people the news and information they need, the ability to connect, and the means to make their voices heard” (Internews.org, website, 2012). Their mission is based on capacity building for local communities, and emphasizes the power of having the voices of locals be heard through their own sources of media. Undergirding Quintanillo’s work is his belief that the best form of communication “is face to face” and that media and “technology can enhance the capacity to communicate and listen.” Quintanillo is careful to state that technology is

not the panacea: “it is not a solution, but an avenue to enhance communication”. Therefore for Quintanillo the use of technology for communication in relief situations is “fundamentally about trust” (Jacobo Quintanillo, Interview, August 8, 2011).

When asked how one can establish trust through media or technology sources (as Quintanillo helped establish one of the most trusted and popular daily Creole news programs in Haiti called “Enfòmasyon Nou Dwe Konnon,” ENDK, or “News You Can Use”), Quintanillo responded that it was about building confidence with the listener or user. One does so by “providing a professional service and product that the user relies upon. It must be useful, practical, timely, accurate and relevant to build confidence and trust” (Quintanillo, Interview, August 2011). Specifically, the form of communication that Quintanillo supports during recovery is a two-way form of communication; one that both listens and responds to communities, rather than a one-way form of communication that “tells people what to do”. A two-way form of communication is about “building transparency and accountability”, and for the latter to occur “we need to be able to build up ways to effectively listen and communicate with communities.” Quintanillo warns that if we do not both listen and communicate and establish an open and transparent form of communication “people will disengage from your message (or system) from day one” (Quintanillo, Interview, August 2011).

However, Quintanillo is not unilaterally opposed to all forms of one-way messaging. He cites advantages of this form of mass messaging at the onset of an outbreak or acute emergency (Quintanillo is careful not to call this one-way system a form of ‘communication’). Quintanillo states that an advantage to one-way messages is that they can provide “a clear, unified message to prevent confusion and contradictory messaging”. In this vein, Quintanillo provided me with a great idea - to integrate the provision of one-way messages (such as standardized public service announcements) into MMER if the caller opts out of communicating with a medical responder. In other words, a standardized pre-recorded ‘library of messages’ from the United Nations Cluster system (a project currently being built out by the various Cluster groups, starting with water, sanitation, and hygiene) could potentially be applied within MMER’s IVR pre-recorded system.

Quintanillo concluded our interview with the following suggestion for MMER: “If I leave behind one word today it is institutionalization. Make sure that someone believes in the MMER concept and get an organization to use it, pilot it, and adopt it.” Specifically he suggested organizations such as the International Rescue Committee, Médecins Sans Frontières, and the International Medical Corps.

Jemilah Mahmood - Community Involvement, Local Knowledge and Dissemination

Jamilah Mahmood, at the time of the interview, was Chief of the Humanitarian Response Branch of the United Nations Population Fund (UNFPA). “When you want to start a system, the most important factor...is that the service must be localized. I always have this philosophy – ‘you can think global, but you must act local’, and for health especially you cannot give a diagnosis, provide information or advice without actually seeing someone”. Mahmood urged that for MMER “you have to find a way that this [MMER]...is shared by all the local actors rather than just an external environment”. Dr. Mahmood applies this concept to the way in which affected populations are treated and viewed post-disaster “...you need to think ‘local’ all the time...affected populations are not a homogenous group...there are layers of complexities and various ethnic groups that come into play” (Jamilah Mahmood, Interview, July 2011).

Dr. Mahmood also believes that community engagement is key to long-term disaster relief preparation, recovery and resilience. She specifies, however, that “community engagement is only useful if you can track influence...to see who or what in the community leads to influential change (such as policy or programmatic change), and which voices are not being listened to.” She concludes that most often “it is the most vulnerable that don’t get their voices heard.” The ‘expert blind-spot’ occurs “when individuals come in and see things from their point of view and they are unable to see the holistic picture and the solutions...because often the solutions are found within the community itself.” Dr. Mahmood stresses the point that the international community (or disaster relief agencies) must look at the locals as being the ‘prime movers’ in emergency response, recovery and preparedness.

Therefore the dissemination of disaster relief technology must be one that builds capacity within the community, and ideally integrates, identifies, and utilizes local solutions and knowledge (Mahmood, Interview, 2011). With respect to the form that the technology takes, Dr. Mahmood – similar to Dr. Snoad’s concept of ‘repurposing’ the familiar – believes that for inclusivity purposes, using the simplest and most accessible technology is best.

Finally, similar to Dr. Snoad, Dr. Mahmood underscored the success of call centers post disaster “the call center was the only service with one hundred per cent satisfaction rating by affected populations.” As mentioned in both Chan and Quintanillo’s interviews, Quintanilla also states that expectations of the user/caller need to be established and clarified.

Design Implications

Having established the viewpoints of four leading Disaster Relief professionals on the concept and construction of MMER, we must now turn to and summarize their feedback and its effect upon the construction of the pilot test study, and the future work in the dissemination and continued testing of MMER.

Jennifer Chan's uses her rich experience in working in and helping operate a major field hospital in Haiti, and her research in medical needs post-disaster, to provide examples of case studies that could be implemented and tested for and by MMER. A potential design implication of the post-disaster ailments Chan most frequently observed is that MMER's IVR system could be specifically programmed to handle the most frequent of these disaster-induced needs. This could be enacted by the IVR system being more rigorously trained to pick up key words associated to these ailments through its voice recognition software and to enable more effective triaging at the backend with respect to such ailments. Moreover, Chan provides specific medical suggestions for the use of MMER, which range from obstetrics through to amputation and pneumonia care. These suggestions will likely be applied in the 'technological' testing phase of the MMER system, which will test the robustness of the technological components of MMER, while utilizing specific case studies and medical scenarios to dive deeper into user feedback and usability studies. Moreover, she mentions that the volunteer responders must be trained in disaster relief logistics and scenarios – an element that will be added to the overarching sustainable business plan and management strategy of the MMER system.

Quintanillo underscores the importance of 'institutionalizing' MMER so that it can be adopted, piloted, and streamlined within the operations of an established and respected international medical relief agency. I will utilize this suggestion in my partnership analysis within my business plan for MMER. In addition, Quintanillo suggests tapping into the United Nation Cluster's 'library of messages' – an idea that fits in perfectly with MMER's menu option to conduct a voice-activated medical search of pre-recorded messages (see Figure 23, p.62).

Both Chan and Dr. Mahmood highlight the need to set expectations for the use of MMER for the user/caller. This is reflected and implemented into the system design of MMER through the front-end automated 'welcome' message imbedded within the IVR system, in addition to the format of the outreach initiatives.

An important perspective upheld by both Chan and Dr. Mahmood is that the MMER service must fit and match with the realities of the ever-changing and dynamic resources of clinics on the ground. This is addressed by having users – such as having local in-field nurses and doctors – calling in to use MMER’s services (e.g., potentially conduct a medical search on the pre-recorded medical topics etc.) Further, the idea of having MMER provide a match for the caller to a clinic on the ground is reflected in the system design as the caller having the ability to request a location of a service provision facility such as nearby clinic or camp. The information for the live medical practitioner to provide the caller with the nearest clinic is therefore already present. Future work can be done to improve this functionality, for example by creating an automatic weekly call through the IVR system to collect basic information on the human and medical resources clinics currently have on hand.

Dr. Snoad’s framework of usability, discoverability, and repurposing has been applied to the design of MMER. The survey design and questions begin to address the issue of usability (i.e., the challenge that the majority of disaster relief technologies do not undertake usability studies). Second, the issue of discoverability was covered in the design of ‘outreach’ initiatives and strategies in the design of MMER. Third, the concept of ‘repurposing’ could be considered addressed with prior exposure and experience with IVR technology (with calling banks or small businesses) and with the prior exposure to general call centers by users.

With regard to call centers, Dr. Mahmood and Dr. Snoad’s underscore the success of call centers in post-disaster situations. They both agreed that the information hot-line or call center concept, implemented post-disaster by international agencies in both the 2005 Tsunami, and in Haiti’s 2011 earthquake, generated high satisfaction ratings by recipients of the service (i.e., the communities served), yet both Dr. Mahmood and Dr. Snoad stated that the idea of call centers as a reoccurring practice had yet to be made a standard, and scaled in disaster relief logistics. They further related the role that call centers had played in the past, to the potential MMER could play in the future.

With respect to the future implementation and testing of MMER, Chan affirmed that the path that MMER is currently pursuing is one that will help ensure a robust proof of concept and ‘test’ to help ensure MMER’s success. Chan stated that for MMER, this would include writing a proof of concept, setting up a pilot test (or tests), examining the non-technical dimensions of MMER’s implementation and interviewing other experts to examine post-disaster conditions and needs, in

addition to researching disaster relief technologies to see what has or has not worked on the ground.

Finally, Mahmood's 'think global, but act local' is embodied in the usability survey design, which serves to examine a specific communities' access and use of mobile phones, health care services, and feedback on the MMER concept.

7.2 Site Selection/GIS Criteria

Having collected, evaluated, and culled feedback on MMER from disaster relief professionals with deep field experience in post-disaster medicine, technology, communications and community engagement initiatives, we now turn to the pilot study of MMER. As underscored by Dr. Mahmood, disaster relief technology such as MMER needs to be localized (i.e., adapted to the needs of the local culture and needs) in addition to being location- and context-specific.

In order to allow for a context-specific roll-out of MMER, an overlay of various data on Haiti - through geospatial exclusion - will be carried out to determine if the technical needs and voice-enabled advantage of MMER are met. This will be done to locate a site-specific region in which MMER can function and best be utilized in Haiti. To analyze the technical robustness and functionality of MMER, geo-referencing data and maps of two leading cell phone companies and tower locations in addition to back-up Internet access by 'department' was mapped and overlaid in GIS (Geographic Information Systems). Second, as illustrated in the site selection map (Figure 28), Haiti's literacy levels (recorded from Haiti's most recent census of 2003) are divided into and mapped onto Haiti's nine departments ("départements") to further define Haiti's spatial distribution of literacy. Specifically, the three departments with the lowest literacy levels are Grand-Anse and Sud-Est, with adult literacy levels of 37%, and the department of Centre at 42.4% literacy, closely followed by Artibonite at 44.8% (with the most pronounced gender gap being in 'Centre' with 33.6% literacy for adult women, and 42.4% for men).

Finally, to find both the location for the pilot, and to understand the context in which MMER would and could function within, local needs, culture and existing health-service access need to be identified and understood (Jamilah Mahmood, Interview, 2011). This will be conducted through the creation of a four-part survey (see section 7.3) that will be distributed and completed in the selected region.

Regions of Interest:

As illustrated in Figure 28, for technical specifications, and to ensure the resiliency of MMER's application in Haiti, I selected Digicel and Voila – the two biggest telecom companies in Haiti for current and redundant cell phone coverage data. Access Haiti, a major internet company was also mapped to provide back-end support and robustness for the IVR/Tropo system that MMER is currently built upon. I finally examined and highlighted areas of high illiteracy, and circled the three regions of highest interest (i.e., regions that displayed technical robustness and resiliency for MMER in addition to high illiteracy rates):

- In the 'Sud' department (near Les Caynes) there is current internet coverage (Access Haiti) in addition to Voila and Digicel network coverage and literacy rates below 50%
- In the 'Artibonite' department both the centers of Saint-Marc and Gonavies have redundant cell phone coverage and Access Haiti Internet access.
- Given the department of Grand D'Anse's historically high illiteracy levels (at 63% adult illiteracy) and its redundant cell phone coverage, in addition to Access Haiti's plans for 'future' coverage of the city of Jeremie, I would select this as a third possible site to carry out a pilot study.

MMER Haiti Site Selection

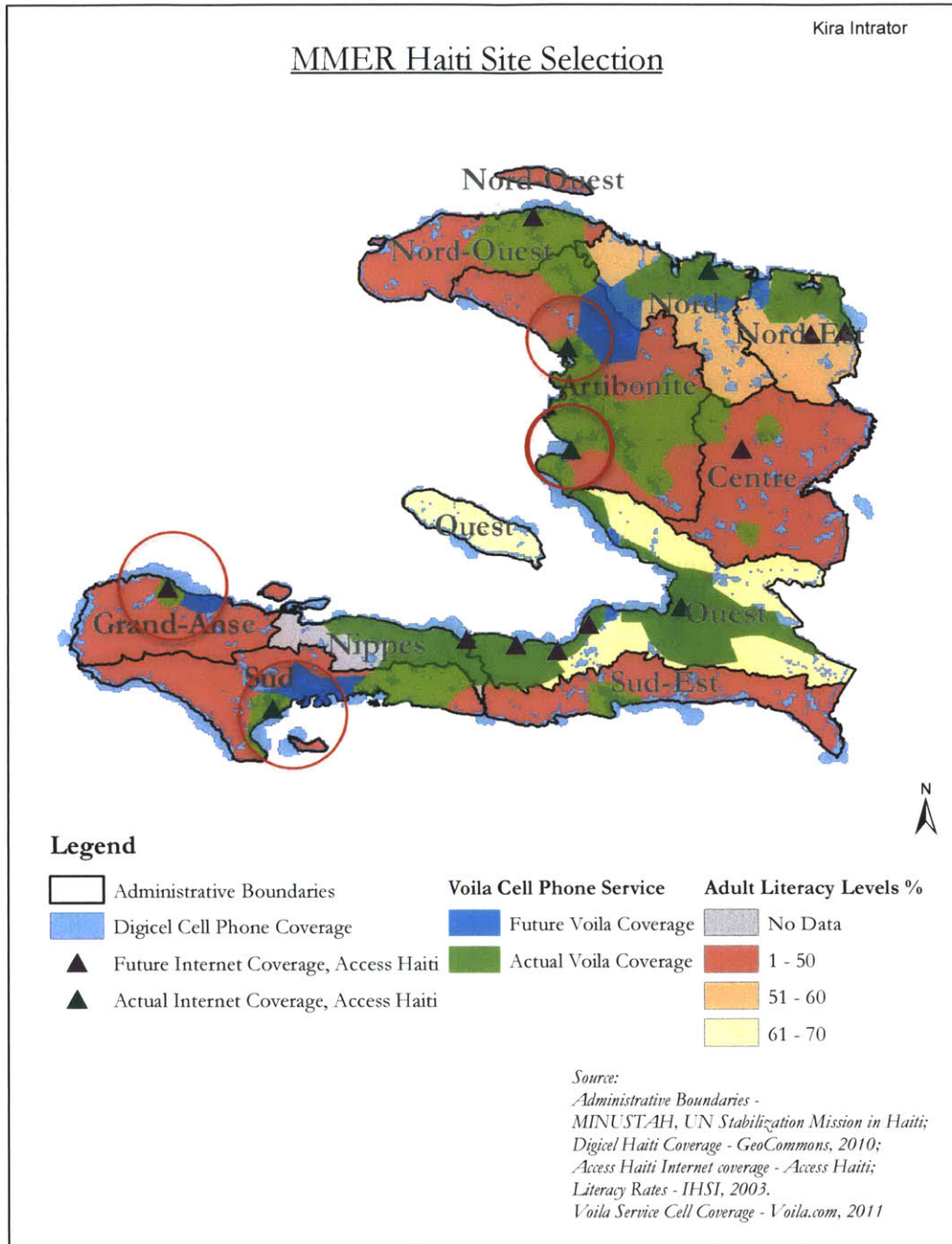


Figure 28: Site Selection Map, Haiti.

7.3 In-field Study & Survey

Having selected three regions of interest in which the pilot would be carried out, we now turn to the objective, methodology, and structure of the survey/study that will be conducted in Haiti¹⁶. The survey is a mixture of quantitative profile and demographic information, and includes open-ended questions in addition to multiple-choice questions on health care access.

The initial pilot survey and project objective is twofold: first, to assess the target population's access and use of mobile phone technology, and second, to assess their access to medical services and health care (the latter is a suggestion provided by Dr. Snoad; Interview, July 2011). After the pilot survey is complete, processed, and analyzed, user feedback on the MMER concept and application will be collected during the technological testing phase with the complete prototype of the MMER application (See Appendix One for sample questionnaire, and Chapter Eight for timeline). At the front-end, basic demographic and quantitative profile data will be collected from the interviewee, including age, gender, level of literacy, living situation (e.g., temporary, camp, permanent), and location of residence. The demographic data will not only provide context as to the interview sample, but will enable us to break down and compare the feedback and information provided by markers such as age, gender, or level of literacy. This will be conducted first by understanding the survey interviewees' current use of mobile technology, and then by examining whether individuals would benefit from MMER. The survey methodology (i.e., the way in which the assessments will be made) will be to determine the individual's general health concerns and access to health care, and their experience with technology; specifically with regard to their use of mobile phones and prior experience with IVR systems.

Prior to conducting the survey with one or more people, the research member will obtain an informed verbal consent from the interviewee. Verbal survey data will be collected (as opposed to having interviewees fill out the surveys by hand) to ensure that illiterate or semi-illiterate individuals have equal access and ability to understand and complete the survey, with the verbal dialogue taking no more than thirty minutes.

However, key elements and decisions on the implementation of the survey would be determined at the time of the pilot, as they would be dependent on the partner organization or institute that

¹⁶ The final selection of the pilot site will be dependent on external factors such as funding, feasibility, and established partnerships. All three selected areas fit the requirements and needs of the pilot study.

would carry out and manage the survey in-field. These considerations include: the type of recruitment methods used to obtain the survey responders, the incentives or remuneration provided to interviewees (e.g., payment or non-payment), and an understanding of the type of access, relationship (and trust) the field partner has with the responders and community members. Below is an overview of the survey structure and its objectives:

Survey & Research Title:
ASSESSMENT OF CURRENT AND POTENTIAL USES OF MOBILE PHONE
TECHNOLOGY FOR MEDICAL ACCESS AND HEALTH CARE SERVICES.

Segment of the Population I wish to include in my study:
The criteria for subject selection include that the research subjects are: (a) approximately 50% men and 50% women (from a total sample size of 50), (b) that the individuals are illiterate or semi-literate, (c) that they must be over the age of 30 (to help determine technology access and those who might typically not be as familiar with texting). The participants will verbally agree to be in the study; the Committee on the Use of Humans as Experimental Subjects (COUHES) regulations and requirements will be met and followed.

Survey Objective:

- *Assess Current Use of Mobile Technology.* Do the interviewees own or rent their mobile phones? How accessible is their mobile phone? Do they feel at ease using a mobile phone (and in what capacity/use)? What is the primary use of their mobile phone? How does technology fit into their life?
- *Assess Access to Health Care* What is the interviewee's current access to healthcare? How do they access healthcare? Whom do they see to address their health issues?
- *Assess whether or not the interviewees would benefit from MMER.* How, or in what circumstances do they see themselves using an application like MMER? Do they have feedback for the concept, idea or design of MMER?

The MMER pilot survey adapted three questions on health care access from New York City's Community Health Survey (Community Health Survey, 2010, NYC Department of Health and Mental Hygiene, Bureau of Epidemiology Services, New York¹⁷). Examples of these questions are as follows:

1. **Question** - Would you say that in general your health is excellent, fair/average or poor?

¹⁷ NYC Community Health Survey, 2010 (NYC CHS), CHS Coordinator, NYC Department of Health and Mental Hygiene Bureau of Epidemiology Services 125 Worth Street, Room 315, CN-6 New York, New York 10013

2. **Question** - Do you have one person or more than one person you think of as your personal doctor or health care provider?
 - a. INTERVIEWER PROBE IF “YES”: Do you have only one or more than one?
3. **Question** - Do you have a doctor or other health care provider you see regularly if you are ill or need a checkup?

The survey also used as a reference a National Science Foundation study research protocol and technology assessment model (Bagozzi, 1992) technique used by the Mixed Emerging Technology Lab at the University of Central Florida in a study they conducted in Haiti in 2011 to assess mobile technology use and inter-agency coordination. Finally, the survey structure, length, and questions were reviewed and vetted by an MIT Community Innovator’s Lab affiliate based out of Port au Prince, Haiti.

Sample Survey

I. Demographics¹⁸

1. What is your gender?

<input type="checkbox"/> Male
<input type="checkbox"/> Female
<input type="checkbox"/> Other

2. What is your age?

<input type="checkbox"/> 18-20
<input type="checkbox"/> 21-30
<input type="checkbox"/> 31-40
<input type="checkbox"/> 41-50
<input type="checkbox"/> 51-60
<input type="checkbox"/> 61-70
<input type="checkbox"/> More than 70

3. Can you read or write in Creole?

- i. Yes, I can read and write in Creole
- ii. Somewhat, I can read signs and numbers
- iii. No.

4. Can you read or write in French?

- i. Yes, I can read and write in French

¹⁸ The structure of the ‘Demographics’ survey section was taken from, and based upon the University of Central Florida’s Mobile Phone analysis survey, supported by the National Science Foundation, 2011.

- ii. Somewhat, I can read signs in French
- iii. No.

5. Are you an original resident of this department or did you move here from elsewhere?

- i. Yes, original resident
- ii. No, I moved from another region of Haiti to here

6. What is your residence type

- i. I live in a refugee camp
- ii. I live in a temporary settlement
- iii. I live in a permanent/rebuilt house
- iv.

II. Cell Phone Access & Usage

1. Do you have access to a phone

- i. Yes, I own one
- ii. Yes, I rent one
- iii. Yes, my family owns one and we share it
- iv. No
- v. Other (explain) _____

2. Do you use cell phones?

- i. Yes
- ii. No

b. If YES, how often do you use the mobile phone?

- i. Every Day
- ii. Every Week
- iii. Every Month
- iv. When needed (depending)

3. Did you use a cell phone one to three weeks after the earthquake?

- i. Yes
- ii. No

b. If yes, what did you use it for?

(e.g., to receive messages, or who did you contact/why etc.)

III. Medical Access & Needs

1. Would you say that in general your health is excellent, fair/average or poor?

- i. Excellent
- ii. Fair/Average
- iii. Poor

2. Do you have a person you think of as your personal doctor or health care provider?

- i. Yes
- ii. No

b. INTERVIEWER PROBE IF "NO": How do you get medical advice or care?

3. Do you have a doctor or other health care provider you see regularly if you are ill or need a checkup?

- i. Yes
- ii. No

b. INTERVIEWER PROBE IF "YES": What kind of doctor or healer do you see?

4. **Open-ended Question:**

Are there limitations for you to access healthcare or to get responses to your medical concerns or questions currently? Please Explain.

5. **Open-ended Question:**

What were your most pressing medical needs after the earthquake struck (within a week or three)?

i. A month after?

ii. Six months after?

iii. Currently?

b. Which of these medical needs were addressed?

c. Who addressed these medical issues for you:

- i. Local Haitian clinic
- ii. International Agency/NGO
- iii. Friends/Family
- iv. Healer
- v. Other (explain)

6. **Open-ended Question:**

Is there any important health or medical information that you feel like you have difficulty getting access to?

- i. Yes
- ii. No

a) If "YES" what type of information

Pilot Study Summary

In summary, the purpose of the usability pilot survey is to gain a deeper understanding of future users' health needs, their use of and access to mobile phones, literacy level, and a deeper analysis and understanding of the context and way in which the MMER system could be employed by future users. As underscored in both Jennifer Chan and Nigel Snoad's interviews (2011), it is best to obtain feedback from both humanitarian experts and future users, in order to shape the design and development of the tool to their vision and needs.

We have now examined the feedback provided by experts, integrated these into the system design and survey design, and channeled some of these ideas into potential avenues for exploration in the future. In addition, a site selection analysis for the pilot study was carried out, and three regions of interest were identified in Haiti. Finally, a four-tiered usability survey was created and vetted.

Having completed the planning section of the pilot study, we turn to an overview of the final steps to MMER's development and implementation.

8. CONCLUSION

Summary

The first section of the thesis (Chapters One through Six) provided the **context, relevance of, and need** for MMER within the field of disaster recovery management.

I provided the limitations, challenges and overarching context of MMER by examining the coordination structure, urban complexities, technologies, and information management present in the disaster relief efforts that unfolded following Haiti's devastating 7.0 magnitude earthquake of January 2010. I then placed MMER within the context of crisis communications, history of theoretical trends, and current analyses of disaster 'vulnerability' (as exemplified by the PAR model) in the field of disaster management. I positioned MMER at the recovery phase of disaster relief within the disaster management cycle, and further associated MMER's use with the corresponding form of communication needed (through the use of mobile phones) during the recovery phase of disaster relief.

To provide the relevance of a system like MMER, I identified the growing potential for the use of mobile phone-based applications in disaster relief and recovery by affected populations in low to medium income countries. By focusing on both the fields of mobile health and the challenges and needs faced in emergency medical logistics, a technology assessment and identification of the potential for a new form of medical disaster relief technology was undertaken. I uncovered the challenges of disaster relief logistics and the medical supply chain, and consequently demonstrated the way in which MMER's crisis mapping component could respond directly to this gap.

Need and potential demand for a telephony system like MMER were addressed by mapping and exposing the prevalence of mobile phone penetration and the concurrent lack of access of illiterate communities to disaster relief technologies that are primarily built upon and dependent on short message systems (SMS); thus revealing a significant gap in existing disaster relief applications. Having established the existing gaps and need for a system like MMER, I turned to its system design and user-centered functionalities.

The second part of the thesis (commencing at Chapter Six) served as MMER's 'proof of concept'. I presented MMER's system architecture, its ability to leverage Interactive Voice Response

technology, and elements such as the outreach strategies and campaigns that would be applied prior to MMER’s activation in-field, its user cycle, and architectural stacks. The system design was then vetted and modified according to feedback provided by disaster relief professionals who were subject matter experts in disaster relief technology, community engagement, capacity building, post-disaster communication and media, in-field emergency medical care response, and disaster relief crowd sourced technologies. Finally, a site selection within Haiti was carried out using geospatial exclusion (i.e., illiteracy, redundancy of cell phone coverage, and internet access). A field test and pilot usability survey was then formulated with the guidance of the University of Central Florida’s National Science Foundation project conducted in 2011, a governmental medical access survey, and feedback provided by an MIT CoLab field practitioner based out of Port-au-Prince, Haiti.

MMER Requirements & Selection

We now turn to the evidence that shapes the particulars of how the MMER requirements were configured. The table below indicates how need (as outlined in the summary above) was translated into general parameters for MMER, and in turn what and why specific and current technologies were selected. These sets of needs are answered by front, middle-ware and back-end technologies which remain to be tested at a technological, infrastructural and institutional/human resources level. General parameters were separated from the selection of specific technologies to underscore that MMER is modular in nature; that the current technology selected is ripe and appropriate for current needs (e.g., data access, bandwidth, cell phone towers and mobile phone models with the highest penetration in developing countries). By separating the general parameters needed with the current technology selected, the table below further addresses the evolving pace of technology – that the technologies selected will be replaced with time, and that ultimately the system design is vendor neutral and technology agnostic.

PROBLEM BEING ADDRESSED	GENERAL PARAMETER	MODULAR/ CURRENT TECHNOLOGY SELECTED	ISSUES/QUESTIONS & RESEARCH PATH
Access to medical disaster relief information and technology for illiterate populations	Voice-enabled program	➤ <u>FRONT END TECHNOLOGY</u> -- IVR program with voice recognition software	Technological tests to determine quality of voice recognition software and linguistic capabilities.

<p>Connect high impact global volunteers directly with affected communities. Bypassing chaos of relief coordination</p>	<p>Telephony system (land line and mobile phone) that connects medical practitioners directly with affected communities/local health workers.</p>	<ul style="list-style-type: none"> ➤ <u>MIDDLE-WARE TECHNOLOGY</u> - IVR system: Routing system that enables connection between volunteers and callers. 	<p>Potential limitation to scaling: volunteer accessibility, volume, and length of commitment. Introduces a new channel for potential network overload.</p> <ul style="list-style-type: none"> ➤ Examine different business structures and models for most effective scaling of MMER. ➤ Examine if MMER could provide and sell backend technology to agencies and have agencies take charge of staffing their in-country MMER system (for operations, medical volunteers, etc.) ➤ Identify and form key partnerships to institutionalize MMER within an established organization.
<p>Large call volumes, call centers with human response on front-end unable to handle</p>	<p>Routing system that decreases cost of call (i.e., eliminating need to pay individual at front-end) and is resilient/robust in times of high demand and need</p>	<ul style="list-style-type: none"> ➤ <u>MIDDLE-WARE TECHNOLOGY</u> -- IVR 'Tropo' system for routing ➤ -- IVR server and infrastructure ➤ <u>BACK-END TECHNOLOGY</u> -- IBM Watson for medical triage, efficiency 	<p>Technological assessment to test resiliency and robustness of systems independently and in combination.</p>

<p>Vulnerability of Medical Logistics post-disaster. Essential to have an accurate user-generated medical supply chain analysis. Gap identified in need as latter is not currently in place.</p>	<p>High provenance and pedigree crisis maps that display reported needs, ailments and 'hot spots'. Info vital to pharmaceutical companies, governments, relief agencies, etc.</p>	<p>➤ <u>MIDDLE-WARE TECHNOLOGY</u> -- XML/PHP backend database server (to capture info generated by callers)</p>	<p>Specific software to generate maps from database collected during MMER calls to be further investigated/ determined (e.g., esri, Open Street Maps, Google Knowledge Graph, etc.)</p>
<p>Systematized and standardized health care public service announcements (standardized across agencies, orgs, gov, clinics)</p>	<p>Voice-enabled medical search by topic/ailment with Pre-recorded public service announcement by topic</p>	<p>➤ <u>MIDDLE-WARE/ ANCILLARY TECHNOLOGY</u> -- IVR system – Tropo – has messages pre-recorded within system. Searchable through voice recognition software</p>	<p>Form partnership and discuss with United Nations Cluster system and United Nations Office for Coordinated Humanitarian Affairs for integration and access to cluster-based public service messages (and/or script/text).</p>

Having completed the empirical analysis, proof of concept, design of MMER, and an analysis of the technologies and general parameters needed within MMER, we now look ahead to future research, and a brief summary of a pathway to MMER's implementation.

Implementation & Proposed Future Research

As illustrated in Figure 29, the thesis has reached the end of the 'current research' phase in which the pilot plan, survey design, and appropriate site selection analysis has been completed; yet the usability pilot, technological robustness test, and scaling stage has yet to be accomplished.



Figure 29: MMER Next Steps & Timeline

Immediate next steps in MMER’s development (see Figure 29) would be the completion and analysis of the results of the usability survey study, followed by a technological robustness test (see Appendix One for sample survey that would accompany the technology test) to ensure the ability of MMER’s IVR structure to respond to and route significant call volumes (in the range of hundreds or thousands of simultaneous calls). Moreover, I would secure partnerships with medical agencies, renowned hospitals, and the chief architect or Director of the United Nation’s Cluster system’s ‘library of messages’ (and would wish to invite these individuals onto MMER’s Board of Advisors) to oversee elements such as MMER’s medical scripts, automated questions, user experience, and medical volunteer recruitment. I would further research and investigate means to recruit, assemble, and train high impact medical volunteers through major hospitals or medical schools.

In an attempt to attain scale within low income, high risk, low-infrastructure areas (that are either low-density rural regions or high-density urbanized zones) I have created a sustainable business

plan with the generous financial support of the MIT Legatum Fellowship. MMER's business plan addresses basics such as the cost and type of products sold through MMER's services, the MMER's management structure and team, a market analysis, and MMER's start-up financial data (for its first five years of operation).

A humanitarian disaster relief tool, MMER is low (to no) cost for its immediate users. Catered to illiterate, disaster-affected communities, MMER would make it possible to unite affected communities and their self-reported needs directly to global volunteers and medical expertise, and to provide isolated communities in developing countries access to healthcare information through land-line or mobile phones. Moreover, MMER could generate crisis maps and medical supply assessments to enhance disaster relief logistics, and holds the potential to be scaled up at low-cost and respond to heavy call loads during disaster recovery due to its IVR infrastructure and system design. MMER joins the nascent drive and effort to create locally adapted, low-cost, and need-specific disaster relief technology that simultaneously serves humanitarian agencies, national governments, and most importantly, the victims of natural disaster.

APPENDIX 1 - SAMPLE SURVEY FOR TECHNOLOGICAL TESTING PHASE

Objective: MMER/ Mobile Phone Application Feedback

Script to Explain MMER

The mobile phone idea is to have a call service center that you would use to call in for your medical problems or questions (e.g., questions about pregnancy, disease, infections, or how to treat a wound). The way it would work would be voice-based (instead of text messaging) so that you could speak your responses, instead of write or texting them. After you dial the number, a computer service would respond and would ask you a few questions about your age and location and would ask you to describe your medical symptoms. You would be then transferred to a medical specialist who speaks Creole or French, and who could respond to your questions over the phone.

[User tries out MMER application independently. Approximate Trial time: 10-15minutes]

In this survey we are looking for ideas and feedback on this phone system from potential future users like you, so please be open with your responses.

1. Do you like the fact that it is voice-enabled as opposed to a text-based?

- i. Yes
- ii. No
- iii. Either option (text or voice) is fine for me.

2. Were you comfortable answering automated questions posed by a phone system (i.e., not a person)?

- i. Yes, I am comfortable speaking to a phone system.
- ii. No, I do not want to talk to a phone system.

a) If 'NO' Why would you not be comfortable with this?

3. Are you comfortable describing your health symptoms over the phone to a phone system (i.e., not a person) to collect information?

- iii. Yes, I am fine describing health symptoms to a machine.
- iv. No, I am not comfortable with this

b) If 'NO' Why would you not be comfortable with this?

4. Have you ever called a telephone system that automatically answers your call and transfers you to a person (e.g., at a bank, clinic, company)?

- i. Yes

ii. No

5. Could you imagine using this system to ask questions about your medical needs or queries?

i. Yes

ii. No

General Feedback

6. What do you like about this phone service idea?

7. What do you not like about this phone service idea?

8. Do you have any suggestions or ideas on how to improve the application?

APPENDIX 2 - SUBJECT MATTER EXPERTS EVALUATING MASTERS THESIS

Field		
IVR Systems		
	SUBJECT MATTER	FACULTY/STAFF
	<i>Mobile Technology & mHealth</i>	Dr. David Metcalf (UCF) Director, Mixed Emerging Technology Innovations.
		Dr. Steve Chan (MIT/Harvard) Mentor and Design Guidance
		Luke Read (UCF) Tropo Specialist, Development/Coding Guidance
		Dr. Leo Anthony Celi Medical Informatics Harvard-MIT Health Sciences and Technology and Massachusetts General Hospital
Humanitarian Disaster Relief- based Field Work & Expertise		
	SUBJECT MATTER	FACULTY/STAFF
	<i>Disaster Relief Technology</i>	Jennifer Chan (see below)
		Dr. Nigel Snoad Director, Google Disaster Relief Technology Unit
	<i>Disaster Relief Leadership (Academia)</i>	Dr. Enzo Bollentino Director, Harvard Humanitarian Initiative
	<i>Anthropological/ Field-Based Methodology & Research</i>	Meredith McLaughlin Qualitative & User Experience Specialist, Formerly with Harvard-MIT Health Sciences & Technology
		Community Innovators Lab, MIT (CoLab)
		Dr. Tracy St. Benoit (UCF)

	<i>Disaster Relief Communications & Media</i>	Jacobo Quintanillo, Humanitarian Director of Internews
	<i>Disaster Recovery Community-based initiatives & Capacity Building</i>	Jamilah Mahmood Former Chief of the Humanitarian Response Branch of the United Nations Population Fund (UNFPA),
	<i>Emergency Medical Practitioner & Crowd Sourced Disaster Relief Technology</i>	Jennifer Chan Emergency/post-disaster medical practitioner & crowd sourced disaster relief technology evaluation
Social Entrepreneurship/ Business Planning		
	SUBJECT MATTER	FACULTY/STAFF
		Dr. Steve Chan
		Will Guyster; Legatum Center for Development & Entrepreneurship. MIT.

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