Preventing India to Leverage Power of Mobile Technology: Development of a Bilingual Mobile Health Tool for Heart Patients

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Abstract: Background: Mobile health technology offers promising means to implement public health strategies for the prevention and management of chronic conditions. However, at the moment, there is a dearth of both; specific mobile health tools tailored for the knowledge and language needs of Indian population; as well as enough systematic and scientific clinical data to analyse their impact in varied Indian socioeconomic and disease populations.

Objective: To develop a smartphone-based bilingual educational mobile application for heart patients and pilot test in an Indian clinical setting.

Methods: An Android™ based mobile application was developed according to a systematic instructional design model. Thereafter, expert assessment was done by 3 software engineers and 2 healthcare professionals using a peer-reviewed, objective and multidimensional Mobile Application Rating Scale (MARS). A pilot user satisfaction evaluation was done based on feedback from 35 Coronary Artery Disease patients visiting Cardiology outpatient Department of a North Indian tertiary care centre.

Results: An Android™ based mobile application named as ‘Happy Heart’ was developed. The content was developed in both Hindi and English under professional supervision. For this mobile application, the Mean MARS score was 3.60 ± 0.86 and subjectivity score was 3.30 ± 1.03. The overall user satisfaction response for the mobile application was 4.09 ± 0.75 indicating that most of the testers found it useful.

Conclusion: This mobile application is developed as a research tool to further conduct a clinical study in Coronary Artery Disease Patients. Current evaluation was a pilot testing wherein this application showed promising results.

Keywords: CAD secondary prevention, cardiovascular agent, coronary artery disease, lifestyle modification, m-health, medical education, mobile health technology, patient education.

1. INTRODUCTION

Cardiovascular Diseases (CVD) are the predominant cause of mortality and morbidity worldwide [1]. Over the last few decades, India has also evidenced an alarming increase in the prevalence of CVD with the disease burden being higher in India as compared to the global average [2-6]. Among all, Coronary Artery Disease (CAD) is the most common type of CVD [7]. One of the major reasons behind this increasing disease burden has been the drastic lifestyle changes within Indian society. Lack of physical activity, smoking, inappropriate diet, increase in consumption of fast food, packaged food, and sweetened beverages are to name a few culprits [8, 9].

The silver lining in this grim situation is that CVD is a form of non-communicable disease attributable to several modifiable risk factors and despite the critical fatality rate, it can be prevented by taking necessary precautions [10-13]. Especially, in diagnosed cases of CAD, secondary prevention is critically important to avoid future recurrences. Studies show that adults with optimal levels of risk factors at midlife have a 70% to 80% lower risk of CVD mortality [14-16]. On the other hand, absence of established risk factors at the age of 55 can be associated with a lifetime CVD risk of

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5% to 8% only [17, 18]. Thus, timely prevention of CVD risk factors plays a very important role in minimizing an individual's long term CVD risk. This opens a key opportunity window to leverage non-pharmacological prevention and management strategies to tackle this rising CAD disease burden in India. Patient education/counselling towards medication compliance and lifestyle changes plays a pivotal role in this area. Several lines of evidence indicate that diet and therapeutic lifestyle modification can prevent and manage chronic diseases including CAD, diabetes, stroke, etc. [19-23]. Finland and Singapore are inspiring success stories to significantly cut down CVD mortality rate by implementing such community interventions [24]. American Heart Association/American College of Cardiology Foundation (AHA/ACC) and the European Society of Cardiology also recognize Patient Education as an important component of comprehensive cardiac rehabilitation and give it Class I recommendation for patients with non-ST-elevation Acute Coronary Syndrome (ACS) and with very high CVD risk [25, 26].

Considering the already strained current status of Indian healthcare system, the conventional route of delivering this required education and continued patient support through our healthcare network in the world’s second-most populous country is not a viable solution. Achieving the requisite success in CVD prevention is highly challenging and requires innovative, scalable, widely acceptable and affordable approaches and tools.

Over last decade, India has made significant progress in the area of digitization. As per McKinsey, after China, India is the second-fastest-growing digital economy in the world [27]. Driven by rapid internet growth even in rural areas, India’s digital connectivity is estimated to increase from 15% (2014) to 80% by 2034, with a 58% increase in the number of rural internet users by 2034 [28, 29]. Mobile health (m-Health) tools are one of the most significant and promising advancements in healthcare digitization arena with power to change the dynamics of patient care landscape and serve as a vital tool in prevention and management of CAD [30, 31]. As defined by the World Health Organization, m-Health is a term used for “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants (PDAs), and other wireless devices” [31]. Use of m-Health tools is widely explored in the management of several health conditions worldwide and has demonstrated positive health outcomes by leveraging the power of patient education; engagement and continuous reinforcement for therapeutic lifestyle changes [32-37].

Increasingly vast coverage and penetration of mobile services in India and the success of m-Health worldwide provide enormous opportunities for healthcare delivery through this route in India.

However, there are still substantial barriers to scale up the acceptability and usability of m-Health tools by Indian masses; especially in the rural and less educated patient population. Language and internet self-efficacy are the major barriers in this regard. Currently, there is scarcity of m-Health tools customised to meet the needs of Indian population. For instance, in North India, Hindi is the most commonly used language for verbal and written communication. However, there is scarcity of m-Health tools delivering validated good quality educational content for CAD patients in Hindi. In addition, there is a dearth of systematic and scientific clinical studies to evaluate the impact of such tools in varied Indian socioeconomic and disease populations.

This project aimed to develop and pilot test an educational mobile application to be used as a research tool for further conduction of a large scale clinical study in CAD patients. The study site for this planned research work is a tertiary care centre in North India. With this context, it was imperative to develop an indigenous m-Health tool tailored to the needs of this specific patient population and the planned research study. Pilot testing gives an opportunity to gauge patient satisfaction levels before large scale use of the tool.

2. MATERIALS AND METHODS

The objective of this work was to develop a smartphone-based bilingual educational mobile phone application for heart patients. Fig. (1) gives an overview of the mobile application development process.

2.1. Concept and Analysis

Target users for this mobile application were diagnosed cases of CAD visiting Cardiology Outpatient department at a tertiary care centre in Gurugram, Haryana, India. Following the review of health information needs for CAD patients based on literature search and brainstorming with experts, the purpose of this tool was agreed as:

“A free, easily accessible, user-friendly m-Health tool providing accurate, specific, validated health information to users about CAD; risk factors; and its management through positive lifestyle modification in simple, clear, understandable language of their choice”.

Scope of this tool extends not only to CAD patients; but also to caregivers; and all other heart patients who can benefit from positive lifestyle changes.

2.2. Content Development

A detailed review of patient education requirements with regard to CAD was done. Thorough literature review, analysis of existing educational brochures and leaflets for CAD patients were conducted. Relevant information from articles, textbooks and internet websites was extracted and synthesized. Interview with cardiologists, patients, physiotherapists, dietitian and nursing staff was conducted. Based on all the inputs, a content menu with 6 modules consisting of main contents and sub-contents was finalized (Fig. 2). Content writing was done by the researcher as per the principles of good scientific writing, keeping language simple enough for patients to comprehend. Apart from basic heart and heart disease-related information special and deliberate repeated
emphasized the importance of diet, stress reduction, and physical activity in the prevention and management of heart diseases. We curated the medical content to keep it simple, easily understandable, avoiding medical terminology wherever possible and not overloading information. Repeated information about diet and exercise was intentional to encourage behavioural modification. Throughout most of the content we adhered to, the “Question-Answer” and “Simple Statement” format to deliver messages in a straightforward manner. Videos were made for “Message from Cardiologists, Yoga expert and Physiotherapist”. A self-help BMI calculator is also part of the app.
2.3. Software Development

Happy Heart mobile application was developed according to the steps of systematic instructional design model by a professional software engineer [38]. Based on the purpose, scope, and content structure, the design and framework of the mobile application were finalized. A basic framework and storyboard were prepared and consulted with the Director of Cardiology for appropriateness. Considering that the majority of the patients from target population were Android™ phone users, coupled with the time and cost involved in the development of an iPhone Operating System (iOS) application, we decided to develop this mobile application only for Android™ and not iPhone. A mobile application was developed using a Macintosh environment with a built-in Java SE development kit 8 and Android Studio. The mobile application was tested on various Android™ based phone models and adapted to look and appear alike regardless of phone model changes.

Based on the content menu, information was uploaded onto the mobile application. The format of content was finalized after trial and error with multiple formats e.g. in-app pages, HTML pages, slideshow, etc. In App pages give maximum control but were found to be the most difficult to manage because of the large amount of content to be uploaded. HTML pages were easier to develop but were neither user-friendly nor visually appealing. In the end, we chose slideshow format because of better readability, easy content organization, and the ability to deliver information in a controlled manner. To create slideshow pages, we used the open-source HTML presentation library from https://revealjs.com. This library allowed us to create slides responsive to different mobile screen sizes. In the mobile application content, slides open in autorun mode but can be changed to self-control if desired. Pictures and graphics were included as appropriate to enhance appeal. A “Mark complete” Button functionality is given at the end of each topic to record completion.

The first prototype of the mobile application was developed followed by review from relevant experts. After multiple rounds of revision in content and user interface, finally, first version of the mobile application was released.

2.4. Expert Assessment

The mobile application was evaluated by three professional software engineers and two healthcare professionals using Mobile App Rating Scale (MARS). MARS is a peer-reviewed, objective, multidimensional measure for trialling, classifying, and rating the quality of mobile health applications [39]. MARS assesses mobile application quality on a 5-point scale (1-Inadequate to 5-Excellent) across 5 core criteria: engagement, functionality, aesthetics, information quality, and subjective quality.

2.5. User Satisfaction Evaluation

The user satisfaction survey was conducted in Paras Hospital Gurugram, India. This is a reputed multispeciality tertiary care centre located in the centre of Gurugram catering to patients from the city and nearby town and village areas. Approval was obtained from the Hospital’s Independent Ethics Committee to use their premises and contact patients after obtaining consent. CAD patients visiting the cardiology outpatient department at Paras Hospital Gurugram were randomly requested to participate in the survey. The usability of this mobile application extents to all those heart patients who can benefit from positive lifestyle modification. However, the survey was intentionally limited to CAD patients considering the inclusion-exclusion criteria of further planned large scale clinical study using this tool. (This clinical study was undertaken during the writing of this research paper). Those patients who consented to participate in the survey installed the mobile application and provided their feedback using a structured questionnaire. The questionnaire was designed based on earlier work done by Min Jung Cho et al. [40] to evaluate the level of satisfaction with multimedia learning content. The questionnaire included 14 items evaluating opinions on a 5 point scale (1=Poor/Strongly Disagree to 5=Excellent/ Strongly Agree) on the overall experience, quality of content, usefulness, and mobile application design and functionality. The sample size for conducting this survey was based on similar pilot studies conducted in the past to determine user satisfaction for various types of m-Health tools [41, 42].

3. RESULTS

3.1. Happy Heart Mobile Application Development

An Android™ based mobile application (app) named Happy Heart was developed. This mobile application is freely available from Google Play store at https://play.google.com/store/apps/details?id=com.consultancy.adsam.happyheart

The Android™ based development environment used Macintosh operating system Mojave and 2.6 GHz dual Intel Core i5 processor with a built-in Java SE Development Kit (JDK) 8. The development tools were Android Studio and Android Software Development Kit (SDK) 26. Testing of the mobile application system was conducted with an Android Virtual Device, and the final version of the application system was run on the Google Pixel XL, Note 3, and Motorola C. The size of the mobile application was 27 MB.

A few screenshots of the mobile application are collated in Fig. (3). Upon installation of this mobile application, firstly the 'home screen' appears. To choose language preference out of English and Hindi from a drop-down menu (further language display is based on this language selection), is the second display. Hindi is the most commonly used language followed by English for reading and writing purpose by our target population. Hence, the content was developed in both Hindi and English whilst users can change their language preference setting anytime they want.

Next screen is “End-user license agreement”. This includes patient pertinent details about the study and informed consent form. Only after “Accepting” this page, one can proceed and view the contents. Next screen asks for patient
Fig. (3). Screenshots from Happy Heart mobile application.
name, sex, age and mobile no. Once the basic personal information is filled, the overall content appears on the screen arranged in 6 modules as shown in Fig. (2).

Under additional options, there is change language, patient information, BMI calculator and privacy policy statement. Slides and images were stored locally so that users don’t have a dependency on internet access to view the key content. However, embedding video files inside the mobile application would make it bulky, hence we kept videos online outside of the application. For videos, we created a YouTube channel; uploaded all videos there; and added link directly in the application. We integrated YouTube player in the mobile application so that user can directly watch videos inside the application itself. This ensured that the size of the application remained less, was easy to install and be more responsive. However, the downside was that, to view videos, user would need an internet connection.

A BMI calculator tool is also given as an additional feature. This tool calculates BMI based on gender, height and weight. We also added support for automatic update of the mobile application to allow users to get the latest content and/or features automatically using Android™ application update feature.

One of the key user-friendly features of Happy Heart mobile application is that the content display format gets adjusted as per phone model making it easy to read for the elderly and even less adept smartphone users.

3.2. Expert Assessment using MARS Tool

Three independent software engineers and two healthcare professionals rated the Happy Heart mobile application using MARS tool [39]. Each rater downloaded the application and provided feedback using this tool.

A summary score, referred to as the MARS mean score is calculated as the mean score across the 4 objective criteria excluding subjectivity score. Happy Heart mobile application achieved a mean MARS score of 3.60 ± 0.86. This indicates that application was rated as above average by the experts. For subjectivity, score was 3.30 ± 1.03. Engagement score was the lowest (2.84 ± 0.80) while the functionality score was the highest (4.05 ± 0.68) of all parameters. Aesthetics score was 3.66 ± 0.72 and information score was 3.85 ± 0.69. The descriptive statistics for the Happy Heart application MARS ratings are plotted in Fig. (4).

3.3. User Satisfaction Evaluation

Thirty-five randomly selected CAD patients who consented to participate in the survey were given the test link for application installation. They downloaded and used application for 2 weeks; followed by providing feedback using user satisfaction survey questionnaire. The mean age of users was 54, of which 22.86% were female and 77.14% were male. A total of 57.14% belonged to urban region while 42.86% patients were from rural area. More than half of the patients (54.28%) were graduate or above.

Overall, average of satisfied users (who rated application 4 and above) accounts to 80%. More than 95% of users were satisfied with the usefulness, 67% were satisfied with the design, layout and functionality and almost 80% were satisfied with the quality of content. Table 1 summarizes mean values with standard deviation and percentage of users who rated the mobile application 4 and above for various individual questions asked in the questionnaire.
Table 1. User’s satisfaction analysis for “Happy Heart” mobile application (n = 35).

<table>
<thead>
<tr>
<th>Questionnaire Category</th>
<th>Mean ± SD</th>
<th>No. of Users Rated ≥4(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall experience</td>
<td>4.09 ± 0.70</td>
<td>28.0 (80)</td>
</tr>
<tr>
<td>Quality of content</td>
<td>4.30 ± 0.77</td>
<td>28.33 (81)</td>
</tr>
<tr>
<td>Content structure</td>
<td>4.46 ± 0.70</td>
<td>31.00 (89)</td>
</tr>
<tr>
<td>Information provided</td>
<td>4.40 ± 0.77</td>
<td>29.00 (83)</td>
</tr>
<tr>
<td>Language used</td>
<td>4.03 ± 0.79</td>
<td>25.00 (71)</td>
</tr>
<tr>
<td>Usefulness</td>
<td>4.44 ± 0.59</td>
<td>33.25 (95)</td>
</tr>
<tr>
<td>This app is useful tool</td>
<td>4.46 ± 0.56</td>
<td>34.00 (97)</td>
</tr>
<tr>
<td>An app is useful tool</td>
<td>4.63 ± 0.60</td>
<td>33.00 (94)</td>
</tr>
<tr>
<td>Applying the information</td>
<td>4.40 ± 0.65</td>
<td>32.00 (91)</td>
</tr>
<tr>
<td>Application design</td>
<td>4.44 ± 0.59</td>
<td>23.67 (68)</td>
</tr>
<tr>
<td>The overall composition</td>
<td>4.20 ± 0.63</td>
<td>31.00 (89)</td>
</tr>
<tr>
<td>It is easy to access the app</td>
<td>3.63 ± 0.73</td>
<td>17.00 (49)</td>
</tr>
<tr>
<td>It is easy to use the app</td>
<td>3.97 ± 0.45</td>
<td>31.00 (89)</td>
</tr>
<tr>
<td>The design, color, font size of the content is appropriate</td>
<td>3.97 ± 0.51</td>
<td>30.00 (86)</td>
</tr>
<tr>
<td>The videos in the app are effective</td>
<td>3.46 ± 0.74</td>
<td>17.00 (49)</td>
</tr>
<tr>
<td>BMI calculator is a useful tool</td>
<td>3.40 ± 0.85</td>
<td>16.00 (46)</td>
</tr>
</tbody>
</table>

4. DISCUSSION

Lately, m-Health technology has gained increasing interest as an innovative, affordable and scalable mean to deliver patient education and support outside of conventional health care setup [43-45]. However, despite rising internet and smartphone penetration, low internet self-efficacy and unavailability of quality health education content in local languages are the biggest formidable barriers for the success of m-Health tools in India. The motivation behind the development of Happy Heart mobile application was to cater to the specific needs of our target patient population that majorly comprises Hindi speaking, Elderly, Rural North Indian CAD patients with a low internet self-efficacy. As a modern educational strategy, this project intended to develop and deliver learning material for even less adept smartphone users in a convenient and affordable manner.

Health information is vast and if imparted, can be overwhelming and boring. To ensure effectiveness, knowledge needs of target audience play a critical role in determining the level and extent of information to be delivered. In contrast to the conventional print media like booklets, pamphlets, etc., scope of delivering information via a mobile application is huge. The type of media options is also diverse like text, images, videos, etc. Thus, the most challenging step in mobile application development was the concept and analysis phase. Out of numerous technologically feasible options and vast amount of CAD data available, choosing the key features, platform, framework and most importantly determining the content menu and structure was most challenging. This was sorted by continuous engagement with experts and patients during the planning and development phase and making changes in an agile manner along the way.

Overall expert assessment using MARS tool rated Happy Heart mobile application as average. Especially engagement score is the lowest. This is understandable due to multiple reasons. a) this mobile application was only android based b) lack of features like games/quizzes, etc. c) a higher ratio of text versus video content; d) variation in the length of content for each topic e) dependency on internet access to view videos.

This highlights certain limitations of this application. Due to time, resource and budget constraints, we had to prioritize the content and features that could be included in this version of the application. This application is only android based limiting its user base. This can be changed in future versions. Generally known engagement features like quizzes, animation, gamification, etc. were not included which if incorporated, may have increased user engagement, functionality, aesthetics and thereby overall quality. In general video, content increases engagement and acceptability. However, after careful consideration of various technical aspects, speed, responsiveness and affordability, video content was developed selectively to deliver expert messages only. The
video quality may also be improved by making them with professional help.

On the positive side, most of the patients we approached readily agreed to participate in the survey. This showed their enthusiasm and curiosity to explore a new form of learning and the associated benefits of gaining health-related information. Knowing that content is available in Hindi enhanced the promptness to participate. As per the survey results, most of the patients were satisfied with the mobile application. The user satisfaction results from this study are similar to the one done by Min Jung Cho in Korea [40]. Although in small sample size but our study results are encouraging as they indicate positive patient interest level; thus opening new avenues for learning and self-care in chronic disease management in Indian population.

However, there are several areas to progress this research further. The user satisfaction in this study was from a pilot survey based on feedback from a small no. of patients. Further, studies can target to gather feedback from a larger population to get more reliable data. Moreover, studies can be designed to see degree of satisfaction and effectiveness in various age groups or socioeconomic segments. Importantly there is also lack of scientific information on the correlation between “User Satisfaction” and various tool-related elements like variety of content; length of content; and its arrangement and delivery. Further research in this area will be very useful for mobile application developers and healthcare providers to develop more engaging and effective m-Health tools for Indian population.

CONCLUSION

In healthcare set up, usually, doctors don’t have enough time to engage in detailed patient counselling about home based self-care and disease management. At the time of popularity of smartphones, educational mobile applications may serve as potentially effective and affordable tools to implement public health strategies and facilitate an increase in knowledge and awareness among patients and caregivers for better disease management. Based on expert evaluation and user satisfaction survey results, ‘Happy Heart’ mobile application showed promising results. However, as this was a pilot testing, results from a further study using this tool shall bring more interesting insights on effectiveness of such tools in Indian population.

LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbr</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ACCF</td>
<td>American College of Cardiology Foundation</td>
</tr>
<tr>
<td>ACS</td>
<td>Acute Coronary Syndrome</td>
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<tr>
<td>AMA</td>
<td>American Heart Association</td>
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<tr>
<td>app</td>
<td>Application</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>CAD</td>
<td>Coronary Artery Disease</td>
</tr>
<tr>
<td>CVD</td>
<td>Cardiovascular Diseases</td>
</tr>
<tr>
<td>iOS</td>
<td>iPhone Operating System</td>
</tr>
<tr>
<td>JDK</td>
<td>Java SE Development Kit</td>
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<tr>
<td>m-Health</td>
<td>Mobile Health</td>
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<tr>
<td>MARS</td>
<td>Mobile Application Rating Scale</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistants</td>
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<tr>
<td>SDK</td>
<td>Software Development Kit</td>
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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Approval was obtained from the Independent Ethics Committee of Paras Hospitals Gurugram, India.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Informed consent to participate in survey was obtained from patients visiting the Out-Patient Department of Cardiology at the Paras Hospitals, Gurugram, India.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES


