THE ROLE OF TECHNOLOGY IN EDUCATING DIABETIC CHILDREN

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Abstract—Diabetes is one of the chronic diseases which have been commonly found in many regions and the number of diabetic people is increasing rapidly across the globe. Unlike other diseases, diabetes is a condition where an extensive care and guidance is needed to manage the disease, without which serious complications may arise. Therefore, there is a need to educate people and create awareness about self-management techniques, especially with diabetic children. Diabetic children need more care compared to the adults and it is alarming to observe that the number of diabetic children is increasing rapidly across the globe and also in Saudi Arabia. Saudi Arabia is also a country where there is high penetration of mobile and internet technologies in the recent years. Considering these factors, this study aims to develop a website system integrated with multimedia technologies like games, videos, and books for educating and creating awareness among the diabetic children. To achieve this aim, both qualitative and quantitative methods are used. To gather requirements for the website development, diabetic children along with their parents are interviewed informally. Using the waterfall model, the Diabetic Children Education System was developed. The usability of the system was evaluated using a survey questionnaire, and the results have shown that all the participants were highly satisfied with the system. In order to analyse the impact of the system in educating and creating awareness, a diabetes knowledge test (DKT) questionnaire was developed. Both surveys are conducted online using a survey link. The DKT was conducted before and after using the system by participants, and was completed by the parents by discussing with their diabetic children. The results have shown that there was a significant improvement in the diabetes knowledge of the participants. The study has concluded that the use of web technologies in education and awareness among the diabetic children can achieve good results and can improve diabetes management.

I. INTRODUCTION

Diabetes has become one of the major health concerns in the last few years across the world. It is one of the most commonly found chronic diseases globally, and the number of diabetic people has been increasing rapidly. About 415 million people have been diagnosed with diabetes, and 318 million adults have impaired glucose tolerance which puts them at high risk of developing the disease in future. About 5 million people died because of diabetes and diabetes-related complications in 2015. Moreover, the treatment of diabetes and its related complications were cost around 5-20% of health expenditure in most of the countries worldwide. Additionally, the prevalence of the disease is also increasing in the recent years. One in every 11 individuals have diabetes and one in 15 individuals have impaired glucose tolerance in 2015, which is projected to increase to one in ten individuals by 2040 (International Diabetes Federation, 2016).

It has been observed that the cases of diabetes growing among the children under 14 years in the past few years. More than half a million children are having diabetes, and about 86,000 newly diagnosed cases of diabetes are found every year.

Rank	Country/territory	Number of children with type 1 diabetes
1	United States of America	84,100
2	India	70,200
3	Brazil	30,900
4	China	30,500
5	United Kingdom	19,800
6	Russian Federation	18,500
7	Saudi Arabia	16,200
8	Germany	15,800
9	Nigeria	14,400
10	Mexico	13,500

Figure top 10 countries for number of children with type 1 diabetes worldwide (2013)

The international diabetes federation has classified kingdom of Saudi Arabia as the seventh highest countries in getting diabetes with children while around 16,200 children in region are diabetic and the number of cases increasing rapidly every year (International Diabetes Federation, 2016). This is one of the serious concerns in the country as it highlights the immediate need for the various efficient systems in place for managing the diabetes among the children and the adults. In the last few years, it has been observed that the technology is expanding at a faster pace, and has made its presence in every sector including businesses, healthcare, and even in the peoples' lives. Internet technology along with mobile phones has brought a revolution in the ways of information exchange and service transfers and deliveries. Various organizations have been utilising these technology changes in order to improve their processes and service delivery. Technology, especially internet and mobile technologies are also being used in the healthcare sector as it can provide various benefits like reduce operational costs, improve resource utilization, process efficiency, and service delivery (Mowafa et al., 2014). However, it is also essential that there should be enough penetration of mobile technology in to the people for launching and utilising mobile technologies in the healthcare sector. In parallel to the increasing diabetic population in the country, there has been a rapid increase in the mobile phone users in Saudi Arabia in the recent years. There are more than 51 million mobile phone subscriptions and about 78% of the populations have broadband access in the country (CITC, 2013; Saudi Gazette, 2015; MICT, 2015). Considering the rising diabetic population and increasing mobile and internet technologies in the country, and with the focus on the chronic disease management such as diabetes management, the modern technology especially mobile health technologies can be an effective and efficient strategic tool in improving the disease management and awareness in Saudi Arabia.

Marjorie Cypress, President of American Diabetes Association has said that "Diabetes is a serious epidemic facing not only our nation, but the world, - But we can make progress in the fight to Stop Diabetes by educating people about the vital importance healthy living plays in helping to prevent type 2 and manage all types of diabetes" (Alexandria, 2014). Awareness and education can play an important role in managing diabetes, which needs regular monitoring and many other self-management techniques. Therefore, there is a need to find various approaches in creating awareness and educating the diabetic people about self-management techniques and in this process technology can be used to find effective and efficient solutions.

1.2. Aim & Objectives of the study
This study aims to investigate the use of modern technology in improving the diabetes awareness for diabetic children and their families; and develop multimedia website for creating awareness. The objectives of the study include the following:
- Investigate the nature of diabetes condition, types, and the techniques of self-management.
- Investigate the role of internet and web technologies in the process of creating awareness, especially multimedia technologies like videos, games, e-books.
- Investigate and analyse the needs of the diabetic children for managing their condition.
- Design and develop a website with various multimedia techniques for creating awareness of diabetes among the children and for educating them.
- Implement and evaluate the performance of the system in educating and creating awareness among the diabetic children.

1.3. Motivation

Children have different requirements to adults in case of managing the diabetes. They need different methods which can be fun to associate with and which can attract and create interest among them. The educational strategy should include fun activities like games and multimedia content to generate interest among the children. Technology can be used to fill these requirements. In this new age of technology, there are a lot of strategies like games, videos tutorials, books and blogs that are suitable for children. Furthermore, Internet technology plays a significant role in delivering the services; as it would help in delivering healthcare services remotely, reduce number of hospital visits, enable remote monitoring, and improve disease management process. The rapid development of technology and penetration of internet technologies in to the people has enabled the researchers to investigate the possibilities of using these technologies for effective healthcare delivery. Various studies have been conducted in this aspect for diabetes management. Considering these supporting factors, this study would focus on conducting the similar research in Saudi Arabia, where the studies among the diabetic children are limited. The outcomes of the study would help in taking the approach further by adopting new technologies combined with various therapies.

1.4. Scope

As discussed in the previous sections, diabetes awareness is a cornerstone of managing diabetes effectively. The scope of this study is limited to investigate the use of web technologies for diabetes management by creating awareness among the children and families in Saudi Arabia.

II. DIABETES EDUCATION

Diabetes education is one of the major solutions for improving the diabetes management. Diabetes education should be imparted to children for managing self-care activities and to fully support themselves. Self-care activities include behavioural aspects such as following a diet plan, avoiding high fat foods, daily exercise, self-glucose monitoring, and foot care etc. (American Association of Diabetes Educators, 2016). In UK, the National Institute of Clinical Excellence (NICE) guidelines recommend that diabetic patients and/or their carers should be offered diabetes education programmes to help them in managing their condition. It aims to provide the participants with knowledge, skills and empowering them to have effective control on their condition (NICE, 2016). Few studies explored the improvements in diabetes patients' health awareness after enrolling them in the diabetes education courses. In a randomised controlled trial study conducted by Davies (2008) using cluster analysis approach, evaluated the effectiveness of a structured group education program on psychosocial, biomedical and lifestyle measures in newly diagnosed T2D patients at 13 primary care sites in the UK. A total of 824 participants (55% men, mean age 59.5 years) were included in the study. The participants were given an education program of six hours by two trained healthcare professional educators. This intervention was compared with the traditional approach of diabetes care over the course of one year. The study has found that there was a significant improvement in weight loss, smoking cessation and positive improvement in beliefs about the illness (Davies, 2008).

Another study conducted by Joann & Sarah (2013) examined the role of a structured diabetes self-management education program in sustaining patients with suboptimal control. A total of 523 adults with T2D and HbA1c levels greater than 7% participated in a randomised control trial study, divided in to control and intervention group. The intervention group participants were assigned to receive confidential individual education (IE), group education (GE) based on the U.S. Diabetes Conversation Map, while the control group participants received usual care for a period of 12 months. Medication use, physical activity, recommended food score (RFS), problem areas in diabetes (PAID), diabetes self-efficacy (DES) and A1C levels were quantified at the baseline and after one year via electronic health records and quarterly mailed surveys. The outcomes were assessed using linear mixed models. The IE involved three 1-hour individual sessions spaced about one month apart and presented by nurses or dietician-certified diabetes educators through the conventional method of the care system. The GE involved four 2-hour sessions delivered one week apart by the same certified diabetes educator (either a nurse or a dietician) and based on the U.S. Diabetes Conversation Map program authorized by the American Diabetes Association. The study found that the two different types of diabetes education programs have improved diabetes knowledge and self-efficacy of the participants; although IE was slightly more effective than GE (Joann & Sarah, 2013). Another study conducted by Hussein et al. (2011) focused on using mobile messaging technology for improving awareness about diabetes. A structured diabetes education program with use of SMS technology in Iraq was conducted for investigating the use of SMS in improving diabetes health awareness. It was found that the structured diabetes education proved to be highly effective in improving the diabetes information. Various studies as discussed have concluded that education programs and mobile technologies could be highly beneficial and effective for creating awareness among the diabetes patients.

2.2. Technology Solutions for Diabetes Management

Various technology solutions are being deployed in the process of diabetes management, and also in educating and creating awareness about the diabetes. Some of the major solutions include:

2.2.1. Websites

Websites are the most commonly used technology applications for diabetes management and also education, delivering care etc. There are various websites developed by healthcare institutions, government agencies, and research organizations for imparting diabetes knowledge and also for diabetes management. Diabetes information is also presented on the healthcare organizations website, which can easily be read and understood by people. Private organizations also play an important role in creating awareness about diabetes through websites like (www.diabetesselfmanagement.com), (www.lillydiabetes.com) etc. where complete information about diabetes, its complications, and self-management techniques is published. Similarly, government bodies like (https://www.cdc.gov/diabetes/home/), and research organizations like (http://www.diabetesatlas.org/) also play an important role in educating the people. In a review study conducted by Brown et al. (2007) on website intervention has found that, websites are most commonly and extensively used applications for diabetes management, accessed by all the involved parties including physicians, patients, and administrators. Emails also play an important role in the information transfer and communication in the process of diabetes management.

2.2.2. M-Health Applications

The number of people using mobile phones has been increasing rapidly across the globe. Mobile technology has many advantages, as it can enable 24x7 access to all the services using mobile internet technologies like mobile applications, and also have greater reachability of healthcare solutions to the people enabling remote access. There are various mobile applications available for diabetes management with various features like glucose monitoring, reminders, education through videos and books, booking hospital appointments etc. They are available on all platforms including android, Blackberry OS, Apple iOS, Windows OS etc. Some applications are available for free while some are charged. Some of the major mobile applications for diabetes management found include BG Monitor Diabetes (android), BlueLoop (android, iPhone), Carb Counting with Lenny (android, iPhone), Diabetes Pilot Pro (iPhone), Glooko (android, iPhone) etc. Among these BlueLoop, Carb Counting with Lenny are specifically designed for diabetic children with more attractive and interactive features. In a study conducted by El-Gayar et al. (2013) it was found that m-health applications had high potential in diabetes management; however it was also highlighted that these applications must be user-centric, social, and also highlighted that high costs as a drawback for greater reachability.

2.2.3. Integrated Systems

Integrated systems are highly technical systems were the mobile communication technologies are integrated with other therapies for diabetes like Cognitive Behavioural Therapy (CBT), social aspects like social networking etc. for effective diabetes management and education. These systems are currently in the focus of many research works. In a study conducted by Alanzi et al. (2014) and Alanzi et al. (2016), social networking and CBT was integrated in to a mobile application system with website access at physicians end and mobile application access at patients end for diabetes management, awareness and education.

2.3. Diabetes Management in Saudi Arabia

There is a rapid increase in the chronic diseases in Saudi Arabia in the recent years. About 78% of the deaths in the country are related to various chronic diseases; and about five per cent of these deaths are attributed to diabetes. In addition to the rising diabetic population, there is a huge increase in the healthcare expenditure for treating diabetes. In 2015, healthcare expense of $1145.3 per person was incurred in treating the diabetes (International Diabetes Federation, 2015). According to International Diabetes Federation (2016) Saudi Arabia also ranks among the top countries in the world with high prevalence of diabetes among children. The recent studies shown that the diabetes incidence was estimated at 27.5 per 100,000 with 17% annual increase; and the prevalence was estimated at 159 per 100,000 which is expected to increase as child gets older (Sherif, 2015). Unfortunately, the data on diabetes challenges among children in Saudi Arabia is limited. In parallel to the increasing diabetic population, there has been rapid development in using internet and mobile technologies in the country. High penetration of mobile and internet technologies was observed in the recent years in Saudi Arabia. It ranks among the top countries in the world in terms of mobile penetration rates (72.8%), and more than 60% of the population have access to internet on their mobile devices. Various services like emails, chatting, online shopping, education etc. were accessed on mobile phones (Bahijri et al., 2016; AlQulaity et al., 2015). Though there is an extensive scope for launching technology solutions for diabetes management in Saudi Arabia, the research work in this aspect was very low compared to the other developed countries

III. RESEARCH METHODOLOGY

3.1. Introduction

This chapter includes the research methodology of the project. Conscientiously, I introduced some of research strategies, the research method, the research approach, the methods of data collection, the selection of the sample, the research process, and the type of data analysis, the ethical considerations and the research limitations of the project.

3.2. Study Design

The overall design of the study is presented in figure 3.

Figure Study Design

3.2.1. Philosophical Perspective

A well begun work is half done. The research methodology guides the researcher in conducting the research activities effectively by adopting the academically approved approaches which would ensure the minimal risks of failure. To begin with, a researcher must identify the philosophical perspective of the study. There are various philosophical perspectives like positivistic, interpretivistic, realistic approaches. In positivist approach, the researcher believes that factual knowledge gained through observation and analysis is trustworthy. In this approach, it is believed that scientific methods can be used for observation and analysing the data, which then can be interpreted to arrive at a confirmation or conclusion (Saunders et al., 2008). In Interpretivistic approach, the outcome of the research is mainly dependent on the researcher's ideas and approaches; and it works with an idea that social aspects cannot be analysed using scientific methods and techniques especially in analysing the information. Considering the nature of this study, a positivist philosophical approach is adopted.

3.2.2. Study Approach

Usually two major approaches, inductive and deductive approaches are adopted in a research study. In deductive approach, specific confirmations are achieved at the end of the study from general theories, by using different techniques like observation and hypothesis. In deductive approach, the data collected to evaluate hypotheses related to an existing theory. For deductive approach, the hypotheses that been sated need to be tested for confirmation or rejection during the research process. Deductive sometimes called top-down approach or waterfall approach as it works from more general to more specific. Moreover, the arguments in deductive approach are used based on laws, rules and accepted principles. On the contrary, in inductive approach the arguments are based on observation. For inductive approach, the data is collected to inquire into a phenomenon, identify themes, patterns and create a theoretical framework. Moreover, when the premises true the conclusion must be true too in deductive approach. For inductive approach known premises are used to generate non-testable conclusions. The inductive approach starts with research questions and the aims that need to be achieved during the research process.The inductive is called bottom up as it works moving from specific to the general. In Inductive approach, observations are made to form patterns and generalised theories are formulated using tentative hypothesis (William, 2006). As this study focuses on observations like design and testing the diabetes awareness system using scientific methods for data analysis to arrive at specific confirmations, deductive approach is adopted in the study.

3.2.3. Choice of Methods

Mainly qualitative and quantitative methods are used in any research study. A qualitative research is descriptive, as the research topic is being fully described and it is investigational in nature. On the other hand, the quantitative research is aimed at gaining depth in specific field or event and giving a description or causation. The qualitative research commonly uses investigational questions such as How? and Why? questions. Quantitative research seeks to use questions that appropriate to a large sample of population such as Where? When? and What? In qualitative research, the data could be used to enhance the understanding of phenomenon and it's a comparison of images, behaviours and words. In quantitative research the data might be presented numerically and it aimed at analysing the measurable data with statistical procedures (Collis & Hussey, 2003; Saunders et al., 2008).

The design goal of qualitative research based on what the researchers are already looking for. To ensure the flexibility that needed to provide, the design might be developed as the project in progress. On the other hand, the research design in quantitative research is clearly specified in advance in which the type of data, data collection and analysis methods are defined. In qualitative research, the information is collected through different strategies such as interviewing, observing and etc. In quantitative research, surveys, questionnaires, equipment and other tools are used to collect the numerical data. In qualitative research, the information is selected from small non-random sample, whereas in quantitative approach large sample populations are used (Collis & Hussey, 2003). Considering the objectives of the dissertation both qualitative and quantitative research methods are used in this study. A quantitative research methodology was adopted as the study aims to find out the answer to an inquiry through numerical evidence. The main characteristic of quantitative research is that generates numerical data or information that can be converted into numbers. Its basic advantage, which also constitutes its basic difference with qualitative research, is that it offers a complete description and analysis of a research subject, without limiting the scope of the research and the nature of participant's responses. Qualitative approach is used for collecting the requirements for website by interviewing diabetic children and their parents. Considering the above discussed approach, this study adopts multi methods in the research work.

3.3. Data Collection and Analysis techniques

Data collection strategies in this study include interviews and surveys. Non-formal unstructured interviews are conducted with diabetic children and their parents to gather the needs and requirements of the children for diabetes management. Unstructured and non-formal interviews are used as there is a need for friendly and more convenient environment for children while asking the questions. Surveys are used for collecting the data from the users of the website. The survey questionnaire includes various question related to the functionality of the website. Another survey was conducted using Diabetes Knowledge Questionnaire for analysing the impact of the website in creating awareness among the diabetic children. The details and results of the survey process are explained in the next chapters.

3.4. Ethical guidelines

The following ethical guidelines are adopted in this study.

* The personal data collected from the survey participants will not be disclosed to anyone, without prior permission from the participants.
* The information gathered from the survey process and interviews will be used only for academic purpose.
* The survey and interview participants are fully informed about the need and the reason for taking their responses.

IV. SYSTEM EVALUATION

4.1. Testing & Evaluation

The diabetic Children Education System developed in this study can be evaluated from two different perspectives. The first is from technical point of view, which evaluates the functionality of the websites according to the user requirements; and the second is from clinical perspectives, where the impact of the system on increasing the awareness among the children is analysed. In both aspects, a questionnaire based survey was used collect the data and the results are analysed to arrive at specific confirmations.

4.1.1. Technical Evaluation

The system has been built and launched using the HTML, PHP programming languages and MYSQL database. The selection of these languages enables the user to enrich the website with multimedia content with rich graphics, which can be easily accessed and viewed by the users. The screenshots of the website are presented in the previous chapter, where it can be observed that multimedia content like videos, games etc. being accessed using a web browser. From technical perspective, the system can be evaluated by usability testing.

Figure snapscreen of website usability questionaire

The usability testing is a process where, the system is tested by the actual users who determine if it is meeting all the specified requirements; and also other features like usability features easy to use, GUI interface, navigation etc. which include both functional and non-functional requirements are also evaluated. A standard usability questionnaire was developed for evaluating the system. The questionnaire had 8 questions focusing on various functionalities of the system. The questionnaire was distributed online using surveymonkey.com and the survey link was sent to all study members via Email after 2 weeks of using the system. A screenshot of the survey questionnaire is presented in figure 8.The participants were informed about the purpose of the survey and are ensured that the personal data collected would not be shared with any unauthorized sources without prior permission from them. A total of 10 participants took part in the survey and their responses are presented in table 1.

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
It is easy to navigate through this web site.	7	2	1	0	0
It is easy to find what I want on this web site	8	2	0	0	0
This web site loads too slowly	0	1	1	0	8
The graphics on this web site are pleasing	9	1	0	0	0
It is easy to use this site upon my first visit	6	3	1	0	0
Clicking on links takes me to what I expect.	9	1	0	0	0
The organization of information on the system screens is clear.	8	1	1	0	0

Table 1. Usability Survey Responses

Majority of the participants are satisfied with almost all the functionalities of the system. Graphics and hyperlinks for routing to specific information on the website received highest scores (9), followed easy to access and information organization (8), Navigation (7). Though some people (3) find the easiness in using the website on first visit as satisfactory, majority (6) of them were highly satisfied. The speed of the website is good as it was ranked by 8 participants as highly satisfied. From these results it is clear that majority of the participants are highly satisfied with the features and the functionalities of the system.

4.1.2. Clinical side

The website includes YouTube videos about diabetes which are created by health institutions and professional experts. In addition, the website also includes books which are designed especially for kids. It also includes games to improve diabetes awareness and other visuals ads regarding diabetes. To explore the impact of the system in improving the diabetes awareness, the diabetes questionnaire was used in the tests is described in the table 1 in the appendix B. The questionnaire was adapted from the DKQ "Diabetes Knowledge Questionnaire," - Garcia and Associates for the diabetes self-management project at Gateway Community Health Centre, Inc. with support from the Robert Wood Johnson Foundation® in Princeton, NJ (Farmer, 2005). The questionnaire is distributed online using Google forms and the link is sent to all study members via Emails. The participants were required to fill the questionnaire before they use the website, to test their knowledge before the study. Then the participants are allowed to use the system for two weeks. At the end of two weeks study, the questionnaire was res-sent to the participants to analyse their post study diabetes knowledge. The questionnaire was filled by the parents by discussing the questions with their diabetic children. Pre and Post study scores of the participants were compared, and the results are presented in table 2.

	Pre	Post
1	44.00	71.00
2	52.00	64.00
3	39.00	55.00
4	35.00	60.00
5	41.00	64.00
6	52.00	50.00
7	53.00	67.00
8	31.00	50.00
9	61.00	69.00
10	54.00	61.00
Average	46.20	61.10
STDEV	9.62	7.43

Table 2. Diabetes knowledge test outcomes

The mean baseline score for the website's users was at 46.20% which rose significantly to 61.10% in 2 weeks. It is also important to note that all users scored less before using the website, which reflects poor diabetes knowledge. However a significant improvement was observed in the awareness of diabetes after a two week study.

V. DISCUSSION & CONCLUSION

5.1. Discussion and Conclusion

The main aim of this study was to investigate the role of modern technology in creating diabetes awareness among the diabetic children. The literature review and systematic review of prior studies analysed suggest that the technology solutions can be highly beneficial in creating awareness among the diabetic patients. In addition, the increasing internet usage in Saudi Arabia has an added advantage for testing the impact of the technology systems in this aspect. Web technology coupled with multimedia techniques like videos, books, and games are used as the technology intervention in the study. The pre and post study results showed that the use of diabetic children educational website can help in improving the diabetic children and their families' awareness regarding diabetes. The participants have shown significant improvement in increasing their awareness about the diabetes after the intervention study of two weeks. However, the study has few limitations like small sample population and short duration of study. However, the study has proposed a feasible solution for creating awareness among the diabetic children in Saudi Arabia which is observing a fast paced development in the implementation of internet and mobile technologies. With the increasing widespread use of internet technologies and easier accessibility by the people across different geographical locations makes the website a feasible and cost effective solution.

Some of the immediate benefits of the website are that it would not require significant capital investments to the stakeholders such as the hospital, patients, and the government and families, and can have greater reachability with remote access for diabetes management, can minimise healthcare costs, and reduce hospital visits. From the results of the study, it can be concluded that the diabetic children educational system had shown significant improvements in creating awareness among the diabetic children. This study can form a basis for future research works in the aspects of using various technologies for creating diabetes awareness which can result in effective diabetes management. Technology solutions like m-health applications, technology devices like glucose monitoring devices coupled with m-health applications, and other behavioral therapies can be used as an intervention with large sample population in Saudi Arabia.

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