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Development of m-health monitoring systems in India and Iraq

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***Abstract*—Two separate projects have been carried out to implement m-health programs in India and Iraq, and, for each, this paper describes the work performed by the teams involved, presents results and details a number of lessons learned. In general, it is found that although India and Iraq have very different medical priorities, they pose similar issues when introducing m-health strategies.**

I. Introduction

In the last decade, the term m-health has emerged to mean 'mobile computing, medical sensing and communications technologies for health-care' [1]. In its application to remote medical monitoring, m-health encompasses a broad range of technological domains, including the internet, communications and computer systems. M-health is currently bringing together academic research institutions and industrial enterprises to achieve innovative solutions in healthcare delivery and the number of m-health projects in developing countries has continued to increase due to the relative ease of adoption and deployment. Several m-health projects are being demonstrated throughout the developing world, and their benefits and healthcare outcomes impact on many policy issues, including the following [2].

- Wider access to healthcare and health-related information, particularly for hard-to-reach populations.
- Increased efficiency and lower cost of service delivery.
- Improved ability to diagnose, treat and monitor diseases.
- Timelier, more actionable public health information.
- Expanded access to ongoing medical education and training for health workers.

One important emerging m-health scenario is the use of mobile phones, iPods, iPads and other portable devices for the prevention and management of chronic conditions, such as diabetes hypertension and cardiovascular disease.

In this paper we describe two m-health projects funded by the British Council, targeting two different developing countries, namely India and Iraq. Both countries have major problems in managing their large numbers of diabetes and cardiovascular patients [3], yet their mobile phone markets are among the fastest growing in the world. Consequently, the adoption of m-health technologies to manage chronic diseases in these countries is both timely and economically feasible [4].

The first part of this paper describes an m-health system developed for monitoring patients with cardiac disease and diabetes in India. The system has been developed to allow patients in remote rural regions of India to access health centers in large cities. In this approach, wireless medical sensor readings and patient data acquired directly by medical practitioners are combined into a comprehensive set of patient monitoring parameters. Mobile device applications running on a web browser are then used to upload the data over the communications network infrastructure to a central server located at a main hospital for storage, clinician access and diagnosis [5]. As an extra layer of transmission security, watermarking information is embedded in the data to allow verification.

The second part of the paper describes the application of mobile text messaging for the education and monitoring of Iraqi patients and has focused on the well-being of pregnant women with gestational diabetes. As part of this project two text messaging pilot studies have been carried out in collaboration with medical schools in Baghdad, the capital, and Basrah in the south of the country.

II. UKIERI India Project

The last few years has seen the introduction of several m-health systems for monitoring diabetes and cardiovascular diseases. Since this technology has been an active research area in the UK for over twenty years, our UK-India Education and Research Initiative (UKIERI) project was given the remit to transfer this work to India with the aim of improving the monitoring of and cardiac conditions by taking advantage of the existing mobile telecommunications infrastructure in India. The components of the system, shown in Fig. 1, are now in place and technical trials are underway, with clinical trials to follow.

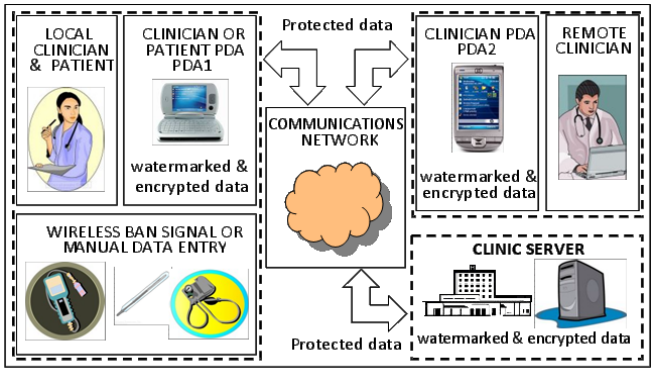

Figure. 1. m-health system implemented for the UKIERI project

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An investigation of previous m-health systems was carried out to highlight aspects that could be adopted for the current project or where new components or techniques needed to be developed. By investigating previous research and eliciting advice from stakeholders, the work has identified and addressed a number of requirements that a system that would need to exhibit to provide the level of monitoring envisaged, and these are listed below.

- To develop a network of wireless sensor nodes worn by a patient to record vital signs. To transmit between nodes, a low power, high data rate protocol has been used as an alternative to the more conventional ZigBee and Bluetooth connectivity approaches.
- To identify specific general health measurements of the patient to be recorded by the system that would provide indicators for trend analysis and early warning of the onset of complications. As well as the vital signs from the sensors, readings from standard instruments recording a patient's well-being and notes recorded by medical practitioners can be gathered.
- To allow access using web browsers, including standard mobile device web browsers, and thereby enabling use of the system without installing a bespoke application. By using features available in the latest browsers, the system's web pages can provide all the facilities required for successful deployment, many of which, until recently, would only have been available in a dedicated application.
- To provide security of the transmitted patient data. This is achieved by embedding identification information that can be used to verify that no tampering has occurred. This additional layer of security has been implemented in such a way that any measures already in place remain unaffected.

The British Council's UKIERI programme, which was instigated at a meeting of the Prime Ministers of the UK and India, has enabled close collaboration between partners from two UK universities, two Indian universities and an Indian hospital. All partners were allotted work packages to complete that were related to their interests and strengths. The PDA application and database systems were developed at Loughborough University, the diabetes monitoring systems at Kingston University [6, 7], the sensor network and telemetry protocols at the Indian Institute of Technology Delhi, the cardiac spreadsheet format at the All-India Institute of Medical Sciences and data security and trend analysis at Aligarh Muslim University.

In the evaluation and technical trials, the system was able to acquire, transmit and display all the information as required in our clinical needs study. We have demonstrated that medical data from a remote patient can be transmitted and that the displayed information can be dynamically changed. An example electrocardiograph image gathered using the sensor nodes and transmitted to a mobile device is shown in Fig. 2. Now, with the system operational, further work is required on data presentation, since this is the part that the end-users, namely the doctors, nurses and paramedics, will interact with the most.

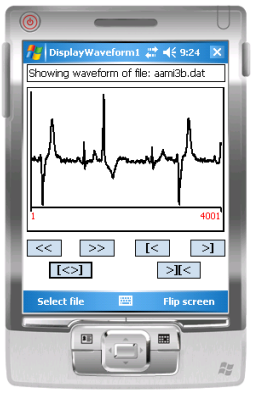

Figure 2. Example Electrocardiograph image displayed on a mobile device

Although it remains to be seen which of the many parameters being monitored will prove to be the most informative in practice in India, initial studies carried out in India using a sample of around 25 patients have provided some early indicators. The cardiac data gathered from these patients has been processed using frequency and wavelet transforms and a suitably small number of features has been selected. The system has shown a success rate of over 75% in being able to classify abnormal cardiac pulses as emanating from patients with a variety of medical issues, including gastric and prostate problems. The results of the study will be particularly useful in the development of a system for the initial screening of patients. In the longer term, trend analysis using the measurements recorded would need to be carried out in order to determine which are the principal parameters required and how they can be best incorporated in a health profile.

The existing prototype system is suitable for demonstration under conditions controlled by the development team. The plan for the next stage of the project is to design a robust miniaturized version of the monitoring system to facilitate proof of operation in rural regions of India. As the system is intended for portable use, consideration will also be given to the potential power consumption savings that result from burst and low-power transmission operation modes. In addition, a series of tests will be carried out to ensure that the transmission of data from the mobile phone to a remote server can be achieved in a sufficiently secure manner for commercial use.

III. DeLPHE-Iraq Project

The DeLPHE-Iraq programme was set up to introduce innovative and strategic e-Health plans for medical education and research in Iraq [8, 9]. The aim was to implement two proof-of-concept m-health projects, including trials to identify and classify the most urgently needed healthcare services.

Two m-health text-messaging pilot studies have been identified, planned and carried out in both Baghdad and Basrah (the main two cities in Iraq) and consists of the following activities.

- Feasibility and acceptability of the Short Message Service (SMS) for pregnant women in support of their healthcare (Baghdad)
- Feasibility of mobile phone text-messaging to support management of Type 2 diabetes in Iraq (Basrah)

Fig. 3 shows a generic block diagram of the m-health SMS system used in these pilot studies. The primary aim of the Baghdad pilot study was to assess the feasibilities and acceptability of this SMS intervention for pregnant women. The need for such intervention is urgent, as maternal death statistics for the years 2007-2009 in Iraq showed that 64.7% of such deaths involved no previous visits to maternal clinics during pregnancy [6]. In this study, two groups were identified: a control group of 146 pregnant women and an intervention group of 97 pregnant women. The women were asked to complete questionnaires to assess their opinions of the health information provided by the mobile phone SMS messages and the effect of such messages on their attendance at the maternal clinics. A special mobile telephone number was provided for the women to access a clinician should they wish to make any enquiries or obtain information regarding the study or any other health-related issues. The results have shown an increase in the number of visits, with a median of four visits for the intervention group compared to a median of two visits for the control group.

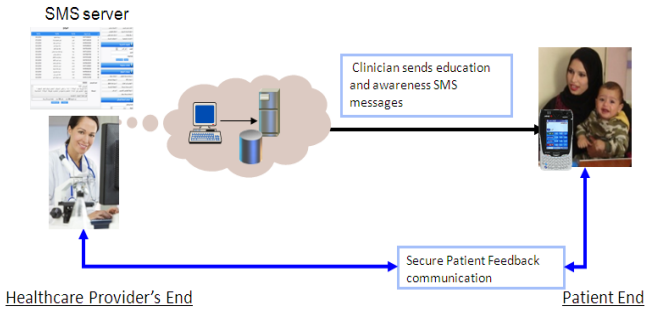

Figure 3. SMS-based m-health system in Iraq

The aim of the Basrah pilot study was to explore the feasibility, acceptability and cost of SMSs in supporting adults with Type 2 diabetes (T2D). In addition, the study aimed to collect data on the potential effect of this intervention on knowledge, glycaemic control and diabetes clinic attendance. Fifty patients who had been diagnosed with T2D in the previous 12 months were recruited from the Outpatient Clinic in Al-Sadar Teaching Hospital in Basrah and were asked to complete questionnaires at the beginning and at the end of the pilot study. During the study, education and awareness SMS messages were sent by the clinician to the patients. The results of the study showed that sending educational text messages via mobile phones significantly increased the knowledge of patients, with the level of knowledge, as assessed by the questionnaires, significantly increasing from a score of 8.57 to 9.85. In contrast to earlier studies investigating SMS patient education, these new results demonstrate that text messaging is a suitable method for providing information to individual patients or larger groups of people. Furthermore, during the period of the study, HbA1c levels in the patients decreased significantly from 9.33 (±1.3) to 8.56 (±1.16).

In conclusion, both pilot studies indicated that by using SMSs for m-health a significant improvement in healthcare can be achieved for patients in Iraq. Plans are currently underway to conduct large, randomized m-health clinical trials for diabetes management in the country.

IV. Conclusions

In this paper we have presented m-health examples from two diverse developing countries, namely India and Iraq. In both countries the potential for adoption of these technologies to improve healthcare services is substantial, with major opportunities to increase disease awareness and implement better management.

Furthermore, from these two m-health studies, several key issues have been identified during the introduction of the systems, and these are summarized as follows.

- The availability of communications and networking infrastructures in both countries can assist the rapid deployment of these applications and systems on a larger scale.
- The inclusion of all the relevant stakeholders (clinicians, patients, telecommunications providers and operators) in the two countries is vital to the larger adoption and successful deployment of m-health services.
- The pilot studies indicated that the acceptability of innovative health delivery mechanisms and services by patients and clinicians in both countries is encouraging and positive. This is an important factor in any successful, larger-scale adoption for patient and clinician-led m-health services.
- There is a need for a strategic plan for m-health in these two countries to deliver not only a patient-centric approach but also a cost effective mechanism for m-health services.

Ultimately the services will be successful in these countries if these and other accelerating factors are considered and lessons are learned from these pilot studies and adopted in the introduction of similar systems in the developing world.

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