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Communications Infrastructure Requirements for Telemedicine/Telehealth in the Context of Planning for and Responding to Natural Disasters: Considering the Need for Shared Regional Networks

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INTRODUCTION

During the course of recent years the frequency and magnitude of major disasters—of natural, technological, or ecological origin—have made the world community dramatically aware of the immense losses of human life and economic resources that are caused regularly by such calamities. Between 1967 and 1987 nearly 3 million lives were lost and property damage of $25-100 billion resulted from natural disasters that adversely affected more than 800 million people.

Particularly hard hit are developing countries, for whom the magnitude of disasters frequently outstrips the ability of the society to cope with them.

A single hazardous event can destroy social and economic infrastructure, including communications, that may have taken years to develop and upon whose vitality local and national economies depend. Frequently in developing countries the capacities of these infrastructures are strained to manage even the most basic of social and economic development programs in normal times, and a single disaster can severely disrupt the community lifelines that provide food distribution, water supply, health care, waste disposal, and communication locally and with the rest of the world.

In order to realize their fullest potential, developing countries need a sustained period of social and economic growth. Major impediments to sustained growth are the disasters which often result in an affected country shifting its economic policies to sustain the energy required to cope with disaster response and subsequent reconstruction. These shifts can intensify a country's financial imbalances and deplete available resources.

In many cases this situation can be prevented, and the recent trend in disaster management has been to emphasize the importance of preparedness and mitigation as a means of prevention. It is believed that effective prevention, mitigation, and preparedness will reduce the need to respond. For example, accurate and timely warning of an impending disaster can save life and property. Of course, there are cases when warning is not possible or the magnitude of a disaster overcomes even the most prepared community.

In these cases a system is needed, preferably one that is already in place, to respond to relief requirements, particularly the delivery of medical care.

There is no generic telecommunications infrastructure appropriate for the variety of applications in medical care and disaster management. With the time I have today I will offer my opinion of the need to integrate "telemedicine/telehealth" into shared regional disaster management telecommunications networks. I will focus on the development of infrastructure designed to serve the needs of disaster prone regions of the developing world. Such shared networks are currently nonexistent, but can be hoped for in the future.

In the broad field of disaster management, the value of interactive real-time telecommunications links between and among meteorologists and volcanologists has long been appreciated and, rudimentary though they might be in technical terms, networks serve their daily needs of preparedness, prevention, and mitigation. Available infrastructure or ad hoc constructions also enable these managers to operate on short notice in relief efforts after a disaster.

These are, of course, different applications from those employed by health care workers and specialists in disaster medicine, but the technologies required, generally speaking, are the same and could be shared. The medical community has been slow to integrate telemedicine/telehealth into standard procedure and particularly so in response to disasters.

There is, of course, no single reason for this, but I suggest that the complications are rooted in the difficulties associated with inter-institutional and interdisciplinary coordination. With other technologies, their application frequently yields a response directly to the professional. With telemedicine/telehealth, sharing of information between or among two or more people is inherent in the application. This, then, introduces a number of issues that necessarily involve more than the individual practitioner. These issues include protocols for delivering (and receiving) care and new approaches to billing and liability and will involve patients, physicians, hospitals, insurers, and others. Even within a single institution telemedicine/telehealth is up against the same gauntlet.

Use of data, audio and video technologies in acute and chronic care has been demonstrated in rehabilitation medicine, reconstructive surgery, burn management, sanitation and epidemiology, preventive medicine, and post-traumatic stress, to name a few. These demonstrations have typically been of short duration, though, and telemedicine/telehealth as a routine practice has been infrequently institutionalized. Further, there has been scarce validation of telemedical systems in the variety of settings and situations required to satisfy the cautious, and sometimes skeptical, medical community of physicians, hospital administrators, and insurance providers.

In urban centers of countries with highly developed economies (locations that provide the economic stimulus frequently needed to motivate the development of new technologies) some telemedicine/telehealth systems can be found operating. But in most remote areas of these countries, and in developing countries in general, such networks cannot be found.

Though it would be difficult to overemphasize the difficulties associated with the lack of access to technology, both developed and developing communities share the sometimes greater challenge of working out the regulatory, institutional, and professional protocols for application of those technologies that *are* available. In short, the challenge in applying telecommunications technology to medicine, and health care in general, is frequently not a question of the suitability, or even availability, of the technologies themselves, but the development of the relationships among the users.

For example, it could be argued that the reason why a telecommunications network that could be shared by disaster managers has not been developed is because the potential users have not decided among themselves that such a network should be developed. It could be further argued that the resources that are currently available within each region—from the governments and private sector of the region's countries, and from international agencies, consortia, and donor countries—are sufficient to cover the expenses associated with such a network if the costs are shared by all.

Certainly there is need. Though not frequently addressed in terms of integrated multi-sector network, this need is commonly perceived by disaster managers specializing in a number of different sectors and phases of disaster management. The technology is available and, arguably, affordable if the burden is shared among a number users (read beneficiaries).

SHARED NETWORK CONCEPT

To be most effective, a shared disaster management telecommunications network should be viewed in a multi-sectorial context. Although it is important to understand the respective interests of each sector, funding and political impetus to the programs will likely be stronger if they can be derived from a coalition of broad public and private sector support.

Disaster managers have long envisioned the value of timely communications, yet resources to establish and sustain the requisite infrastructures have been inadequately allocated in comparison with demand for their service. Financing appropriate technology development to serve the needs of countries prone to disaster would be less burdensome if these technologies could be seen as basic infrastructure requirements. Costs could then be shared by all sectors of the nation and region, and protocols developed for shared access to—and use of—technology resources. A necessary challenge would then be to design these protocols so that they permit international cooperation during times of need.

Post-disaster analysis has frequently shown that lack of communications links able to provide hazard warnings have resulted in catastrophic loss that might have been avoided with adequate warning. Further, inadequate or nonexistent communications links following a disaster can delay relief efforts and medical care, and can cause confusion and overlap in response.

A network that could serve a number of users with differing requirements would have at least four basic components: user workstations (of various sizes and peripheral apparatus), domestic communications links between user workstations and the satellite earthstation, a satellite earthstation, and the international satellite space segment. This network should also be operational and in use (and tested) frequently to ensure its function when needed.

Workstations. In this case the term workstation refers to the terminus (or origination point) of the information network. In the field, workstations are envisioned (depending on need and funding) as macro- or micro-computer-based decision support systems capable of transmitting required information as data, voice, fax, and still frame video. Their primary functions would be to:

- Permit the storage and manipulation of basic information which is routinely collected and maintained concerning availability and location of fire, police and medical resources; evacuation and transportation routes for emergency vehicles; supplies such as food, water, medicines, cots, and blankets; shelter; and medical data, prepared according to agreed upon formats and protocols; and to
- Receive and transmit dynamic, real-time information regarding damage and casualty assessments, patient treatment and evacuation, requirements for medicines and relief support, detection and warning of secondary (i.e., aftershock) disaster threats, etc.

Depending on the need and resources available, these workstations could be adaptable to include (or permanently equipped for) compressed video, and full-motion video transmission.

Domestic Telecommunications Link Between Workstation and Uplink. One of the benefits of a shared network is the reduction of cost. This cost savings is realized, in large part, by the sharing the financial burden of purchase, installation, and maintenance of major resources such as satellite earthstations capable of transmitting and receiving information via international satellites.

Of necessity, then, the earthstations in this network would be located at either one user's site, for example a regional or tertiary-level hospital capable of coordinating a broad range of medical response activity, or at telecommunications facilities that are a part of a country's communications infrastructure. This necessitates the selection of earthstation managers who are willing and capable of working cooperatively with other users of different institutions, agencies, and disciplines. It also requires the establishment of a link between the earthstation and all workstations that are to be a part of the network.

The links that connect these workstations must be resilient to the types of disasters that frequent the area in which they are expected to operate. Ideally they should be redundant and mobile or transportable. And they must also be, by necessity, affordable.

Domestic options, which must be considered on a case-by-case basis, include: HF, UHF and VHF radio, cellular radio, microwave, and satellite.

Although each workstation or cluster of workstations will be able to operate using its own software programs, the technical protocols for transmission of information between the satellite earthstations and user workstations must be compatible.

Satellite Earthstations. A form of VSAT (Very Small Aperture Terminal) network capable of carrying data and voice (and facsimile) traffic is envisioned for the proposed network. VSAT technology permits use of small earthstations which, in a network consisting of several stations, can result in a system that is lower in cost and easier to maintain than its terrestrial equivalent. Further, and importantly, a VSAT network would be more reliable and resilient to conditions common during severe disasters. For example, if one site is damaged in a terrestrial network, it is typically the case that all sites in the chain from that point on are out of business too. Whereas in a VSAT network, if one site goes down other sites are not necessarily affected because of that casualty. Another advantage of a VSAT network is the ease with which additional sites can be added at any time.

The flexibility of a VSAT network also permits a "mesh" network configuration where any site within the network can originate and receive transmissions at any time.

With the requirement of multiple and changing origination points within the network, and because of the small size of VSATs, there is a requirement for a "hub," or master earthstation in a VSAT network. Transmissions from any user within the network are sent to the satellite and received by the master earthstation located anywhere within the footprint of the satellite. The master earthstation then retransmits the information, at greater power, to the satellite for distribution to the other VSATs. This is referred to as a "double hop" and, though the process may sound complex, it is transparent to the user.

Satellite Space Segment. Because of the size and geographical diversity of the regions of the world, a satellite-based network is envisioned and briefly described earlier. Although the amount of time leased on the satellite will be determined by the amount of traffic between the various users, assuming the selection of one satellite that covers an entire region there is no limitation imposed by the satellite on the number of users. Further, assuming that adequate space segment has been leased, any number of groundstations can access the system without additional charge for satellite time. It is also the case that, with sufficient bandwidth and appropriate technical architecture, the system can be used by a number of users simultaneously, each without interfering with the other.

COORDINATION OF INTERNATIONAL EFFORT

Finally, and in brief, the planning and implementation of regional multi-hazard networks, and schemes for their funding, must involve the national, regional and international users in a process that would lead to the identification of a network manager or coordinator.

Because of the international consultation and negotiation that would be required, coordination of technical, programmatic, and funding is a role that might best be played by organizations such as the Office of the United Nations Disaster Relief Coordinator (UNDRO) and the World Health Organization (WHO). Other organizations that might be involved in the process include the International Telecommunication Union (ITU), the World Meteorological Organization (WMO), the United Nations Development Programme (UNDP), and the United Nations High Commission for Refugees (UNHCR).