The Potential of M-Health Systems for Diabetes Management in Post Conflict Regions

A Case Study from Iraq

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Abstract— **The recent developments of m-health technologies particularly in the developing world are increasing sharply due to the importance and accelerated adoption of these technologies in the developing countries. However, there are few if any studies on the effectiveness of mobile health in post conflict regions especially in the Middle East region. In this paper we describe the design, implementation and clinical outcomes of a feasibility study on mobile diabetes management in Basra, Southern Iraq as an exemplar for the effectiveness of mobile health technologies for improved healthcare delivery in similar post conflict regions. The key clinical outcome of this study indicated the lowering of HbA_{1C} levels in the mobile health group indicating the potential of deploying such technologies in these regions where health resources are limited and challenging.**

I. INTRODUCTION

In the last decade the seminal term and concept of 'M-Health' was first defined and introduced as "mobile computing, medical sensor, and communications technologies for health-care" [1]. Since then, this concept has become one of the key technological domains that reflected the key advances in the internet, communications and computing components of m-health within the last decade. The m-health is currently bringing together major academic research and industry disciplines worldwide to achieve innovative solutions in the areas of healthcare delivery and technology sectors. In particular, different m-health applications in the developing world have taken a sharp increase in recent years due to the relative flexibility of adoption and deployment of these applications in these countries. Several m-Health projects throughout the developing world are being demonstrated with concrete benefits and healthcare outcomes and impact policy issues. These include [2]:

- Increased 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 track Diseases.
- Timelier, more actionable public health information
- Expanded access to ongoing medical education and training for health workers.

One such important emerging and transformational m-health platform is the use of mobile phone devices for prevention and management of chronic disease such as diabetes hypertension and cardiovascular disease. It is well known that the rates of chronic illnesses such as diabetes and hypertension are often highest in post conflict countries that lack the human resources and infrastructure to successfully manage them. For example, the overall prevalence of undiagnosed diabetes in the general population of Iraq is 2.14% with the highest prevalence of abnormal glucose homeostasis and diabetes being seen in the age range 40–59 years in both sexes [3]. With over 1 million sufferers, Iraq has some of the highest levels of diabetes in the Middle-East. From the technology perspective, the vastly increased access to mobile phones in low-medium income nations and post conflict regions has provided a unique opportunity for mobile health to be applied to improve healthcare and the management of chronic illnesses such as diabetes and hypertension without the need for massive public infrastructure spending. Although the effectiveness of mobile health in improving healthcare delivery in the developing world has been studied extensively [3], very few studies have addressed these technologies in post conflict regions and middle East countries like Iraq [4,5]. For diabetes in particular, numerous literature reviews and meta analysis studies provide ample evidence on the effectiveness of mobile diabetes management of improved clinical outcomes and patient education in type 2 diabetes [6], but none in for post conflict regions like Iraq. In this paper we present a feasibility study on using mobile phone technologies for type 2 diabetic (T2D) patients in Iraq. We describe the implementation of this program in primary care settings in Southern Iraq designed to assess and improve self-monitoring of blood glucose (SMBG) levels using smart

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mobile phones with automated wireless medical data transfer to remote specialist diabetes health care hospital equipped with disease management system and automated reminder with patient feedback facility tailored for post conflict healthcare environments. The first part of this paper describes the mobile diabetes management system developed for self-monitoring patients with T2D in Iraq together with the design and methods used in the feasibility study. The second part of the paper describes the clinical outcomes of the study and discusses the limitation and the challenges encountered during such study. The final part presents the key outcomes and concludes with lessons learnt on how to develop a general framework for the successful deployment of mobile health systems in post conflict regions

II. Mobile Diabetes System Methods

A. The DIAR System for Mobile Diabetes Management

In this section we describe the (*DIAR*) mobile diabetes self management system designed and tailored for this feasibility study and requirements.

Fig (1) shows the general architecture and key components of the *DIAR* system. It consists of two main components: (i) The mobile self-monitoring of blood glucose (SMBG) system and (ii) the remote web interface and health management system. The technical details of the design and development of similar systems has been extensively addressed elsewhere [7,8].

(i) The patient end consists of an Android based smart phone equipped with a special *DIAR* smart App developed for the pilot study. The phone is linked wirelessly via a Bluetooth adaptor (Polymap Wireless, LLC, Tucson, AZ) linked to the patient's blood glucose monitor (OneTouch Ultra 2 blood glucose monitor (LifeScan Inc., Milpitas, CA). The patient glucose level measurements and medical data were sent wirelessly via an internet link to the remote server using local HSXPA (3.5G) cellular and internet network connectivity (Zain, Iraq). The *DIAR* smart application also consists of programmable glucose reading reminders and text messaging menu for patient options to communicate with their healthcare providers for further advice if required.

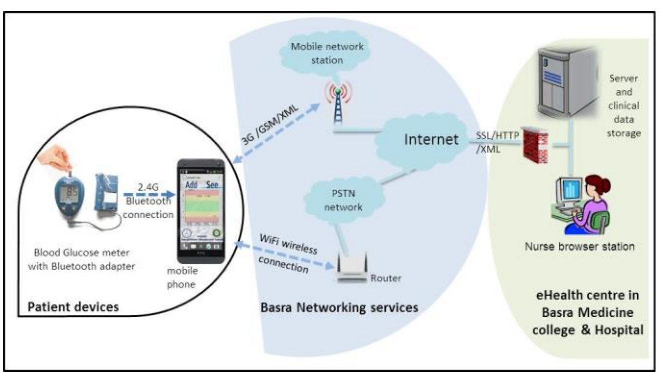

Fig. (1) DIAR Mobile Diabetes Management System Architecture

(ii) The remote server and web interface end consist of the *DIAR* health information and management system. In general, the software system consists of the SQL patient data base and the software engine rules required for the health data information management accessed via secure user dashboard interface. The general software architecture collects and manages the patient personal data and can be updated when and if required. The hosting server is linked via wireless internet connectivity that acquires and stores the individualized blood glucose levels transmitted in real time from the mobile phone units of each patient via the system's data communications and synchronization protocol. Furthermore, the system also provides access to the diabetes specialist nurse /doctor with the relevant patient statistical and graphical representations and data analysis. However, in this version of the system no patient diet plan has been developed. This option can be upgraded in future studies.

The server was located in a secure location within the diabetes unit in the Basra medical school hospital.

B. Feasibility Study Design and Methods

The effectiveness of the DIAR system was evaluated in this feasibility study with (n= 12) patients with Type 2 Diabetes randomize to two groups, intervention (n = 6) and control (n = 6) groups. The selected patients were recruited from the Outpatient Clinic in Al-Mawane Hospital in Basra, Iraq. Table [1] shows the base line demographic and clinical data of the patient samples selected for this study. The intervention period was for 3 months with a follow-up period of 6 months for each group. All patients were within their first year of diagnosis of Type 2 Diabetes, regardless of micro vascular complications. Inclusion criteria included possession of a mobile phone device. Learning sessions of the study were provided to all participants and oral consent and ethical approval were obtained as the standard for clinical research studies in Iraq. Ethical approval for this study was granted by Basrah Medical College, Iraq.

Table 1 Baseline demographic and clinical data of the T2D patients whom complete the study

	Intervention	**Control**	***P***
Number of patients	6	6	
Age, years	54.8 ± 12.7	55.2 ± 10.1	0.961
Duration of diabetes, years	10.7 ± 11.3	9.7 ± 9.4	0.871
Weight, kg	74.5 ± 8.5	74.0 ± 7.3	0.915
BMI	26.8 ± 3.1	26.0 ± 3.5	0.684
HbA1c			
Baseline:			
Pre pilot	8.95 ± 0.73	8.95 ± 2.17	0.065
Post pilot	8.05 ± 1.31	8.7 ± 1.7	0.363
Hypoglycaemia attack		?	
HDL cholesterol, mg/dL	43.4±10.5	46.17 ± 9.9	0.64
LDL cholesterol, mg/dL	137.8±24.3	146.2±22.9	0.56

In the m-health group, each patient in the telemonitoring group was supplied with the smart phone equipped with the *DIAR* diabetes management application together with their wireless glucometer , whilst the control group followed their usual diabetes care pathway plan and follow-up visits. In the intervention group each patient was asked to measure their own glucose levels twice a day (FBS and RBS). Furthermore, eligible participants were evaluated with proper medical consultation before the randomization to assess each patient's medical information that included: the baseline data, daily follow up glucose reading with functional questionnaire before and after the study for evaluation. The baseline anthropometric measures were obtained, including blood pressure weight height; and BMI were then calculated. Laboratory investigations were obtained using standardized Laboratory tests in pre and post pilot periods including FBS, RBS and HbA1c. Diabetic retinopathy was assessed using digital photography after pupil dilatation and was recorded as present (background, pre-proliferative or proliferative) or absent. All patients took part in a two-hour education session to give instruction in general diabetes care and self-blood glucose monitoring and were asked to complete a baseline questionnaire evaluating their knowledge level. This questionnaire was adapted and translated into Arabic from The Diabetic Knowledge Test [Michigan Diabetes Research and Training Center] from which 14 general questions were used [5]. Each question contributed one mark to a potential total of 14 marks. Glycemic control was monitored by measurement of Glycated Hemoglobin [HbA1c] using the enzymatic method supplied and was measured at baseline and 6 months. After six months follow up, The Diabetic Knowledge Test score was reassessed and marks were compared with baseline marks to evaluate change in knowledge level as the primary outcome.

III. RESULTS

A total of 12 patients with Type 2 Diabetes who were recruited from the outpatient clinic in Al-Mawane Hospital, Basra, Iraq completed the study. This compliance level also considered the accessibility issues and considering the circumstances of the pilot. They were all well matched according to their demographic and baseline clinical data as shown in Table [1]. Statistical analyses in the form of paired t-tests and correlations using SPSS 15.0 ® software for Windows 7 were performed to compare the test scores and HbA1c at baseline and 6 months. A linear regression method was applied to evaluate the effect of other factors including educational level. Findings were considered statistically significant when $p<0.05$. Table [2] shows the summary of the clinical outcomes of the feasibility study.

TABLE 2 CLINICAL OUTCOMES OF THE HBA1C LEVELS IN BOTH INTERVENTION AND CONTROL GROUPS IN PRE AND POST PILOT

Patients	**Telemonitoring**			**Control**		
	Pre Pilot	**Post Pilot**	***P* value**	**Pre Pilot**	**Post Pilot**	***P* value**
1	**10.1**	**7.9**		**12.5**	**11.2**	
2	**8.8**	**7.7**		**9.2**	**9.4**	
3	**8.1**	**8.8**		**8.3**	**8.0**	
4	**8.4**	**6.4**		**6.6**	**7.5**	
5	**9.5**	**10.2**		**10.1**	**9.7**	
6	**8.8**	**7.3**		**7.0**	**6.4**	
Average	**8.95 ± 0.73**	**8.05 ± 1.31**	**0.115**	**8.95 ± 2.17**	**8.7 ± 1.7**	**0.448**

From the clinical outcomes, the mean baseline HbA1c was 8.95% [0.73] and decreased to 8.05% [1.31] [*p=0.115*] after the mobile intervention. This result indicates the key outcome of this study on the effectiveness of the mobile management systems and intervention in lowering the HbA1c level. Linear regression showed that age, gender and educational level did not correlate with changes in HbA1c level although baseline and six month HbA1c values were correlated. However, the low number of participants [n=12] is reflected in the statistical significance of the results. There were no changes in total cholesterol, HDL cholesterol, triglyceride and LDL cholesterol levels before and after the follow-up period of the study. Furthermore, the outcome of the questionnaire survey showed that all patients were satisfied with mobile health intervention and agreed that the service should be continued as part of their medical care after the study. They also reported that they had received timely reminders from the system at appropriate times and more than 90% of patients found the *DIAR* system was acceptable and easy to use for their diabetes management. The participants' level of knowledge increased significantly after the intervention which is consistent with the findings of similar mobile diabetes intervention studies elsewhere [6,7].

IV. DISCUSSION AND CONCLUSIONS

This feasibility study demonstrates that mobile diabetes technologies can be considered as an acceptable approach to improve education and management of diabetes participation in Iraq as an exemplar for a post conflict region. This is to the best of our knowledge the first such m-health intervention in Iraq or any post conflict area. Provision of improved glycemic control and education through mobile phone technologies represents an effective and available approach to provide knowledge for patients with Type 2 Diabetes in Iraq. However, several problems were encountered during this study. These included (i) the difficulty of recruiting the patients (ii) the low number of the patients in the study (iii) the lack of sufficient healthcare diabetes specialists and clinicians in the region and (iv) lack of experienced technical support from the telecom and IT for healthcare providers. Some positive outcomes from this study were observed such as the keen acceptability of the patients for using this technology and also the positive reception of the doctors and care givers to such innovations in providing better diabetic healthcare services in Iraq. Unfortunately there is currently no accurate prewar cost statistics on the burden of diabetes in Iraq to compare it with the postwar era statistics to provide an accurate cost and economic analysis for such technology for pre and post conflict conditions. Initial experience in mobile health intervention in Iraq suggests that this method of communication can offer a cost-effective approach for healthcare support and better quality of life to patients given the increasingly widespread use of smart mobile phones in Iraq [4]. In general , healthcare education, services and research in Iraq has been deteriorating for several decades because of neglect, sanctions, absent internet services and turmoil in recent years by the political instabilities. It is recognized that Iraq lacks quality health services in urban and rural areas, the general population healthcare status is poor, the prevalence of chronic disease and cancer in recent years is increasing and there is clear deficiency of evidence based disease management strategy [8]. However, the need for innovative strategies for the delivery of healthcare research and better medical education based on emerging communication, computing and internet technologies for enhanced healthcare services is both urgent and timely. However, this problematic outlook in healthcare is paralleled and especially since 2003 with the wider introduction and exponential usage of computers, mobile phone and Internet technologies in Iraq, these constitute an existing and enabling communications infrastructure for better healthcare delivery systems. The recent mobile subscriber forecast for Iraq envisages more than 30 million users by the end of 2015, equivalent to a penetration rate of 75.6%. By the end of 2015, it is predicted that Iraq's mobile penetration rate will have risen to more than 93% [9].

Mobile health is becoming one of the fastest growing areas of effective healthcare delivery especially in low to middle income countries [3] with health education and awareness programs being increasingly recognized as the key players. However, in post conflict regions like Iraq the need for such technology to deliver care especially in underserved and remote areas is urgent and timely. Particularly since Iraq's current health infrastructure is based on primary health centers and secondary care hospitals. There are approximately 2053 primary health centers [8]. At present the vast majority of health services are provided centrally and 50% of the doctors are based in Baghdad alone with no reliable referral system and often the relationship is suboptimal. In addition, there is currently in Iraq an estimated average of 6.2 doctors per 10000 of the population [8]. Furthermore, the prevalence of chronic conditions in Iraq such as cardiovascular diseases, diabetes, malnutrition and cancer are one of the highest in the region and constitute major causes of mortality in the country. The adoption of new e-health and m-health strategies in these countries is urgent. However, major obstacles including wide spread corruption, political and security challenges in addition to lack of the medical and engineering expertise in these areas constitute major challenges in Iraq and other similar post conflict regions. Finally, the key recommendations for developing successful mobile health strategy and framework in Iraq and possibly other post conflict regions include:

(i) The need to identify and address the key national healthcare priorities and services that can make use of m-health technologies adaptable to these priorities. (ii) The establishment of strategic and sustainable national m-health plan (iii) Development of both medical and technology sectors in the country with private and public partnership (PPP) to ensure successful and sustainable m-health services and, (v) The need for introducing relevant educational courses in digital health as part of the post graduate medical educational curriculum is important and timely, (iv) The establishment of a governmental regulatory body to supervise these services and oversee the relevant security, privacy and ethical issues.

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