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A review of m-Health e-Emergency Systems

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***Abstract*— Rapid advances in wireless communications and networking technologies, linked with advances in computing and medical technologies facilitate the development and offering of emerging mobile systems and services in the healthcare sector. The objective of this paper is to provide an overview of the current status and challenges of mobile health systems (m-health) in emergency healthcare systems and services (e-emergency). The paper covers a review of recent e-emergency systems, including the wireless technologies used, as well as the data transmitted (electronic patient record, biosignals, medical images and video, subject video, and other).**

I. INTRODUCTION

M-Health can be defined as 'emerging mobile communications and network technologies for healthcare' [1]. This concept represents the evolution of 'traditional' e-health systems from desktop platforms and wired connections to the use of more compact devices and wireless connections in e-health systems. The emerging development of m-health systems in the last decade was made possible due to the recent advances in wireless and network technologies, linked with recent advances in nano-technologies, compact biosensors, wearable devices and clothing, pervasive and ubiquitous computing systems. These advances will have a powerful impact on some of the existing healthcare services and will reshape the workflow and practices in the delivery of these services [1].

A brief review of the spectrum of m-health systems and applications and the potential benefits of these efforts was presented in a recent paper by our group [2]. Moreover, an edited volume was published [1], covering a number of areas in mobile m-health systems. The objective of this paper is to provide an overview of the status and challenges of m-health in emergency healthcare systems and services (e-emergency). The paper reviews recent e-emergency systems, including the wireless technologies used, as well as the data transmitted (electronic patient record, biosignals, medical images and video, and other).

Wireless telemedicine systems and services are expected to enhance traditional emergency care provision not only within the Emergency Department but also in a variety of pre-hospital emergency care situations where geographically remote consultation and monitoring can be implemented [3], [4]. A timely and effective way of handling emergency cases can prove essential for patient's recovery or even for patient's survival. The ability to remotely monitor the patient and guide the paramedical staff in their management of the patient can be crucial. M-emergency becomes important in facilitating access to effective and specialist directed care. Some benefits of prehospital transmitted ECG for example, as documented by Giovas *et al.* [5], are the following: reduction of hospital delays, better triage, continuous monitoring, ECG data accessible for comparison, computer aided analysis and decision making, and prehospital therapy in eligible subjects with acute myocardial infarction (AMI). This paper provides an overview of the main technological components of m-health e-emergency systems.

The structure of the paper is as follows. Section II covers an introduction to wireless transmission technologies. In section III, an overview of m-health e-emergency systems is documented based on published journal, conference papers, and book chapters. Section IV addresses the future challenges and section V the concluding remarks.

II. WIRELESS TRANSMISSION TECHNOLOGIES

In this section we briefly describe the main wireless technologies that are used in wireless telemedicine systems, namely GSM, 3G (W-CDMA, CDMA2000, TD-CDMA), satellite, and wireless LAN (WLAN). Emerging wireless technologies such as Wi-Max, Home/Personal/Body Area Networks, ad-hoc and sensor networks are also described. These systems are summarized in Tables 1a & 1b.

GSM is a cellular system currently in use, and is the second generation (2G) of the mobile communication networks. It had been designed for voice communication (circuit switched), but can also carry data. In the standard mode of operation, it provides data transfer speeds of up to 9.6 kbps, whereas the enhanced technique High Speed Circuit Switched Data (HSCSD) makes possible data transmissions of up to a maximum of 115 kbps [6]. The evolution of mobile telecommunication systems from 2G to 2.5G (iDEN 64 kbps, GPRS 171 kbps, EDGE 384 kbps) and subsequently to 3G (W-CDMA, CDMA2000, TD-CDMA) systems facilitates both an always-on model (as compared with the circuit-switched mode of GSM), as well as the provision of faster data transfer rates, thus enabling the development of more responsive telemedicine systems. High Speed Downlink Packet Access (HSDPA) [7] is the latest system enhancement of W-CDMA networks, resulting in higher data transfer speeds, improved spectral efficiency and greater system capacity. With a theoretical peak of 14.4

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Mbps (typically around 1 Mbps), telemedicine systems can benefit from data transfer speeds currently only feasible on wired communication networks [6], [8].

Satellite systems are able to provide a variety of data transfer rates starting from 2.4 kbps and moving to high-speed data rates of up to 2x64 kbps and beyond. Satellite [9] links also have the advantage of coverage all over the world, but require line of sight and comparably higher power for similar bit rates.

WLAN is a flexible data communications system implemented as an extension to or as an alternative for a wired LAN. Using radio frequency (RF) technology, WLANs transmit and receive data over the air, minimizing the need for wired connections. Thus, WLANs combine data connectivity at tens of Mbps with limited user mobility, becoming very popular in a number of vertical markets, including the healthcare, retail, manufacturing, warehousing, and academia. These industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real-time information to centralized hosts for processing. However, WLAN coverage is limited in distance to an area covering about 100 meters per cell (access point), or the coverage area of a ‘private’ entity, as for example the hospital premises, with the use of multiple access points.

To extend coverage over large distances, wireless mesh networks are also being considered. These networks are peer-to-peer multi-hop wireless networks, in which stationary nodes take on the routing functionality thus forming the network’s backbone. Basically, these act as a gateway to high-speed wired networks for mobile nodes (clients) which communicate in a peer manner.

WiMax is a wireless digital communications system defined by the IEEE 802.16 standard. Its advantage over WLANs lies in the fact that WiMax can provide broadband wireless access up to 50 km for fixed stations and 5 km-15 km for mobile stations, thus intended for wireless “metropolitan area networks” (WMANs) [10]. It is anticipated that utilization of this attractive feature will lead in a vast deployment of WiMax systems; however the adoption of WiMax at this point in time is still at an early phase. Today wireless LANs and MANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of applications. These technologies have slowly started penetrating the health sector.

Home/Personal/Body Area Networks allow connectivity of devices in the vicinity of tens of meters. Bluetooth or RF technologies may be incorporated to set such networks up. In disaster control cases, Bluetooth connectivity may be utilized to link ad-hoc networks to existing cellular networks.

While the aforementioned wireless systems are based on infrastructure and base stations connected to a wired backbone network, ad-hoc and sensor networks do not require any wired infrastructure. Mobile ad-hoc networks or MANETs are a collection of geographically distributed mobile nodes that interact ‘on the move’ with one another over a wireless medium instead of communicating wirelessly to a base station [11]. These kinds of networks are particularly useful in the absence of a wired infrastructure or under strict time constraints when no time is available to set a network up. This characteristic may prove particularly useful for emergency systems. Wireless sensor networks WSNs differentiate from MANETs which are more human oriented and instead are focused on interaction with the environment. They incorporate sensors and actuators and environment oriented as they are, they measure and can influence this environment according to the occasion, as documented by Akyildiz *et al.* survey [12], before the recorded information is communicated wirelessly for further processing. They are hence somewhat embedded in the environment [11]. Besides their numerous applications WSNs are also applicable in the health sector where they may be used to monitor, for example, post-surgery state and recovery or surveillance of chronically ill patients.

III. 4. M-HEALTH E-EMERGENCY SYSTEMS

One of the first telemedicine sessions was reported by Eithoven 100 years ago in his seminal paper “Le telecardiogramme”, 100 years ago, where the successful transmission of about one hundred ECGs through a distance of 1.5 Km was demonstrated, connecting his lab with the University Hospital in Holland [13]. Since then many systems have been presented worldwide, the most recent of these are summarized in the following section.

A. An Overview

The MEDLINE and IEEE Explore databases were searched with the following keywords: wireless telemedicine emergency, wireless telemedicine ambulance, wireless telemedicine disaster, wireless ambulance, wireless disaster, and wireless emergency. The number of journal papers found to be published under these categories is around 180. Out of these a total of 33 applications were selected and are briefly summarized in Table 1. These systems cover the whole spectrum of wireless emergency telemedicine applications presented during the recent years. The papers are grouped using the wireless technologies types which are: GSM/GPRS, 3G, satellite and wireless LAN. The data transmitted are coded under the columns: “ECG and other biosignals”, “IMG” for medical images or patients images, “EPR/Data” for Electronic Patient Records or just DATA, “Video” for video conferencing or medical video transmission. The column “Web” identifies which of the applications were developed supporting web technologies. The majority of the applications (21) used the GSM/GPRS network while a lot of applications use Wireless LAN (11) in order to transmit data.

The applications presented in the other two categories 3G and Satellite are rather limited.

In the first group of applications which use the Mobile Telephony networks GSM/GPRS, we have the highest number of applications. These applications could be divided into two main categories, those transmitting biosignals

Table 1a. Selected applications of m-health e-emergency systems that use GSP/GPRS and 3G networks

Commun. Technol.	Author	Year	Data Transmitted				Web application	Comments
			ECG and/or other signals	IMG	EPR/ DATA	Video		
GSM/GPRS	Karlsten *et al.* [14]	00	✓					Ambulance triage support
	Yan Xiao *et al.* [15]	00	✓			✓		Ambulance neurological examination support
	Anantharaman *et al.* [16]	01	✓					Pre-hospital support
	Rodrvguez *et al.* [17]	01	✓					Cardiac arrest treatment
	Istepanian *et al.* [18][19]	01	✓	✓				Transmission of ECG data and still images for emergency use. Compression of ECG using a wavelet compression method
	Pavlopoulos *et al.* [20]	01	✓	✓				Portable teleconsultation medical device
	Chiarugi *et al.* [21] & Kouroubali [22]	03 05	✓					Transmission of 12-lead ECG in order to support ambulance and rural health centers emergencies (HygeiaNet)
	Kyriacou *et al.* [23]	03	✓	✓				Wireless transmission of biosignals and images from a Rural Health Center and a moving ambulance vehicle to a central hospital
	Clarke *et al.* [24]	04	✓					Wireless connection to sensors and transmission of data from an ambulance
	Kyriacou *et al.* [25]	05	✓	✓				Ambulance emergency support through wireless transmission of biosignals and images
	Salvador *et al.* [26]	05	✓				✓	Transmission of ECG and other parameters to support patients with chronic heart diseases
	Clemmensen *et al.* [27]	05	✓					Transmission of ECG signals to a cardiologist's PDA to improve time to reperfusion
	Campbell *et al.* [28]	05	✓					Wireless transmission of ECG from Emergency medical care personnel to the department and through wireless LAN to the on-call cardiologist who is carrying a PDA
	Giovas et. al [5],	06	✓					Wireless transmission of 12-lead ECG from a moving ambulance vehicle to a central hospital
	Sillesen *et al.* [29]	06	✓					Transmission of ECG signals to a cardiologist's PDA in order to improve time for PCI treatment
	Schδchinger *et al.* [30]	99		✓				Early hospital admission
	Reponen *et al.* [31]	00		✓				Transmission of CT scans using GSM and PDAs. Images transmitted to a neuroradiologist for preliminary consultation
	Oguchi *et al.* [32]	01		✓			✓	Use of personal handyphone system to transmit CT images using a web based application
	Voskarides *et al.* [33]	02		✓				Transmission of X-ray images in emergency orthopedics cases
	Hall *et al.* [34]	03			✓			Wireless access to Electronic Patient Record
	Kontaxakis *et al.* [35]	06				✓		Tele-echography system and 3D-ultrasound
3G	Chu *et al.* [36]	04	✓	✓		✓		Trauma care through transmission of patient's video, medical images and ECG
	Garawi *et al.* [37]	06				✓		Tele-operated robotic system for mobile Tele-Echography (OTELO-Project)

such as ECG, Oxygen Saturation, Blood pressure etc., and those transmitting medical images or just pictures of a patient. Some of the presented applications are a combination of both categories. Most of the applications concern the transmission of biosignals and images in order to support prehospital treatment such as [18], [20], or the transmission of biosignals in order to monitor patients with chronic heart diseases [26]. Some of the applications concern the transmission of images only [30]-[33]. Imaging modalities are rapidly changing, thus affecting the medical procedures and the need for new telemedicine applications in order to support these procedures. Finally, one application is used for the access of electronic patient records [35].

The second group covers those applications that use 3G mobile networks. The first one [36] concerns the transmission of biosignals and images of the patient, something that has been extensively presented by many applications in earlier stages. The second one [37] investigates the transmission of real time ultrasound video captured via a remotely controllable robotic arm.

Table 1b. Selected applications of m-health e-emergency systems that use Satellite and Wireless LAN

Commun. Technol.	Author	Year	Data Transmitted				Web application	Comments
			ECG and/or other signals	IMG	EPR/ DATA	Video		
Satellite	Kyriacou *et al.* [23]	03	✓	✓				Wireless transmission of biosignals and images from a Rural Health Center and a moving ambulance vehicle to a central hospital
	Strode *et al.* [38]	03		✓				Examination of trauma using focused abdominal sonography (military)
	Vieyres *et al.* [39], & Canero *et al.* [40]	05				✓		Tele-operated robotic system for mobile Tele-Echography (OTELO-Project)
	Virgin Atlantic Airways [41]	06	✓	✓				The Tempus 2000 device will be used for monitoring a passenger's blood pressure, pulse rate, temperature, ECG, blood oxygen and carbon dioxide levels in emergency cases.
Wireless LAN	Garrett *et al.* [42]	03				✓		Echocardiogram transmission in cardiac emergency from an ambulance in transit to a tertiary care facility
	Lorincz *et al.* [43]	04	✓					Sensor networks for emergency response, system tested using two vital signs monitors
	Clarke *et al.* [24]	04	✓					Wireless connection to sensors and transmission of data from an ambulance Telecare project
	Maki *et al.* [44]	04	✓					Wireless monitoring of sensors on persons that need continuous monitoring, when an emergency occurs the specialized personnel listens a sound alarm or a notification through mobile phone
	Campbell *et al.* [28]	05	✓					Wireless transmission of ECG from Emergency medical care personnel to the department and through wireless LAN to the on-call cardiologist who is carrying a PDA
	Palmer *et al.* [45]	05	✓				✓	Wireless blood pulse oximeter system for mass casualty events designed to operate in WIFI hotspots. The system is capable of tracking hundreds of patients. Suitable for disaster. Control
	Lenert *et al.* [46]	05	✓		✓			Medical care during mass casualty events, transmission of signals, alerts monitor.
	Nakamura *et al.* [47]	03				✓		Wireless emergency telemedicine LAN with over 30 Km distance used in the Japan Alps used for mountain climbers emergency telemedicine
	Pagani *et al.* [48]	03		✓			✓	Web based transmission of cranial CT images. Comparison of the results
	Kim *et al.* [49]	05		✓				Transmission of CT and MRI images through a PDA and wireless high-bandwidth net to neurosurgeons
	Hall *et al.* [34]	03			✓			Wireless access to Electronic Patient Record

This application was developed by P. Vieyres and coworkers [39], and initially exploited using satellite links (see Section 4.2 for more details).

Moving to the next category of communication links, the satellite links; we have only found four new significant studies. We do note however that a significant number of studies using satellite links were published prior to these studies (not reported here). The applications found here, mostly concern the transmission of ultrasound video [38]-[40]. Two of the papers [39], [40] also include the use of a robotic mechanism in order to remotely control the ultrasound acquisition as described above, in the section of 3G networks, while the other two papers [23], [41] concern the transmission of biosignals and images for emergency cases. The Virgin Atlantic press release [41] announces the first wireless telemedicine system that will be adopted by a major airline carrier that will be available in all its flights.

The last category of applications covers the use of Wireless LANs. Basically these applications are for disaster control cases where a lot of injured people might be concentrated in a small area and a Wireless LAN is used in order to monitor the condition of these people. Most of the applications presented here concerns the transmission of biosignals, and the use of sensor networks [43]-[46]. Three of the applications are transmitting images [47]-[49], with CT images transmitted in [48] and CT and MRI images in [49]. Also, one application is used for the access of electronic patient records [34].

IV. Future Challenges

In this section, future challenges in the following areas are given: communication for wireless e-Emergency systems, computer technology, biosignals, emerging technologies on the transmission of wireless digital images and video, and other significant issues.

A. Communication for wireless e-Emergency systems

Communication for wireless e-emergency healthcare systems, until today, was performed mainly using 2nd Generation Mobile Telecommunication Systems, such as the GSM which is a standard used almost everywhere in the world. During the last years, the introduction of new mobile telecommunication systems (2.5 Generation), like the GPRS system which provides much higher bandwidth (theoretically up to 171.2 kbps, typically about 35 kbps [2] enables the transmission of much more information which can prove useful for the healthcare providers and crucial for patient's treatment.

Recently, in many countries 3G mobile networks like the UMTS ([8] UMTS forum) are currently installed and operating, which provide bandwidth up to 2Mbps (maximum, typically hundreds of kbps) something that will enable the transmission of more information like continuous 12 leads of ECG when monitoring cardiac patients from a moving ambulance vehicle. Furthermore the current introduction of new services like video telephony through wireless networks will be an addition that can help with communications between a health care provider (nurse, paramedics) and an expert doctor. Another important factor is the installation of wireless networks in cities (e.g. WiMAX with tens of Mbps) something that will be able to significantly improve communication in wireless health care systems operating within city boundaries. WiMAX is currently being standardized, with some commercial applications installed already. The use of such networks will be very important because health care providers will have immediate and high speed telemedicine access from anywhere in the area of a city.

Using sensor networks data gathering and computation can be deeply embedded in the physical environment. This has the potential to impact provision of e-ambulatory care, e.g. resuscitative care, see Lorinz *et al.* [50], by allowing vital signs to be automatically collected and fully integrated into the patient care record and used for real-time triage, correlation with hospital records, and long-term observation.

The use of locating systems such as the GPS (Global Positioning System), the GIS (Geographical Information Systems), and intelligent traffic control systems also have potential to improve health care services.

B. Mobile Computing Technology

Changes in commercial computer systems are rapid and continuous. New systems are presented every day. Modern portable computer systems have smaller size and weight but provide almost the same computational capabilities as non portable computer systems. The use of these devices in wireless telemedicine application is something that was presented some years ago but capabilities were limited due to the size or the computational capabilities of the systems. Nowadays the introduction of portable devices like PDAs, Smart Phones, Small Size laptops, Pen-Tablet PC's is something that enables wireless telemedicine systems designers to create faster, better and smaller systems. Such efforts have already appeared and will continue to appear during the next years.

C. Biosignals

Biosignals acquisition is another technological field which affects wireless telemedicine systems. The collection of biosignals [51] -[54], such as ECG, until now was performed using expensive devices which could only be handled and supported by medical personnel. Nowadays the collection of biosignals, such as ECG, can be performed by very small devices. These are not always devices on their own but they might connect to a PC in order to display the signals or to a mobile phone in order to send the signals, or even have Bluetooth or GPRS connectivity to wirelessly transfer the signals. They might be wearable, have the shape and weight of a necklace etc. These devices will enable the use of wireless telemedicine systems almost anywhere and at less cost. Such devices can be used for home care purposes much easier than the standard medical devices.

D. Emerging Technologies on the Transmission of Wireless Digital Images and Video

The future needs of signal and image processing applications in e-health will involve a multitude of different signals, ranging from one-dimensional signals such as the ECG to real-time color video signals. There will also continue to be strong demand to move more and more services to smaller, low-power, compact computing devices.

There has been substantial progress made in the processing and analysis of one-dimensional biomedical signals (see [55]). Their bandwidth requirements can usually be met, and their strong diagnostic value makes them an essential part of most future collaborative systems. They are essential for continuous, real-time monitoring. Clearly, if a medical condition can be detected using a one-dimensional signal, such as the ECG, then we should avoid using images and/or video to accomplish the same task. In joint-processing, it is important to consider the use of one-dimensional signals to reduce bandwidth and computational requirements of higher-dimensional signals. Furthermore, we should consider scalable coding systems, where one-dimensional biomedical signals belong to the base-layer with strong protection from transmission error.

Due to the high-bandwidth requirements, image and video compression methods will continue to play an important role in future, real-time collaborative environments (see [25], [39]). Scalable image and video coding will see continual development [56]. For medical imaging applications, there are many challenges in defining diagnostically relevant scalable methods. There are obvious applications in object-based scalability, not only where the object is of diagnostic interest, but also in defining the base layer and enhancement layers so that the base layer is of diagnostic significance. In transmitting video images of the patient, on-going and future research on facial image coding will be important in determining the patient's feelings and reactions during medical exams. There is also a need to consider new image compression models that correspond more closely with the structured texture and image acquisition characteristics of medical video.

From the wireless communications perspective, video image compression research will continue in areas such as error-resilience and error-concealment [57], [58]. Especially for error-resilience methods, there will be strong interest in new encoding schemes that allow for robust decoding. For medical imaging applications, a small percentage of errors could be tolerated and their effects minimized through error-concealment. Future research in error-concealment methods should take into account the complex nature of biomedical images. Over a single video, different interpolation schemes should be employed for text objects, background, and texture objects.

Many signal and image processing challenges lie in the joint processing and transmission of biomedical signals, images (see [25]). We list challenges in three areas: (i) multi-modality signal synchronization, (ii) joint signal, image and video compression, and (iii) interactive collaborative environments. The basic application is the development of high-quality collaborative environments, where a variety of biomedical signal and images are exchanged. For joint decoding, there are significant synchronization issues. Clearly, the one-dimensional biomedical signals should correspond to the video images. As an example, we note the synchronization of the ECG, respiratory, 2D, and Doppler signals in ultrasound systems. In addition, we note that two-way voice communications must be synchronized to all clinical signals, as well as to real-time video images of the patient and the doctor. Re-synchronization in the presence of wireless communication errors will require innovative error-resilience methods.

There are many challenges associated with the use of interactive, collaborative environments. As an example, all the MPEG-2/MPEG-4 functionalities (see [59], [60]) need to be re-thought of, in the context of synchronized, jointly-compressed signals. The users may be reviewing a particular signal, asking to see the corresponding signals (images or video) from other modalities. Such an interactive preview capability requires the development of fast joint-decoding methods. For real-time collaborative work, the heterogeneity of the networks, computing systems and image displays, will be best served by innovative, scalable, network-aware systems. In conclusion, we note that the high quality, robust, requirements of e-health systems will only be met by addressing particular clinical needs.

E. Other Significant Issues

Legal, liability, ethical issues as well as the workflow of m-health services [61] will have to change to enable the effective and efficient use of these systems. Starting from legal issues the introduction of new services will have to be covered by several laws National, EU laws in the case of European countries or Federal laws for the United States. These laws will have to cover all issues, including the responsibilities during an emergency or home care incident. Furthermore, the liability of systems will have to be covered by standards which will describe everything that a system should follow. Even though there has been significant effort in creating a standard for collecting and exchanging biosignals [62], [63] (like DICOM for images) no standard is widely used by manufacturers of commercial biosignal monitors. Such issues will need to be resolved in the near future in order to cover liability and interoperability of medical devices.

On the other hand several ethical issues will also have to be covered when using these systems; such issues concern the exchange of medical information through public networks thus having potential problems with security. This is currently being addressed with effective security systems available, however the tradeoff between a 'heavy' security system (thus impacting on system load and friendliness) versus a lean implementation with just adequate security is still a matter of intense research [64].

V. Concluding Remarks

This paper reviews wireless technologies. It also provides an overview of recently published wireless emergency healthcare systems, in which some of the reviewed technology is presented. These systems clearly demonstrate the benefits and the need for their wider deployment.

Even though, Einthoven in 1906 demonstrated the successful transmission of ECG [13], the wide use of e-emergency systems including the monitoring of ECG for prehospital care is still lacking. Similarly, the transmission of echography video in teleradiology for various organs using satellite connections has been proven feasible and successful in numerous cases [35], [39]. Early security concerns are currently been addressed and successful secure e-health applications are rapidly becoming commercialized, with many well known health and IT vendors appearing in the marketplace. However, in a recent study carried out by the World Health Organization (WHO) on e-health tools and services including m-health, it was concluded that countries need: support in the adoption of policy and strategy for the development for e-health; advice on needs assessment and evaluation of eHealth services; information on best practice and trends; and advice on e-health norms and standards. That is countries require consultancy services to assist in all aspects of e-health, and a need for education and training in this area [65].

The know-how and technology developed lately in disaster management is leading to the development of new approaches to emergency evaluation, triage, and treatment in prehospital and hospital care and services [66]. The ability to provide timely "hands-on" expertise to the trauma patient, irrespective of the specialist's location, facilitates the potential for real advancement in the field.

However, m-health e-emergency is still largely undeveloped. The success, experience, and benefits of clinical services in emergency telemedicine have only recently been published on a large scale of emergency cases by the telemedicine program at the State University of New York at Buffalo, School of Medicine, and the Erie County Medical Center (UB/ECMC) [67]. In addition, it was shown that the use of emergency telemedicine services could result in an approximately 15% decrease in ambulance transports when it is added to the prehospital care provider's services, with emphasis given on younger subjects [68]. More convincing studies similar to these ones are encouraged in order to help in the wider deployment of e-Emergency systems.

In particular the transmission of echography video in the monitoring of pre-hospital subjects in cardiac emergencies (as for example using wireless LAN connections [42] and in trauma cases using satellite connections [38]) has been demonstrated in only a very limited number of cases. It is expected that the recent wide availability of portable ultrasound systems, the wide availability of 3G systems and beyond, and the further development of video systems will facilitate the spread of video systems both for the transmission of ultrasound exams, as well as for the transmission of subject video and teleconferencing applications.

Concluding, it is expected that m-health e-emergency systems will significantly affect the delivery of healthcare; however, their exploitation in daily practice as well as the monitoring and evaluation of these systems still remains a novel goal, yet to be achieved.

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