Disaster E-Health:
A New Paradigm for Collaborative Healthcare in Disasters

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ABSTRACT

Disaster management and disaster medicine are well-established disciplines for responding to disasters and providing care for individuals whose health and well-being has been affected. However, these disciplines have different origins, development, and priorities so that communication and coordination across them during disasters is often lacking, leading to delayed, sub-standard, inappropriate or even unavailable care. Moreover, neither discipline exploits the new range of e-health technologies such as the electronic health record or telehealth and mobile health that are revolutionizing non-disaster healthcare. We need a new paradigm that applies information and e-health technologies to improve disaster health planning and response. This paper describes the initial stages of a project to develop such a paradigm by scoping and developing the area of disaster e-health.

Keywords

E-health, disaster management, disaster medicine, disaster e-health

INTRODUCTION

A survey of recent natural catastrophes reveals the enormous scale, complexity, and destructive power of such events (Al-Shaqsi, 2013). These characteristics produce rapidly changing scenarios, incomplete data, limited time to make decisions, and high stress levels so that, unsurprisingly, post-event analysis (Russo, 2011) exposes frequent failures of communication that result in poor emergency management and responses, both within and between response agencies.

In addition, disaster management and the well-established discipline of disaster medicine have different origins, development, and priorities so that communication and coordination across them during disasters is often lacking leading to delayed, sub-standard, inappropriate, or even unavailable care. This concern has prompted Bissell (2005) to comment that, "*Emergency management and the health sector are natural allies that have, seemingly, only recently begun to recognize each other*".

Moreover, neither discipline exploits the new range of information technologies such as cloud computing, big data analytics, the Internet of Things, social networking etc., or prominent e-health technologies, for example, the electronic health record and telehealth and mobile health that are revolutionizing non-disaster healthcare (Topol, 2012). Although the application of these and other decision support technologies in disasters is increasing, their use is ad-hoc and there have been few attempts to derive the substantial gains in speed of response and integration of care they make possible (Prijatelj, and Rajkovic, 2009; van Gemert-Pijnen et al, 2011). There is consequently a need to systematize their usage across the boundaries of disaster management and disaster medicine. In short, we need a new paradigm that applies information and e-health technologies to improve disaster health planning and response before, during, and after a disaster.

DISASTER MANAGEMENT, DISASTER MEDICINE, AND E-HEALTH

Disaster management is defined as '*the coordination and integration of all activities necessary to build, sustain and improve the capabilities to prepare for, respond to, recover from, or mitigate against threatened or actual disasters…*' (Department of Homeland Security, 2007). These four activities; mitigation, preparedness, response, and recovery comprise the disaster (emergency) management cycle (Warfield, 2008), which emphasises the iterative sequence that begins and ends with mitigation.

Disaster e-health applications and protocols appropriate to each phase of disaster cycle should be designed to reduce disaster risk, minimize the impact of an event on infrastructure and human life, and return the situation to pre-disaster levels as soon as possible.

Disaster medicine is the '*area of clinical specialization that deals with the provision of healthcare to disaster survivors and responders and the planning of medically related disaster preparation, planning, response, and delivery*' (Hogan and Burstein, 2007). The discipline defines protocols for dealing with clinical events in a disaster, the competencies (Subbarao et al, 2008) required for clinical personnel, training of personnel, and related aspects of emergency care. With the possible exception of electronic triage (Sakanushi et al, 2013), as with disaster management, there is no extended and systematic use of modern e-health technologies (Haikerwal, 2011) and their ability to provide seamless care for immediate intervention or longer-term treatment. Crucially, disaster medicine clinicians are seldom trained to be aware of these technologies or to acquire competency in their use.

E-Health is the '*transfer of health resources and health care by electronic means'* (World Health Organization, 2013). E-health technologies are revolutionizing not just how we plan and deliver mainstream healthcare but even how we think about it. These technologies have the potential to exert the same major impact on the health component of disaster management. As indicated, in a disaster situation, members of a multidisciplinary medical team have to function under highly adverse and dangerous conditions so that rapid and accurate communication between the specialists is literally vital. E-health technologies such as the electronic health record, computerized decision support systems, and mobile health apps, together with established protocols for their use under emergency conditions, have a central role to play in these circumstances.

DISASTER E-HEALTH – THE VISION

Only recently have researchers (Latifi, 2011; Sieben et et al, 2013) begun to consider the role of e-health technologies in the disaster management cycle and their integration with disaster medicine to improve healthcare delivery in, and after, crises. For example, in telehealth (Norris, 2002), the remote delivery of healthcare is clearly well-suited to emergencies where infrastructure is compromised, and the electronic health record is a key factor in diagnosis and the accurate prescribing of medication.

This paper describes the initial stages of a project to synthesize the components of disaster management, disaster medicine, and e-health into an inter- and multi-disciplinary domain of **Disaster E-Health** (Figure 1), which we define as '*the application of information and e-health technologies in a disaster situation to restore and maintain the health of individuals to their pre-disaster levels*'.

The broad vision is first to understand the contributing features of disaster management, disaster medicine, and e-health that facilitate or hinder communication and healthcare delivery in emergency events, and then develop scenarios for improvement. These scenarios then reveal the competencies and protocols needed by the various practitioners and the training prerequisites to provide them.

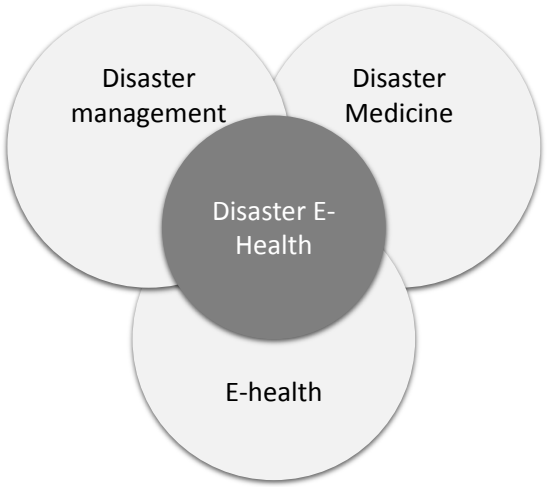

Figure 1: Disaster E-Health and Its Components

Ultimately, the accumulated knowledge can be used to define good practice, inform policy improvements, and achieve standardization across different disaster regimes and emergency agencies.

DISASTER E-HEALTH – A METHODOLOGICAL APPROACH

We have begun the extended process of developing Disaster E-Health by first carrying out scoping reviews of the relevant literature on disaster management, disaster medicine, and e-health. This methodology is especially suitable for this purpose since scoping studies are exploratory projects that systematically map the literature available on a topic, uncovering the key concepts, theories, sources of evidence, and gaps in the research (Anderson et al, 2008; Levac et al, 2010).

The scoping process starts (Arksey and O'Malley, 2005) by defining a range of research questions suggested by the considerations noted above, *viz* how to use information technologies to improve communication between disaster managers and clinicians, and how best to integrate e-health applications into mainstream disaster responses. Examples are:

- How should e-health applications be embedded in disaster preparation plans?
- How can Disaster E-Health be integrated with mainstream approaches to disaster management and disaster medicine?
- How do we improve the e-health awareness and skills of emergency managers and clinicians?
- What e-health competencies should disaster management personnel have?
- What is needed to realize the benefits of Disaster E-Health?

These questions are deliberately high-level to capture the broad range of relevant studies and issues. As we accumulate and refine knowledge we can then select key studies and themes that generate more specific queries such as:

- Should a telehealth infrastructure be a mandatory component of a disaster plan?
- How can we best use mobile and RFID health technologies in disasters?
- How can electronic health record implementations best meet the needs of disaster victims and responders?

This approach has been trialled taking as a starting point the new information and e-health technologies identified in the Introduction. The importance of these technologies is reflected in the literature dealing with established and emerging practice. Table 1 lists these technologies with representative citations and an identifying abbreviation. Currently, the electronic health record and telehealth have the most citations in the literature of disaster-related healthcare.

Published studies have then been used to generate projected disaster e-health scenarios categorized according to the disaster phases. A selection of the scenarios is shown in Table 2. The bracketed abbreviations represent the e-health technologies in Table 1.

These tables summarize the work done so far. This preliminary sweep of the disaster e-health landscape suggests that the scoping approach can be used to refine the research questions, identify the technologies that will have the major impact in disaster healthcare, and make recommendations for their effective use.

The next stage will expand the literature reviews to yield a more extensive knowledge base that allows us to rank the key technologies more accurately (including by cited applications), explore their interaction, and begin to consider design factors for practical applications.

Information Technology	Citation	E-Health Technology	Citation
Big data (BG)	Freeman, 2013	Electronic health record (EHR)	Brown et al, 2007
Cloud computing (CC)	Caspi, 2013	Telehealth (TH)	Callaway et al, 2012
Internet of Things (IoT)	Smith, 2012	Mobile health (MH)	Haynes et al, 2008
Social networking (SN)	Dhillon et al, 2013	Decision Support (DH)	Bar-el et al, 2013

Table 1: Selected Information and E-Health Technologies

When this point is reached, we envisage that the combined data will be used to coordinate an extensive Delphi study (Linstone and Turoff, 1975) that will consult disaster management and disaster medicine experts and the public. The results of this study will provide answers to the central research questions and recommend those technologies that are likely to bring the greatest healthcare benefits, and as important, suggest ways in which they can be implemented and made acceptable to disaster victims and responders.

The implementation process will necessarily involve the development of competencies and workflow protocols and is a long-term goal. At present, our sights are fixed on scoping and scenario creation to provide a rigorous basis for the subsequent work.

DISCUSSION AND CONCLUSION

The overall goal of this research is to improve communication between disaster managers and healthcare providers, and embed information and e-health technologies into disaster management and medicine thereby providing disaster responders and survivors with the competencies and tools needed to deliver collaborative, effective, and appropriate healthcare. This is a long-term ambition, but the results of the study presented here demonstrate the feasibility of the goal and a road-map for achieving it.

Disaster Phase	Disaster E-Health Scenarios
Mitigation	• Use of big data to characterize injury patterns (BG) • Big data sets that alert to cultural, ethnic and religious issues (BG) • Health risk identification, sharing of plans via teleconferencing (TH) • Mobile technologies for public health messages (MH) • Availability and sharing of EHRs in the cloud (EHR and CC) • International exchange of disaster healthcare experience (CC) • On-line big data compilations to counter epidemics (BG and CC)
Preparedness	• Plans for evacuation and in situ or hospital treatment (DS) • Cross-national plans for accessing electronic health records (EHR) • Provision of computer-based care protocols and pathways (DS) • Mobile healthcare apps for victims, volunteers, and responders (MH) • Context-aware simulation and training programmes (TH, MH and SN) • On-line education of clinicians to create competencies (TH) • Standards and protocols for wearable health data devices (IoT)
Response	• Remote triage of injured patients before arrival at hospital (TH) • Automated contextualised health advice (MH) • Telemonitoring of patients via wearable sensors (IoT) • Direction of medical teams to crisis areas identified by sensors (IoT) • Victim identification via Google person finder (SN) • Crowd sourcing of situations for rapid response (SN)
Recovery	• Teleconferencing support for patients with mental stress (TH) • Mobile apps for direction to resources - e.g. food and water (MH) • Help for patients to recover at home - e.g. wearable sensors (IoT) • Web sites to support crisis patients and their carers (SN) • (G)mail groups for healthcare support when and where needed (SN) • Organised crowd sourcing to deploy scarce health resources (SN)

Table 2: Disaster Phases and Projected Disaster E-Health Scenarios

An important objective en-route is to increase the awareness of e-health capabilities and improve practitioners' ability to manage health issues at each stage of the disaster management cycle. The impact will, however, extend beyond centralised emergency response, since it will demonstrate how e-health technologies can be used to encourage active collaboration between responders and citizens in crisis situations, how the technologies can upskill survivors to care for themselves and others when professional help is unavailable, and how crowd sourcing can be used to improve resource utilisation.

As the work progresses, we shall acquire a more detailed understanding of the critical aspects of collaboration and what is likely to work and not. The results will refine the criteria for judging the likely success of Disaster E-Health implementations. These criteria will include technical factors such as interoperability, resourcing, and industry trends and innovations, and, equally important, non-technical considerations such as practitioner and citizen acceptance. Also, whilst preliminary study has not differentiated between disaster types, countries, or organisational structures, it would be useful to see if these factors influence communication or e-health applications choices.

Critical to this success will be the selection of e-health technologies and protocols that promote both efficiencies and effectiveness in healthcare delivery and management during disasters. The simplification of procedures, particularly for collaboration, communication, and the exchange of data, and the institution of seamless workflow regimes that foster resilience, are therefore essential. Similarly, the integration of e-health technologies, such as the EHR with big data systems and cloud and mobile computing, will release enormous benefits.

This integration should be especially valuable for developing countries where infrastructure and trained personnel are often in short supply. In these circumstances mobile and telehealth technologies can create temporal dynamic configurations tailored to specific geography and resources (Callaway et al, 2012).

A further objective will be to personalize competencies and protocols so that they meet more closely the health needs of individuals and groups with differing physical or cultural requirements. Thus, one can imagine disaster e-health applications that cater specially for children, those who are blind, have motor disabilities, or ethnic or religious preferences, and persons with special medical conditions such as HIV.

Above all, continuing education and change management will be needed and the pervasiveness of mobile technologies may well mean that members of the general public are early adopters. Achieving the goal will be a protracted process but one that will be as worthwhile as it is inevitable.

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