Mobile Phone Including Smart Phone based Persuasive System Design for controlling Hypertension and Diabetes in Bangladesh

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Abstract

Hypertension (HTN) as well as type 2 diabetes (T2D) is considered as two of the leading medical and public health problems in the world. Despite several interventions, both these diseases are on the rise in Bangladesh, which is characterized by socio-cultural differences and limited access to latest technology. Literature survey revealed gaps including lack of a mobile based HTN and T2D control framework as well as service for developing countries and lack of instant peer support. Besides, simple SMS reminder service is not very effective. In this paper we have tried to answer the two research questions (1) how to develop a framework for designing a multi-intervention service for HTN and T2D prevention and control in Bangladesh and (2) how to develop a service based on the framework. We have adopted Hevner's design science framework, social cognitive theories and persuasive technology for answering these questions. The result of this study includes the development of a mobile phone based multi-intervention framework as well as service for HTN and T2D prevention/control in developing countries especially Bangladesh.

Keywords

Hypertension, type 2 diabetes, mobile intervention, Persuasive System Design, developing country

INTRODUCTION

Type 2diabetes (T2D) and Hypertension (HTN) are considered to be two of the leading causes of death worldwide with an estimated 9.4 million deaths and 347 million people suffering from these two diseases. Both are considered as risk factors for heart attacks, strokes, heart failures, coronary artery diseases and cardiovascular diseases. There is an increasing trend in prevalence of HTN as well as T2D globally. It is further estimated that the prevalence of diabetes among adults will rise to 439 million by 2030 (Shaw et al. (2010)) and prevalence of HTN will rise to 1.56 billion adults worldwide by 2025 (WHO,2000). According to studies, HTN and type 2 diabetes coexist in 40% to 60% of patients with type 2 diabetes (Arauz-Pacheco et al. 2002; Sowers et al. 2001). Treatment and control for both these diseases are very similar. Despite various interventions and initiatives, HTN and T2D are on the rise especially in low and middle income countries. Rising costs of healthcare have promoted the development of low cost web cum mobile based interventions globally (Carrasco et al. 2008; Joo et al. 2007; Logan et al. 2007; Patrick et al. 2009). Most of these interventions have been SMS or web based and with no instant peer support. Studies have mostly taken place in developed countries, but hardly any developing countries. Considering a developing country, such as Bangladesh, prevalence of type 2 diabetes is as high as 8.1% in urban and 2.3% in rural areas, while prevalence of hypertension in Bangladesh is estimated to be as high as 23.5% (Sayeed et al. 2002). Various SMS interventions for control and prevention of HTN and T2D have been tried but the success ratio is very low. One of the factors identified was that plain SMS do not work. Considering patient profiles in Bangladesh, which is quite different from that of other developed countries, more sophisticated systems and services will have to be designed to control and prevent HTN and T2D.

The development of a Smartphone based multi intervention service framework will go a long way in filling the gaps identified during the literature survey. Socio cognitive theories have proved to be effective in health

behaviour change interventions (Bandura 1998). Persuasive technologies, especially Persuasive System Designs (PSD) are being widely used to bring about behavioural change using socio-cognitive theories that involve persuasion and social influence.

In this paper we have proposed a Persuasive System Design for HTN and T2D management in Bangladesh using mobile phones, including smart phones. The paper is organised as follows: After the introduction, we provide a brief background of the paper where we discuss the health scenario in Bangladesh regarding hypertension and type 2 diabetes and the various interventions. This section is followed by theoretical background of the service design. After that, we have proposed a unique mobile based persuasive system that caters to overall hypertension and Type 2 diabetes management for developing countries such as Bangladesh. The next section describes in details the system implementation features based on the PSD model. This has been followed by the discussion, limitation and conclusion in addition to the future work.

BACKGROUND

Health Situation in Bangladesh:

Despite several SMS based interventions, prevalence of non-communicable diseases like HTN and T2D is on the rise. Researchers predict that there will be 10.4 million diabetic people by 2030. Unmet needs for medical care are higher for chronic illnesses like Diabetes than for acute illnesses in rural Bangladesh.(Alam et al. 2010)
As for HTN, approximately 20% of adult and 40%-65% of elderly people in Bangladesh suffer from HTN. A Recent NC risk factor survey in 2010 found that 11.4 million people in Bangladesh are hypertensive. High incidence of metabolic syndrome and lifestyle-related factors like obesity, high salt intake, and less physical activity are major causes of HTN in Bangladesh (Islam et al. 2012). The detection and treatment status of HTN is not satisfactory. However, with the increase in mobile phone subscriptions and access to better and affordable technologies, there is a scope for designing mobile based services that can improve the prevention and control of these non-communicable diseases.

eHealth and mHealth Services for Type 2 diabetes and Hypertension:

Various eHealth and mHealth services have been introduced in Bangladesh for the control and prevention of HTN and T2D. Two of them have been widely accepted in Bangladesh.

- Bangladesh network for non-communicable diseases surveillance and prevention (BanNet): BanNet is the forum for active collaboration of organizations/institutes that aims at promoting and conducting systematic collection, compilation and dissemination of information on NCD surveillance.
- AMCARE: AMCARE is a telemedicine service provided by Telemedicine Reference Centre Ltd. (TRCL) in collaboration with the Diabetic Association of Bangladesh (DAB). It provides patients with 24/7 access to doctors by phone, SMS and voice reminders for medication and tests, and regular tracking of blood sugar data by mobile phone(ICT et al. 2010)

The current interventions have low success rates since simple SMS or voice reminders are not effective. Due to illiteracy, a large chunk of the population is unable to read messages (Padmanesan et al. 2013). These interventions also lack peer support which is one of the leading factors for behaviour change for curing/preventing lifestyle related diseases like HTN and T2D. A smart mobile based multi intervention service based on PSD model that caters to all these problems needs to be developed to address these areas.

Diabetes and hypertension risk factors in Bangladesh:

Following are some of the common risk factors for both diabetes and HTN in Bangladesh:

- **Use of tobacco:** In Bangladesh, more than half of adult males and one-third of adult females consume tobacco in any form, smoking or smokeless. A recent study conducted by WHO Bangladesh found that 41% of the major tobacco related diseases are attributable to tobacco usage(Zaman et al. 2006).

- **Food habit:** High prevalence of hypertension in Bangladesh is attributed to high intake of salt (BBS 2003).

- **Physical activity**: Inadequate physical activity is a major risk factor. It leads to uncontrolled HTN and T2D. The global estimate for prevalence of physical inactivity among adults is 17%. In Bangladesh, people in the rural area undergo fairly moderate physical activity because of their traditional lifestyle whereas in urban areas it is very low. More than half (57%) of the rural and only 10 % of urban adults 'usually' have moderate physical activity(Rahman et al. 2005)

Control of these three risk factors will help in controlling/preventing HTN and T2D. Current interventions cater to a combination of either one or two of the above factors at a time but none include solution for controlling all the three risk factors in a single system or application.

Mobile Phones including smart phones: Ubiquitous modes of communication

Globally, mobile phones have proved to be ubiquitous mode of communication (Kaplan 2006). Out of 80% of world population - that is 6.7 billion people using mobile phones, 1.8 billion are smart phone users (ITU 2013). Bangladesh, with a population of 161 million, has 102.99 million active mobile phone subscriptions according to the Bangladesh Telecommunication Regulatory Commission. According to reports, mobile phone penetration is 66.36% among the whole population, with a growth of 10% per annum (BTRC 2013). Additionally, there are 4.96 million Smartphone subscribers in Bangladesh, boasting an impressive 222% growth in Smartphone purchases in the year 2012 to 2013 alone. Despite the jump in Smartphone purchases, its penetration still remains at 3.1% for the whole population but is definitely on the rise.

These promising numbers of mobile phone penetration have propelled the development of various mhealth initiatives and interventions for control/prevention of HTN and T2D in Bangladesh. There is scope for development of multi intervention services using mobile phones as well as smart phones for developing countries.

SOLUTION BASED ON HEVNER'S FRAMEWORK FOR DESIGN SCIENCE RESEARCH AND SOCIO-COGNITIVE APPROACH:

Hevner's framework (Hevner et al. 2004) for design science research, as shown in figure 2, was used for the identification of the problems, which was followed by literature review, development of the PSD framework for HTN and T2D and finally, the development of the Smartphone based service. The most common risk factors for HTN and T2D include use of tobacco, food habit and physical activity. Studies show that behavioural change initiatives have been highly successful in controlling these factors. Various health interventions have been designed using health behaviour theories. Some of these theories include Social Cognitive Theory (Bandura 1986), as shown in figure 1, Protection Motivation Theory (Rogers et al. 1976), Theory of Reasoned Action(Ajzen et al. 1980), Transtheoretical Model(Prochaska et al. 1997) and Health Belief Model(Rosenstock et al. 1988). Of these theories, we have selected the Social Cognitive Theory for designing the content of the Multi intervention service for managing/preventing HTN and T2D. According to this theory, environmental factors and personal factors interact with the behaviour of a person to bring about change. Behaviour is also impacted by social support and self-regulation. These factors have been considered for designing the service for HTN and T2D.
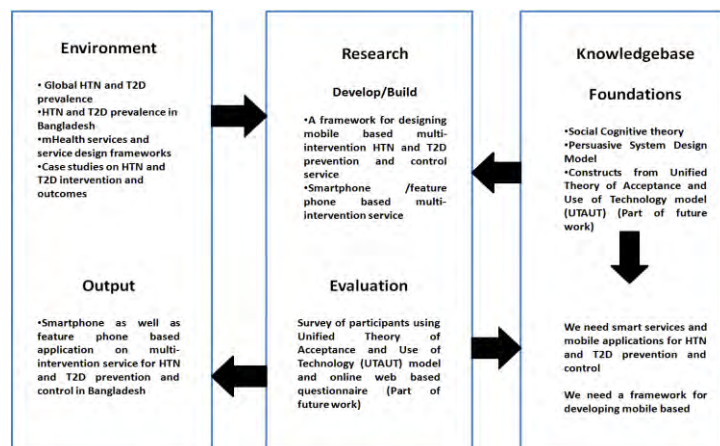

Figure 1: Social Cognitive Theory (Bandura, 1986)

Figure 2: Hevner's framework for design science research

Persuasive Technology and PSD model:

According to Fogg (Fogg et al. 2003), technologies using persuasion and social influence to change behaviours are known as persuasive technologies. These focus on interaction between computational technologies like mobiles and humans based on psychological theories for studying behaviour change issues. Various persuasive systems have been developed for disease management and control. The Persuasive System Design model by Oinas-Kukkonen (Oinas-Kukkonen et al. 2009a) provides a framework for designing IS services that can be used in the context of healthcare and disease management. The model talks about factors to be considered while designing a system but does not explain the software requirements and implementation features. We have

thereby adapted the model for designing the persuasive system for HTN and T2D prevention/control in Bangladesh.

As per PSD model by Oinas-Kukkonen as shown in figure 3 and figure 4, the system design involves three steps, namely:

- Understanding key issues
- Analysing context
- Designing the system features

Based on the PSD model by (Oinas-Kukkonen et al. 2008), we have developed the system model for controlling/preventing HTN and T2D in developing countries like Bangladesh.

Figure 3: Steps in persuasive system development by Oinas-Kukkonen et al. 2009

Analysis of HTN and T2D interventions in the context of PSD model

We selected 11 mobile based interventions of HTN and T2D and analysed their features according to the components of the PSD model (Oinas-Kukkonen et al. 2009a) in Table 1.The analysis helped in identifying the features missing in the interventions and were thus included in the multi-intervention service proposed later in this paper. None of the mobile based interventions had instant peer support component for behaviour change. They were all SMS or web based interventions and all were conducted in developed countries, but none in developing countries for HTN and T2D.

Table 1: Analysis of SMS based HTN and T2D interventions as per PSD model.

Primary Task Support	(King et al. 2008)	(Liu et al. 2008)	(Atienza et al. 2008)	(Beasley et al. 2008)	Ellrott 2005	(Newton et al. 2009)	Nguyen 2009	Prestwich 2009	Prestwich 2010	Sirriyeh 2010	Burke 2010
Reduction	y	y	y	y	y	y	y	n	y	n	y
Tunneling	y	y	y	y	y	n	y	n	y	y	y
Tailoring	y	y	y	y	n	n	y	y	n	n	n
Personalization	n	n	n	y	y	n	n	n	n	n	y
Self Monitoring	n	y	y	y	y	y	y	n	n	n	y
Simulation	n	y	n	n	n	n	n	n	n	n	n
Rehearsal	n	n	n	n	n	n	n	n	n	n	n
Dialogue Support											
Praise	n	n	n	y	y	n	y	n	n	n	y
Reward	n	n	n	n	n	n	n	n	n	n	n
Reminder	y	y	y	y	y	y	y	y	y	n	y
Suggestion	y	n	y	n	y	n	y	n	n	n	y
Similarity	n	n	n	n	n	n	n	n	n	n	n
Liking	y	n	y	y	y	y	y	y	y		y
Social Role	n	n	n	n	n	n	y	n	n	n	y
system credibility support											
Trustworthiness	y	y	y	y	y	y	y	y	y	y	y
Expertise	y	y	y	y	y	y	y	y	n	y	y
Surface credibility	y	n	y	y	y	y	y	y	n	n	y
Real world feel	n	y	n	n	n	n	n	n	n	n	n
Authority	n	y	y	n	y	y	y	y	y	n	y
Third party endorsements	n	n	n	n	n	n	n	n	n	n	n
Verifiability	n	n	n	n	y	y	y	n	n	n	y
social support											
Social Learning	n	n	n	n	n	n	n	n	n	n	n
Social Comparison	n	n	n	n	n	n	n	n	n	n	n
Normative Influence	n	n	n	n	n	n	n	n	n	n	n

Primary Task Support	(King et al. 2008)	(Liu et al. 2008)	(Atienza et al. 2008)	(Beasley et al. 2008)	Ellrott 2005	(Newton et al. 2009)	Nguyen 2009	Prestwich 2009	Prestwich 2010	Sirriyeh 2010	Burke 2010
Social Facilitation	n	n	n	n	n	n	n	n	n	n	n
Cooperation	n	n	n	n	n	n	n	n	n	n	n
Competition	n	n	n	n	n	n	n	n	n	n	n
Recognition	n	n	n	n	n	n	n	n	n	n	n

PROPOSED PERSUASIVE SYSTEM DESIGN FOR HTN AND T2D SERVICE IN DEVELOPING COUNTRIES (BANGLADESH)

Based on the Persuasive System Design (Oinas-Kukkonen et al. 2009a) , some features were identified which should be considered when designing a system for HTN and T2D service for a developing country.

As per the model in figure 4, the system design accordingly follows three steps. The steps are described in details below.

Step 1: Understanding Key Issues

This step has 7 factors that have to be considered for any system design. In the context of developing countries, these factors are as described below:

- Adaptability: The HTN and T2D service should be designed in such a way so as to be able to adapt to the user's behaviour change. System should be able to understand change in user needs and modify feedback/ suggestion accordingly.
- Commitment and consistency: System should provide instant options to user when user is craving or needs information/feedback/suggestion.
- Direct and indirect strategies: User characteristics vary, hence a combination of strategies should be provided to cater to different kinds of users.
- One step at a time: The system should provide gradual support to user for a consistent outcome throughout the intervention period.
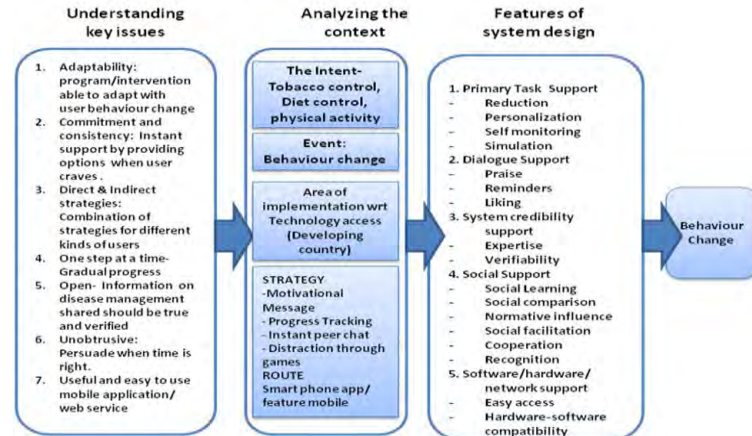

Figure 4: Persuasive System Design for HTN and T2D in developing country adapted from PSD model (Oinas-Kukkonen et al. 2009a)

- Open: The information on HTN and T2D management should be true and verified

- Unobtrusive: System should be designed so as not to be unobtrusive and provide information/ feedback/ query according to the user's comfort.

- Useful and easy to use: Service or system should be easy to use and useful.

Step 2: Analysing the Context

This step consists of 4 factors:

- The Intent: HTN and T2D prevention/control - This will be done through tobacco control, diet control and physical activity

- Event: The system's main focus will be behaviour change of the user for a healthy lifestyle

- Target for Implementation with respect to technology access: For designing the system the target population has to be considered. In this model the target population will be users from a developing country.

- Strategy: There will be a combination of strategies like motivational messages, instant peer support, progress tracking, and distraction options.

Step 3: Finalizing the features of system design

In this step the service or system design features will be finalized. The system design model has been adapted from PSD model(Oinas-Kukkonen et al. 2009b) As per our model, the system will provide 5 major kinds of support. We have further added software/hardware/network support to the list of features in the PSD model for developing countries.

(a) Primary Task Support

- Reduction: The system should be able to make the task easier for the users. The HTN and T2D service design has very simple steps for users.

- Tunnelling: The system will guide the users throughout the behavioural change process by providing messages, regular updates, progress tracking and suggestions depending on their change in behaviour.

- Tailoring: The system will provide tailored messages for each of its users. The information will be specific to the needs of the user in concern and will be unique for each.

- Personalization: The system will provide personalized content for the user based on his profile or individual health information.

- Self monitoring: The system will provide opportunity for each user to self - monitor his/her progress. It will provide instant statistics and progress track reports to users.

- Simulation: Users will be able to gauge the final outcome from the system such as when will they be able to quit tobacco consumption depending on their current rate of smoking, or time required to lose weight according to their current schedule of physical activity or diet control.

(b) Dialogue Support

- Praise: Based on user behaviour change system will generate messages or notifications praising the user on his/her attempt. It helps in motivating the user further to change behaviour.

- Reminder: The system will push regular reminders to the user.

- Linking: The system will have a look and feel that will be appealing, while being easy to use as well.

(c) System Credibility

- Expertise: The system will provide information on disease management at regular intervals.

- Verifiability: All the information provided through the system will be verifiable

(d) Social Support

- Social Learning: The system will provide a snapshot of the progress of the user as compared to other users of the same combination of services.

- Social Comparison: User can compare his/her performance with respect to that of other users. However, personal information about other users will not be visible to any user.

- Normative influence: Instant chat support of the system will allow users to be motivated by their peers and thus will be more likely to adopt target behaviour faster.

- Social facilitation: The system will allow users to see cumulative progress of other users.

- Cooperation: The system will help users to help others or get help/suggestion from their fellow users whenever they are craving for tobacco or food or help compare physical activity.

- Recognition: System will provide recognition to user depending on his/her progress. Other users will be able to see the top performers and can give their feedback or ask for suggestions from these users.

(e) Software/hardware/network support

- Easy access: The system should be designed such that users get easy access to it with their limited access to technology or service in the context of a developing country like Bangladesh.

- Hardware-software compatibility: While designing the system/service, hardware software compatibility should be kept in mind with respect to the technology availability in developing countries. In case of Bangladesh, the mobile app or service for HTN and T2D should be compatible with the Smartphones or feature mobiles used in that country.

PROPOSED SYSTEM DESIGN COMPONENTS

The system will provide an overall multi intervention service package for management and prevention of HTN and T2D. It will cater to the three leading factors like tobacco use, food habit and physical activity for every patient, depending on his/her requirement. The system will act as a personal virtual disease management tool and support provider. The main features of the system are given below in figure 5.
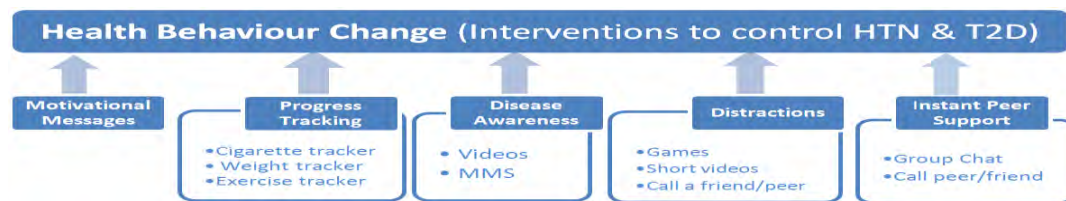
Figure 5: Interventions for controlling/preventing HTN and T2D

Motivational Messages: Based on Social Cognitive Theory for behaviour change, precompiled tailored messages will be pushed to patients'/participants' mobile phones to motivate them for any or all of the following
- Tobacco control
- Diet control
- Physical Activity

Table 2: examples of motivational messages for the multi intervention service

Hello Sharik, Feel the incredible personal power of knowing U kicked the habit U had for so long!!
What's the result of smoking too much?? Coffin!
Hey Zee, Be cool, Don't be a smoking fool!
If you smoke, you are a joke.

This feature will be enabled on mobile phones including smart phones. The messages will be personalized and tailored based on user information provided by the patient during signup or registration (as per table 2)

Disease Awareness and Information:

Regular mms, voice messages or video links will be shared with participants to create awareness regarding HTN and T2D. For smart phone users, the video can be seen through the mobile browser. Since majority of the population in Bangladesh own feature phones, disease related information will be shared through short video messages or mms in the native language.

Providing Distractions:

Whenever the participant is craving to smoke or eat, he/she can press a button on the Smartphone application that will direct him/her to preselected mobile games or motivational videos (as per figure 7). Through collaborative filtering, the embedded games and videos will be sorted according to the user's likes and views. For users with feature phones, in case of craving they can send a specific message like 'crave' to a pre-specified number. The system will automatically send a combination of video message/motivational message or connect him to a friend or relative whose number will be collected from the user during sign up. This will provide distraction through instant peer support.

Social Chat/Peer Support:

Smart phone users are provided real time chat support through the application for receiving or providing peer suggestions or feedbacks to fellow users (as per figure 8). Each user is added to a chat group the moment he/she registers. All the chats are saved in the cloud for future analysis. For feature phone users, each user is added to a

SMS chat group of minimum 3 and maximum 5 people. The user can thereby chat with the group for peer support through SMS, with all the members in that group receiving the message.

Progress Tracking:

For smart phone users, information like number of cigarettes smoked, calories taken, amount/type of food consumed and hours of adherence to exercise schedule will be collected on a regular basis through pop up survey notifications as well as through personal profile data (as given in figure 6). The data will be tracked on a regular basis. Users can track their progress through the app. For feature phone users, survey messages will be sent to them in the form of SMS or voice call, depending on the information for tobacco control, diet control or physical activity. By messaging 'Progress' to a predefined number, they can track their progress by getting the information in message format. The system also collects and analyses data regarding the body pressure and weight on a regular basis. Based on the progress, the system will push notifications or personalized motivational message

Figure 6: Motivational message and progress tracker

Figure 7: Games for distraction
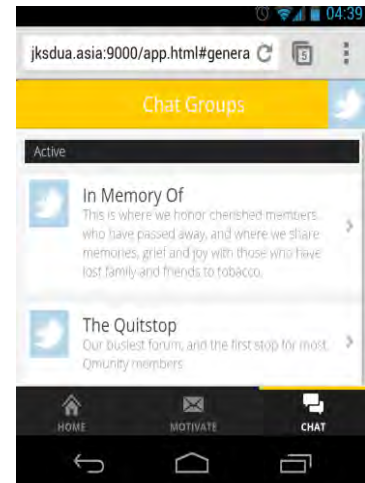
Figure 8: Instant chat for peer support

DISCUSSION

The Persuasive System Design has been developed for control/prevention of HTN and T2D with special focus on developing countries like Bangladesh. Various factors need to be considered in such cases where majority of people have limited access to technology and services and a large part of the population is illiterate. Reasons for tobacco addiction also vary from those in developed countries due to socio-cultural differences. This new multi intervention service design based on persuasive system will allow users having smart phones as well as feature phones to control/prevent HTN and T2D gradually through the control of risk factors like tobacco control, physical activity and food intake. Its major implication on theory includes the development of a modified Persuasive System Design framework which can be used for designing HTN and T2D prevention and control services for developed as well as developing countries. The implication to practice would involve the design of a Smartphone based service for prevention/control of HTN and T2D. This design can be used for developing similar services for smoking cessation, obesity and pain management etc. In the next step a multi intervention service toolkit will be developed, using the same framework, that can be used by any organisation to easily design and modify the service as per its requirement for control and prevention of various diseases through behavioural change.

Limitation:

The system has some limitations. Firstly, the present message template contains messages only in English. The messages will be configured in the local language, Bengali for the local population at a later stage. With the present design, the patients will receive SMS and updates only on English.

Secondly, the feature phones get limited access to progress tracking when compared to other users, besides limited access to instant peer support service due to limited features on feature phones, notwithstanding the high cost of telecom service. Smartphone users get more access to progress tracking and multiple users.

Thirdly, with the mobile application, patients cannot directly call a doctor. This feature will be added at a later stage.

Lastly, involvement of doctors through this application is limited at present. The patients can leave a message for the doctor through the chat facility and they can reply back to the patients whenever they have time. A cost incentive model might motivate the doctors to get involved more in these initiatives. The authors plan to study this as well in the future.

CONCLUSION AND FUTURE WORK

Many mobile based interventions for HTN and T2D management face technology challenges while being implemented in developing countries. Most of the services in the past had to be restricted to SMS reminder service. Keeping these issues in mind we have proposed a Persuasive System Design for developing multi intervention service for controlling/ preventing hypertension and type 2 diabetes specifically in the context of developing countries like Bangladesh. Users in developing countries have limited access to technology and services. Considering this problem, the new system design will help in developing services for control and prevention of HTN and T2D irrespective of the kind of mobile phones being used by the user. In the proposed multi intervention service that has been developed using the persuasive system model for developing countries, new features like instant peer support through mobile phones have been provided. This new model will be an effective way to design services for developing countries as most users have access to mobile phones.

Future work will include the following - Firstly, testing the design in Bangladesh or a developing country will be included in the future work. Secondly, the system will be modified to include options for other languages. This will enable the implementation of the system in other developing countries like India, Africa etc. Thirdly, the service can be modified by including a higher level, case based recommender system (Ghorai et al. 2013) using case based reasoning for tailoring of information based on the user's progress and profile.

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