

Developing Mobile Graphic Reminders for Reinforcing Compliance in Tuberculosis Treatment in Africa

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Abstract-A mobile graphic reminder is part of an application that reminds a patient about the need to follow the routine of taking medicine, and helps to monitor this process. The program is especially helpful for patients with limited literacy, language barriers or deaf. The purpose of this paper is to present and discuss (1) the benefit potential of visual-based communication in the medical context; (2) how graphics as reminder interventions to support tuberculosis (TB) treatment were designed and developed; and (3) how these graphics were evaluated. Thirty-four people, including TB patients, TB health workers and academics from the University of Cape Town, South Africa and Zanzibar, Tanzania participated in the evaluation exercise. The findings revealed that participants interpreted the meaning of most of the graphics correctly. It also found that the applications of images in the medical context might have potential to support patient treatment compared to other mobile interventions. The developed graphics are then embedded with mobile application on supporting TB patients to adhere to treatment through reminder methods. The paper contributes to mobile health (ICT4D) of developing an approach of mobile graphic-based reminder applications with literacy level, language and resource constraints.

Keywords-mobile graphic reminder; ICT4D; tuberculosis; visual communication

I. INTRODUCTION

Pictures and other visual objects such as graphs, symbols and diagrams are extremely prevalent today. People understand and remember what they see much more readily than what they hear or read [1]. Visual communication can be defined as communication through visual aids and is described as the conveyance of ideas and information in forms that can be read or looked upon [1, 2].

Several studies have been conducted regarding the use of images in medical contexts. The research conducted by Tran et al. [3] described transferring images via wireless messaging networks using camera phones to assist the diagnosis of skin diseases. The idea was that the patients could capture their infected skin areas and submit images to a doctor's phone through multimedia systems. The results found that the use of images in diagnosis provided quicker treatment and allows a physician to view and clearly understand the patient's problem rather than in text and speech.

However, the use of images as a reminder system in health contexts is a new area, particularly in Africa. Text-based and speech-based reminder systems present challenges in the developing world. The majority of African countries are faced with the problems of language barriers¹ and illiteracy. In South Africa, for example, there are 11 official languages [4] as well as high illiteracy rates. In Zanzibar, Tanzania however, all people speak one language (Kiswahili), but the problem of illiteracy exists. In these contexts, visual communication is relevant as it is largely free from language and literacy barriers.

This study aims to find out whether a graphical application is more applicable than a text or voice application in supporting tuberculosis (TB) patients in their treatment process. TB patients often forget to take their medicine as scheduled by health professional [5], which leads to difficulty in curing the disease. The number of disabilities and deaths caused by TB continue to increase. According to WHO (world health organization), approximately nine million people are infected annually in the world and almost one million die each year from TB [5]. South Africa is one of the countries with the highest burden of TB, with the WHO statistics [5] giving an estimated incidence of 500,000 cases of active TB in 2011 [6]. It is about 1% of the population. In Zanzibar, in the years 2011 and 2012, 546 and 537 (respectively) new cases of TB were recorded [7]. Zanzibar has a population of 1.3 million [8]. The most commonly found reasons [9] for missed medication are forgetting, family commitments, poor health and competing employment commitments. One way in which to avoid missing medication is by encouraging and motivating patients using reminder methods. This may lead a patient to be cured in the first phase of the TB treatment period. The minimum time for treating TB is six months [5], if a patient properly follows the treatment regulations as prescribed by health professionals. The use of mobile telephones may help patients in their treatment [5]. Mobile communication technology has been used as an intervention that reminds the patients to follow their treatment regimens.

The most commonly used mobile phone services to support patient's treatment are text messaging [10] and phone

¹ Scholars estimate that there are around 3000 spoken languages on the Africa continent [20].

call [11]. Patient received a phone call or SMS (short message service) remind him about a disease care or medication adherence. Compared to phone call system the text message has potential to work in the areas where mobile network is unpredictable, particularly in remote rural areas in developing world. The SMS also offers low-cost services than telephone call. However, both interventions require language skills. The user must be able to read and understand the language.

These technologies: text-based [9][12] and speech-based [13][14], have had use by some people to a limited extent. In this study the graphic-based reminders are proposed as an intervention to support compliance to TB treatment. Unlike text-based or voice-based, the graphic-based application is generally free from language and illiteracy barriers, which enables every person to understand the meaning of a particular reminder. This paper reports on the results of an experiment conducted to evaluate the use of graphics that would support TB treatment through a graphic reminders method.

In a preliminary study [15] that was conducted in Zanzibar from July to August 2013, the participants suggested various TB reminders to include in the proposed method. The collected texts reminders were then designed and developed into graphic reminders. The contribution of this paper is to present findings from the evaluation of graphics and illustrate how the development of a mobile application-based graphic reminder can support TB patients to adhere to their treatment.

The rest of this paper describes the motivation and advantages of the use of graphics as reminders in health contexts and how the collected text reminders were designed and developed into graphic reminders. Section 2 gives an overview of how the graphics were developed. To ensure that the graphics would be understood, the researcher conducted a survey to evaluate the graphics, as described in section 3. In section 4, the results of the survey are presented. Section 5 provides the conclusion.

II. DESIGNING GRAPHIC INTERVENTIONS

A. Development Process

The Adobe Photoshop software and Wacom tablet were used in developing the graphic reminders. The Wacom tablet was originally used to sketch prototype graphics, before Adobe Photoshop was employed to finalize the chosen graphics. Figures 1 and 2 are illustrated examples.

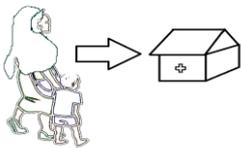


Fig. 1. Go to clinic prototype.

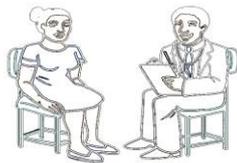


Fig. 2. Consultation prototype.

The advantage of the prototype sketches is that it helps to eliminate ambiguity [16]. It also helps to identify and address problems, for example missing, confusing or misunderstood features. As described in the methodology and results sections (Figures 3 to 17), after sketching several prototypes,

the researcher selected the best sketches and transferred this to Adobe Photoshop for editing, adding colour and design. The graphics were then shown to a number of people for testing. The idea behind this is that an initial design is presented to different people. They provide feedback and suggestions for improvement. These are processed by the developer, who then presents a more refined design. The people provide feedback once again. The process is repeated so that, at each stage, the sketches evolve towards the final design. The desired intention of this research was to answer the followings two questions.

- 1) How can we design, graphic reminders that can fit into various mobile phone screens?
- 2) Are the developed graphics understandable to every person; do they convey the intended meaning?

B. The Graphic Design Principles

Lawson [17] described that a good graphic designer is able to get their clients' messages across using a highly visual approach. The development of graphics in this study considered two principles of visual design as suggested by Impekable [18] - these are consistency and contrast.

- 1) *Consistency*: Consistency means creating a graphic that fits together at different resolutions and on mobile apps, and making sure that the same elements are being repeated to match each graph symbol, such as the same typeface, colour or gradient style.
- 2) *Contrast*: Contrast happens when two related elements are different. Great difference means great contrast. To make contrast work, the differences between the two graphics must be obvious. The differences are in size, colour or type.

Furthermore, mobile phone screens vary in size, contrast and type. Thus, the development considered the size and type of images in order to be compatible with different phones.

C. Graphics Integration with Voice

After the development of graphics is completed, the next part of the project will integrate those graphics with audio. The two languages to be used are English and Kiswahili. These languages are used as the project has two case studies: Zanzibar, Tanzania and Cape Town, South Africa. The choice of language considers the number of people who speak those languages in the relevant areas. In Zanzibar all people speak Kiswahili. This will enable them to understand the meaning of the voice that they will hear once a message is loaded onto the phone as a ringtone. The audio will tell the user that a reminder has been triggered to his or her phone. On the other hand, the majority of Cape Town residents understand English, so it also enables them to understand the meaning easily.

III. METHODOLOGY

A. Study Design

The study sought to find useful images to be used in an application that will support patients in their treatment process through a reminder method. The researcher conducted a survey to evaluate the developed graphics. Thirty four people participated in the evaluation. These include TB

health workers, TB patients (both inpatient and home-based-care patients), researchers and academics. Participants were from Cape Town and Zanzibar as the selected case study² locations of the study. These locations included the following participants:-

Cape Town – included participants from the University of Cape Town. This included academics, researchers and postgraduate students. A total of 17 people participated.

Zanzibar – a total of 17 people participated. These included participants from the State University of Zanzibar, which included researchers and academics, and MnaziMmoja hospital, where TB health workers and TB patients participated. MnaziMmoja hospital is the referral hospital in Zanzibar where all TB patients from central clinics are referred to.

TB health workers and TB patients are the target users of this application, but input from researchers, academics and students helped ensure that the graphics were understood by all. Furthermore, researchers and academics have expert knowledge in the graphic development context and could give suggestions on technical issues, such as graphic appearance and typeface. The participants categorised into three groups;

- Group A: Patients,
- Group B: Health workers, and
- Group C: Academics, researchers and students.

B. Ethical clearance

Ethical clearance for the study was granted by the University of Cape Town, and the Ministry of Health and Social Welfare in Zanzibar.

C. Mode of Evaluation

The evaluation was conducted between September and December 2013. The evaluation was first conducted in Cape Town then Zanzibar and then Cape Town. The two round evaluations conducted, two times in each site. All graphics were printed in colour and circulated to participants individually. The testing criterion was to ensure that each image is understood and conveys the correct meaning of a particular reminder. The reason for paper based evaluation is that once participant provided the feedback it was easy for the researcher to improve image using pencil together with participant, before modified through software.

Figure 3, for example, represents the reminder that the patient is to go to a clinic. Therefore, during the evaluation, it was observed if the participant could describe that correct meaning of the particular graphic. The feedback given helped to improve the development of graphics. Ten graphics were evaluated in the first round as shown: Figures 3 to 12.

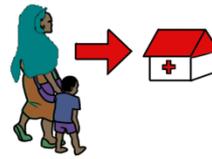


Fig. 3. Patient reminded to go to the clinic.



Fig. 4. Patient reminded to consult with a doctor.



Fig. 5. Patient reminded to take medication.



Fig. 6. Patient reminded to submit his or her smear sputum to doctor for checking.



Fig. 7. Patient reminded to take a glass of milk.



Fig. 8. Patient reminded to eat a healthy meal.



Fig. 9. Patient reminded not to cough in this manner.



Fig. 10. Patient reminded to cough in this manner.

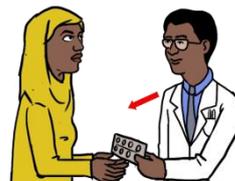


Fig. 11. Patient reminded to collect medication for upcoming days.



Fig. 12. Patient reminded to visit a clinic when feeling unwell.

IV. FINDINGS

This section analyzes the results of the survey that was conducted to evaluate the graphics.

A. Participants

Table 1 shows the details of respondents who participated in the experiments. Of the respondents, 53% (n=18) were male and 47% (n=16) were female. One-third of participants were patients (n=11). All patient participants were from Zanzibar. Four of them were inpatients and seven were out-patients (home-based-care patient).

² According to [21], Case study is an empirical investigation about a contemporary event that exist in its real life context.

TABLE I. CHARACTERISTICS OF PARTICIPANTS

Gender	User Group				Total	
	Patient	Health Worker	Academic/ Researcher	Student	No. Part	%
Male	5	1	10	2	18	52.9
Female	6	3	6	1	16	47.1
Total	11	4	16	3	34	100

No. Part=Number of Participants, %=Percentage of Respondents

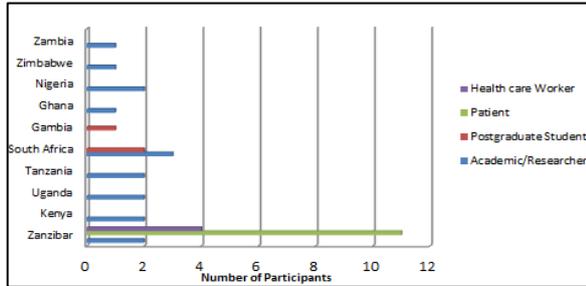


Fig. 13. The Academic and Hospital participants

Figure 13 illustrates the details of where participants come from. Those participants from the University of Cape Town were found they are from different nationalities. As shown in Figure 13 the original countries of participants were: Kenya, Uganda, Tanzania, South Africa, Gambia, Ghana, Nigeria, Zimbabwe, Zambia, and Zanzibar. Different participants were included, to ensure that the graphics conveyed the same intended meaning and did not confuse people regardless of first language, cultural affiliation etc.

B. Results

The findings exposed that participants interpreted the meaning of most of the graphic correctly. There were some graphics that were not clearly understood by some. All respondents interpreted figures 3, 4, 9, 10, 11 and 12 correctly. However, the majority of participants understood the content of figures 5, 6, 7 and 8, but these were found to be more confusing especially for participants from group A and C.

Most of the respondents suggested adding a glass of water in Figure 5. They indicated that showing a pill only does not give a clear message that this patient is reminded to take the medication. Instead, they suggested adding a glass of water as shown in Figure 14. Another improvement was made in Figure 6 that reminds the patient to collect their smear sputum and submit it to the doctor. Before the improvement, sputum bottles were shown in both hands of the patient and the doctor, as shown in Figure 6. The participants suggested that the bottle from the doctor's hand should be removed. This means that the reminder now is clearly interpreted as the patient submitting the sputum bottle to doctor as shown in Figure 15.



Fig. 14. Medication reminder- this figure was obtained based on the feedback in Figure 5.



Fig. 15. Submit sputum reminder- this Figure was obtained based on the feedback in Figure 6.

Furthermore, participants suggested adding a cow to the image in Figure 7. The glass of white liquid does not give a clear message. If the cow image is added in the graphic, it will clearly represent that a patient is reminded to take a glass of milk, as shown in Figure 16. Another improvement was in the meal suggestion reminder as shown in Figure 17. This graphic was obtained after the improvement of Figure 8. The majority of participants from group A and C, including illiterate patients, suggested that Figure 8 was not clear. Based on their cultural values, people do not eat vegetables with a spoon.



Fig. 16. Take milk reminder- this Figure was obtained based on the feedback in Figure 7.



Fig. 17. Get vegetable reminder- this Figure was obtained based on the feedback in Figure 8.

Four graphics out of the ten (Figures 5, 6, 7 and 8) were re-developed based on the respondents' feedback obtained during the evaluation. The other six graphics (Figures 3, 4, 9, 10, 11 and 12) were not re-developed. Based on the participants' feedback, there was no need for new graphics, though there were particular suggestions observed, such as colour, margin and image size. After the modifications have been made, the second round evaluation was conducted, in this time all images were interpreted correctly by all groups. However, again, there were some colour and margin suggestions proposed by minority of participants from group C. In addition, the majority of the participants who participated in the first round evaluation they were also involved in the second round. The second round testing also involved new participants from each group include, three participants from group A, one from group B and six from group C, and together they reached 34 participants as shown in Table 1 and Figure 13. All proposed suggestions were considered and will be adopted during the development of mobile health applications.

Furthermore, participants were asked about the use of visual-based, text-based and voice-based applications and which intervention could be more applicable to support TB patients to adhere to treatment through reminder methods. However, the participants were only shown the visual-based. They were asked about their experiences with the use of SMSs and telephone calls. It found that all participants had use SMS and phone call services before. Accordingly, when they compared these services, they advocate visual that could be more feasible than text and speech. Therefore, the study findings suggested, as found in the literatures, that the use of visual communication could be more applicable and provide a clearer understanding by everyone compared to other mobile interventions.

To summarize, this study was conducted with the aim of finding out whether the developed graphics are understandable and conveyed the correct meaning of a particular reminder and whether graphic communication could be more applicable compared with text and speech. The findings indicated that all participants described the proper meaning of every graphic. However, further suggestions were proposed to improve some graphics. The study also found that the use of graphics in the medical context might have potential of providing a clearer understanding of the intended meaning compared to text and speech.

Additionally, there are extra observations obtained, such as people's cultural values and religious perceptions on what the graphics look like in term of dress and eating style. The findings of this study contribute to the broader project of the development of a mobile reminder application that would be used to support TB treatment adherence in Africa.

The mobile reminder prototype will be developed on Android platform. The motivation to use Android is that according to Michael [19] by the end of 2013 Android was at 78.4% of the operating system market share, making it one of the most used mobile operating systems globally. This leads Android phones to become cheaper and cheaper every day. At present, the price of Android phones is closer to the price of feature phones, which are widely available in Africa continent. However, a next study will find out to what extent the target population use Android phones.

After developing a mobile reminder application another study will be conducted to measure the performance of visual applications compared with text or speech. The prototype application will be installed into different Android phone models with different screen sizes.

V. CONCLUSION

The use of visual objects in communication is very powerful and an invaluable resource in medical contexts, particularly for nonliterate people. However, we cannot draw conclusion based on this paper findings. It found that the use of graphics in the medical reminder system may give patients a better understanding of the intended meaning of the message compared with text and speech. It was also suggested by every participant that the use of graphics could be more applicable in supporting TB treatment. The developed graphics shown in this paper then are embedded with a mobile reminder application to support TB patients in their treatment process. The reminder system helps patients to follow the routine of taking medication.

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