DESIGN CONSIDERATIONS FOR A DISASTER eHEALTH APPLIANCE

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Abstract

Disaster eHealth is a new area of research and endeavour. In order to make a practical contribution Disaster eHealth approaches should consider the role of a Disaster eHealth appliance. Both disaster management and disaster medicine may find that such approaches allow critical information to be gathered and situational awareness improved. This paper proposes the development of a Disaster eHealth appliance to support self-care of chronic disease and caregiving by others. Injuries and disease caused by the disaster may be also supported by this approach. It also attempts to address some of the potential problems and suggest some solutions for the use of such appliances. Re-using existing devices may offer a relatively low-cost and sustainable approach to providing such devices, and infrastructure to use them.

Keywords: eHealth; disasters; healthcare

Introduction

The world has always been beset by natural disasters and the economic impact and costs in terms of human lives and misery are huge. At the same time such terrible events can encourage innovation and cooperation. Disaster eHealth is an emerging paradigm that attempts to identify technologies and skills that will be useful in this endeavour. Disaster e-Health (DeH), has been defined as '*the application of information and communication technologies (ICTs) in a disaster situation to restore and maintain the health of individuals to their pre-disaster state*'.[1]

This paper discusses some for the issues associated with maintaining and using eHealth systems during disasters and identifying some of the potential benefits of addressing the possibility of disaster in the design of eHealth systems.

Dealing with Disasters

Disaster management and disaster medicine are well-established disciplines for responding to natural disasters and providing healthcare for affected individuals. However, these disciplines have different traditions and priorities so that meaningful communication and coordination across them during disasters are often lacking, leading to delayed, sub-standard, inappropriate, or even unavailable care. Moreover, neither discipline systematically exploits the new e-health technologies such as the electronic health record, telehealth, mobile health (mHealth), big data analytics, etc. that are revolutionising non disaster healthcare by improving quality, safety, cost-effectiveness, and access.

Disaster management

Phases of disaster management have been defined as mitigation, preparedness, response, and recovery.[2] Preparedness and mitigation happen before the disaster, with response and recovery after. Disaster management is characterised by a need to assure the quality of situational awareness of disaster managers so that available resources are deployed effectively. Disaster management is a very complex and demanding field.[3]

Disaster and emergency medicine

This area of work deals with dealing with the medical needs of disaster victims. It is characterised by an acceptance that the post-disaster environment may be chaotic and very technology-poor.[4] There is an increasing realisation that healthcare is so dependent on electronic records that restoration of them is a key task.[5]

eHealth

eHealth covers the entire scope of digital technologies applied to healthcare. Traditionally eHealth systems have been seen as enabling technologies for healthcare organisations, but increasingly eHealth systems include therapeutic approaches – often based around mobile devices that are intended to assist with self-care or lifestyle modification.

The positioning of disaster eHealth is shown in Figure 1.

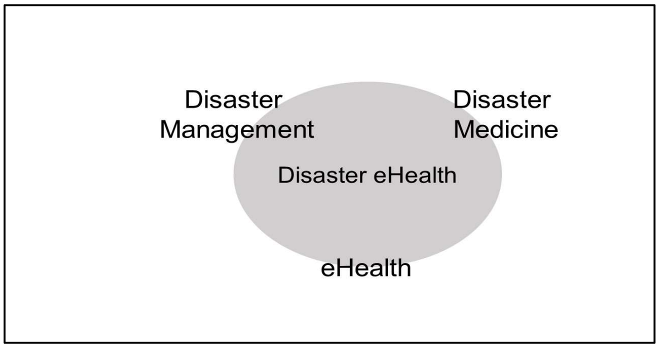

Figure 1. Relationship of Disaster eHealth with other disciplines.

eHealth in Disasters

eHealth after a disaster

Disasters are characterised by mass casualties, but also enormous disruption to infrastructure including transport, power, water and sewerage, as well as telecommunications. Large numbers of people often move, because of immediate danger as well as damage to property and loss of support services such as sanitation and food supplies in the shorter term and schools and workplaces over a longer timeframe. These conditions can have a major effect on the operational use of eHealth systems.

Loss of electrical power is a major barrier to the continuity of eHealth systems, along with loss of network connections and physical storage and computer devices. The movement of people, both temporarily and longer term (for example 11,000 people left Christchurch after the 2011 earthquake), and clinicians and the loss of healthcare premises also make it likely that normal patterns of use of healthcare systems will suffer major disruption. The number of technical and clinical staff trained or able to use eHealth systems may also be reduced.

At the same time eHealth systems face greater demands after a disaster. Systems that support the chronically ill are put under pressure as well as systems that are used to support those injured or affected mentally and physically by the disaster. Because of the disruption to power, water and other services, there may be an increase in the risk of infectious diseases and the need for disease surveillance may increase. The disruption of supply chains may mean that eHealth systems that are used to predict demand, or administer healthcare resources may be compromised and unable to effectively meet demand.

Requirements for Disaster eHealth

Failing gracefully

Because it needs to work in a resource constrained environment an eHealth system that can be useful post-disaster should not fail catastrophically when infrastructure is damaged. This may involve being able to use battery power and not requiring constant connection to a network. Where systems use unique identifiers or central repositories for security and authentication this may be an issue. Computing and storage devices can be selected that allow replication and fault-tolerance. It is likely that infrastructure will be restored partially and intermittently, so systems should be able to work effectively during outages, even when network connectivity has been restored.

Data sharing and conversion

Very commonly, multiple eHealth systems are used to support a person's healthcare. During the response and recovery phases some of these systems may not be available and the interconnections between them may be damaged. Additionally new systems may be introduced as part of the response – for example military systems, or systems from international organisations.

In order to be effective these systems must be able to share data effectively and fulfil the requirements of semantic interoperability. Because of issues with networks and power, information transfer may be "store and forward" rather than via direct connection. Ultimately, during the post-disaster and early recovery period, the forwarding mechanism may even be paper or voice, for critical information.

In terms of the preparation phase, having information residing in a repository that is likely to be unaffected by the disaster – for example on the cloud, or in local non-volatile storage such as a "smart card" may be a useful approach so that a "snapshot" is available.

A Disaster eHealth Appliance

Characteristics of an appliance

The concept of an information appliance has been considered for many years.[6,7] In essence such an appliance is able to support a user to interact with any and all information sources. A disaster eHealth appliance would have the role of being able to collect, store and communicate information about the user to support their healthcare, whether this is done by clinicians across different fields or the users themselves. The term "appliance" is used in this case to emphasise that the functions of the appliance may be performed by many different types of physical device. The combination of device, software and mode of use makes the appliance what it is. The DeH appliance is the local node of an information system that links the survivor to assistance,

Useful technologies

One approach to developing such a device is to look at the reuse of existing technology. A purpose-built device may not be available when it is most needed. Smart cards, especially those that use NFC or RFID technologies may be of use.[8] The repurposing of smart card readers - for example those used in retail or transport for disaster eHealth - may make sense. Storing continuously updated information on a smart card may be a practical approach. Wearable devices may become an important source of data.[9] Again, being used continuously avoids the danger of data not being available when needed. Storage restrictions may be mitigated by retaining the most recent data along with a less detailed summary.

Mobile phones and other consumer electronics devices may also be useful.[10] Traditionally mobile devices have been used extensively for eHealth applications, in therapeutic interventions,[11] and are especially useful in developing nations.[12] Although a network may not be available, a smart phone has large amounts of non-volatile storage available, and can be used to store health data as well as updating it as required (as and when connectivity is available). As the battery is depleted, phone charging will require power sources. Grid-independent power sources such as solar, fuel cell or mechanical means of generation may be used.

To deal with the loss of connectivity, ad hoc and peer-to-peer networking may be more effective than relying on conventional networking infrastructure. Approaches such as Serval, which has developed into a software package that can be run on most consumer networked devices, may be useful.[13]

It is clear that in all areas of eHealth, standards and common representation of information is vital as is the usability of systems.[14] Healthcare standards such as SNOMED CT and HL7 may be appropriate.[15]

Normalising the use of the appliance

During the preparedness phase, the appliance can act as an adjunct to the normal healthcare system. Personal health records and other data can be stored on it and periodically updated from existing applications and the appliance can also update these stores (Figure 2).[16]

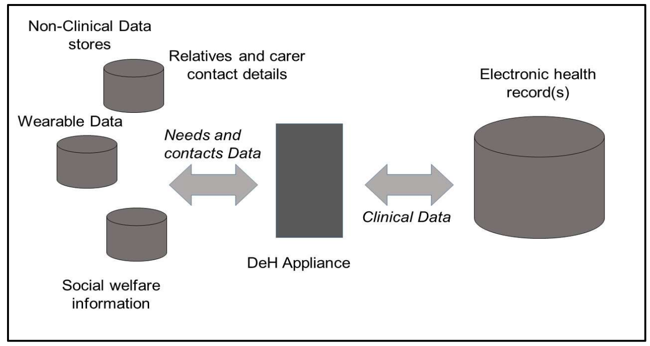

Figure 2. Data flow in the preparation phase.

It may be that with increasing use of wearable technology and social media, these data will be automatically pushed to the appliance, according to personalised rules, better preparing the wearer for an anticipated disaster. A data flow model that retains the most important and relevant data is one of the key aspects of design. (Figure 3)

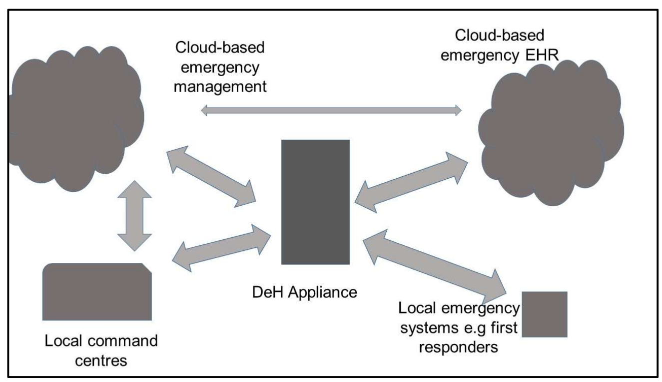

Figure 3. Data flow during the response phase.

Scenarios of use

How might these appliances be used? The intent will be for the disaster eHealth appliance to act as a source of information for both the individual and also the population as a whole. Imagine a scenario where an older person who has a chronic disease such as cardio-vascular disease requiring treatment with warfarin. They find themselves injured in an earthquake along with many thousands of other people.

Before the disaster their disaster eHealth appliance - perhaps a mobile phone - has kept an updated record of their clinical condition, medication, and health providers.

During the response phase, when the user presents at an aid station or command post, the data stored on their device helps the emergency medicine team to identify their medication and determine treatment for them. The action taken by the aid station team can be recorded on the device, along with referral information for the next group of health professionals. Appropriate advice on managing injuries, including sources of medication and prescription data, can be held on the device. At the shelter, where power is available and data can be downloaded, the shelter management become aware of how many people require care for chronic and other disease from the surveillance data, and this can be integrated into a supply chain system that is ordering relief supplies. The patient can be reassured and supported by the self-care instructions on the device, even if emergency staff do not speak the same language. Their regular healthcare providers can also be informed of their location. The device may also be able to perform some physiological measurement, or store the results of an examination at aid centres. During the recovery phase the device would allow their regular healthcare providers to access information on what care they received, and results of any tests carried out during the response phase.

Cloud-based databases may be more resilient than existing systems and easier to integrate with multiple systems that are likely to be present when overseas or international agencies are involved.

The broader picture of the movement of large numbers of people can be extracted from the independent read/write devices located at aid points and shelters and combined via networks, or even the use of physically transported USB memory devices, to the central emergency management centre. If there is the suggestion of an infectious disease outbreak, the potential route, and hence exposure of individuals, can be identified.

Common origin and movement patterns can be identified and thereby the likelihood of casualties in a certain area calculated, and the degree to which people might move in the disaster zone can be anticipated. Likely requirements for relief in different areas can also be estimated, which this may help with the location of supplies.

Privacy and safety

There clearly are potential risks to such an appliance in terms of both privacy and safety of data. Some countries, including New Zealand, have legislation that can suspend normal privacy rules during a state of emergency.[17] However this is not universally true and the situation becomes even more complicated when we consider the interaction of privacy laws between countries that may be involved in a disaster response.

Safety of the data - in terms of preservation and accuracy - are important issues. Normal auditing techniques should be followed to try to mitigate this risk.

Discussion

Climate change, increasing construction in high-risk areas, such as flood plains and population increase are increasing the risk and impact of disasters.[18],[19] In addition, the rising costs of healthcare and burden of disease make traditional responses to the health impacts of disasters more difficult to support. Addressing the issues of healthcare and management of disasters will become increasingly important over time.

We are at an early stage. Technology is bringing us almost universal availability of smartphones within communities, increasing connectivity. Outside of affected zones new imaging approaches including Unmanned Aerial Vehicles (UAV), and smart objects and the Internet of Things. A sustainable approach will require the reuse of existing technology and infrastructure and collaboration between different research and practitioner communities.

Above all, the development of such appliances will involve the appropriate use of existing technology and procedures so that such a device is available and usable in a crisis.

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Conflict of interest: the authors declare no conflicts of interest.

Acknowledgement: This work is part of a collaboration with colleagues around the world, in particular, staff from University of Agder, Norway and the University of Omaha, Nebraska USA. This work has been supported financially by the Royal Society of New Zealand and Auckland University of Technology.

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