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Assessing The Utility Of Swayam Diabetes Mobile Health Application For Self-Care Management Of Type 2 Diabetes In Home Settings

Abhijeet P Sinha[1*], Manmohan Singhal[2], Ashish Joshi[3], Rohitashwa Kumar[4]

[1]PhD Fellow, DIT university Dehradun, Delhi, IND
Orchid ID: https://orcid.org/0000-0002-2299-3475
[2]DIT University, Dehradun, Dehradun, IND
[3]School of Public Health, City University of Memphis, TN, USA
[4]PhD Scholar, DIT University Dehradun
[*]**Corresponding author:**
Abhijeet P Sinha
Email ID: abhijeetpsinha@gmail.com

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ABSTRACT

Background: The prevalence of type 2 diabetes mellitus (T2DM) is increasing at an alarming rate, presenting a significant public health challenge both nationally and globally. The Swayam Diabetes mobile health (mHealth) application was developed and tested to support self-care management of T2DM in home settings. The application incorporates key features such as self-monitoring tools, a daily diary, educational resources, and user support, all designed to facilitate effective self-care management of T2DM in urban home environments.

Materials and methods: A mixed-methods research design was employed, combining both qualitative and quantitative approaches. The Swayam Diabetes mobile application was developed based on pretesting conducted with 18 users. Following this, user testing was carried out with 250 participants who completed a Diabetes Management Survey (DBMS). A follow-up assessment was conducted over six months with 55 users to evaluate the application's utility and gather feedback, using the System Usability Scale (SUS) for usability assessment.

Results: Seventy-eight percent of users preferred using the Swayam Diabetes mobile application to monitor their daily self-care activities, including food intake, nutrition, physical activity, medication adherence, and other diabetes-related information. The study observed a 5.1% improvement in self-care management, with over 55% of participants utilizing the daily diary feature. Participants reported that self-management through the mobile health application was beneficial. However, the study found minimal impact of gender on self-care outcomes.

Conclusion: The Mobile application enabled users to effectively monitor key health aspects such as nutrition, activity, and medication adherence. High user engagement, particularly with the daily diary feature, highlights its value in self-care management. Future research should focus on the long-term impact on clinical outcomes, like HbA1c levels, and assess its effectiveness across diverse populations.

Keywords: *Self-care management, type 2 diabetes management, mobile health, m-health, human-centered application*

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) represents a global health crisis, affecting approximately 463 million people worldwide, with projections reaching 578 million by 2030. [1]. The rising prevalence of T2DM in India is particularly concerning, as the country accounts for one in every six individuals with diabetes, resulting in $8 billion in healthcare expenditures annually [1]. Key risk factors, such as age, obesity, poor diet, and inadequate nutritional practices, contribute to early morbidity and mortality. T2DM patients often face significant challenges in self-management, leading to feelings of burden and discouragement. Patient-centered care is critical, as most of the diabetes management occurs in the home environment [2]. Self-care management programs are essential in empowering patients and their families to engage in crucial activities such as meal planning, exercise, blood sugar monitoring, and medication management. These practices are vital for improving

conditions, selfcare management and overall well-being. The use of mobile health applications has potential to improve self-care management practices [3]. The Swayam Diabetes mobile application was developed and tested with users, incorporating features for self-monitoring, education, and support, aimed at improving T2DM.

Objective:

Assessing the utility of the Swayam Diabetes mobile health application in supporting self-care interventions for T2DM in urban home settings.

2. MATERIALS AND METHODS

A survey was conducted with 250 participants who completed a self-care assessment questionnaire to evaluate the use of the Swayam Diabetes mobile health application in managing self-care for T2DM in home settings[4,5].The primary objective of the study was to assess the utility of the Swayam Diabetes mHealth intervention in promoting self-care behaviors and management practices for T2DM. Specifically, the study focused on evaluating the application's impact on self-care behaviors, including meal planning, dietary management, exercise, daily diary usage, and communication with healthcare providers [9,11,12].

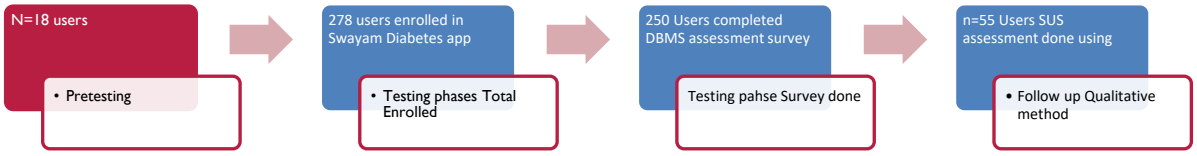

Figure 1: The flow of study, number of users tested in different phases

Step 1-Pretesting: The Swayam Diabetes mobile application was developed with input from 18 users during the pretesting phase.

Step 2-Testing: A quantitative study design was employed, where participants completed a pretested Diabetes-Based Management System (DBMS) questionnaire and consent forms. Data collection involved administering the DBMS surveys to 250 participants.

Step 3- Follow-up: The utility of the mobile health application was further assessed through participant feedback collected from 55 individuals via the System Usability Scale (SUS) during a follow-up phase. This feedback aimed at exploring the application's overall usability and effectiveness [4,5,6] [figure1].

Study Design and Setting

This study was conducted in an urban area of Delhi using a mixed-methods approach, employing an exploratory sequential design that integrated both qualitative and quantitative research. Participants were recruited through outreach, local clinics, and health apps. A total of 278 participants were recruited as users of the Swayam Diabetes application, with 250 retained and completed self-assessments using the Diabetes Based Management System (DBMS) questionnaires, filled in daily diaries, and follow-up surveys through the mobile health app [10,11,13].

Design of user-centred application and testing features

The Swayam Diabetes Care mobile application was developed to support self-care management for individuals with T2DM, with a strong focus on user-centered design. To ensure its relevance and effectiveness, the application was created with significant input from users, gathered through in-depth interviews with 18 participants. This user consultation played a key role in shaping the mobile application's design [9,11,13] [Figure2].

A qualitative exploratory assessment was conducted using semi-structured interviews with a follow-up sample of 55 participants to gather feedback. The primary focus of the study was to evaluate the utility of the Swayam Diabetes application, specifically assessing application features such as the daily diary, diet tracking, exercise tracking, medication adherence, and

nutritional information. These components were designed to improve self-care, adherence, and overall diabetes selfcare management [9,13,14].

Selfcare management android features

Figure 2: Swayam Diabetes android application

1. The Swayam mobile health application had a self-care management tool that tracks and reminds users of their daily regimen. It includes a daily diary feature for recording food intake, nutrition, and other relevant health data [7,8].
2. The application was designed to be interactive and easy to use, with an option to use local language) to enhance accessibility for users.
3. Users could learn about nutrition, daily routines, and best practices through interaction with other users, which helps address inquiries and provides additional support [13,14,15] [Figure3].

Study Participants and Sampling

For the qualitative component of the study, we employed a convenience sampling method, conducting semi-structured interviews with 18 participants. In the quantitative portion, stratified random sampling was used, with a total sample size of 250 participants. The participants were grouped into age categories ranging from 20 to 78 years [9,10,11].

Inclusion Criteria: Adults aged 20 to 79 years diagnosed with Type 2 diabetes, living in urban areas, and using Android phones.

Exclusion Criteria: Pregnant women, adolescents, children, individuals with gestational diabetes, Type 1 diabetes patients, feature phone users, and those from rural areas.

Sample Size Calculation

The sample size was determined based on the total number of registered users (n = 278) in the app, with a retention rate of 90%. The required sample size was calculated as follows: 278=Required sample size/Retention rate (90%). Thus, the required sample size was 250, accounting for a 90% retention rate (n = 250 / 0.90 = 278). Only participants who were actively engaged and had completed at least one diary entry within the mobile health application were included in the survey.

Data Collection

The survey was conducted from June 2022 to April 2023, with 250 participants initially involved. A follow-up was conducted until October 2023, with 55 participants continuing from a retained cohort of 120 users over six months. Descriptive analysis was performed on the collected data, reporting results with 95% confidence intervals and a significant level less than P 0.05. [12,13,14]. The research team explained the study objectives to the participants, emphasizing the commitment required, the potential benefits of the study, and the importance of the results. Participants who expressed a willingness to participate and provided consent were enrolled in the study [14,15].

Participants were provided with questionnaires in a language they could understand, and ethical authorization was obtained with the help of a witness or representative when necessary. To ensure comprehension, the questionnaire was also made available in Hindi for participants who preferred it [12, 13, 14]. All respondents received written informed consent in their native Hindi language, outlining the details of the study. Participants were informed of their right to withdraw from the study at any time without needing to provide a reason. The written consent form included full information about the study, and participants were assured that their decision would not affect their participation in any way [16, 18].

Utility Testing of Mobile Applications for Self-Care Management

Utility testing of mobile applications for self-care management refers to the process of evaluating how effectively a mobile health app supports users in managing their health, specifically for conditions such as chronic diseases like diabetes. It assesses whether the app's features and functionalities meet the intended needs of the users in facilitating self-care behaviors, such as medication adherence, tracking symptoms, managing daily routines, or monitoring health metrics (e.g., blood glucose levels, exercise, and nutrition) [10,11,21]

Utility testing mobile applications for self-care management is a crucial process in evaluating how effectively mobile (mHealth) applications support individuals in managing chronic conditions, such as diabetes. These apps are designed to help users monitor health behaviors, such as medication adherence, symptom tracking, daily routines, and vital health metrics like blood glucose levels, exercise, and nutrition. Utility testing aims to determine whether an app's features and functionalities align with the users' needs and contribute to enhancing their ability to manage their health independently. By examining these elements, the utility testing process identifies potential areas for improvement and ensures that the app can facilitate sustained, effective self-care practices [18,19,20].

The evaluation process in utility testing typically involves collecting feedback from actual users through various methods, including surveys, interviews, and usability tests. This helps assess key factors such as user experience (UX), app functionality, user engagement, and adherence to the app's features. Specific aspects evaluated include the app's ease of use, the relevance and effectiveness of its features, and its adaptability to users' needs, preferences, and health conditions. Additionally, utility testing considers the app's technical performance, its cultural and contextual relevance for diverse user groups, and its overall contribution to improving health outcomes. Ultimately, utility testing provides valuable insights into the app's capacity to support self-care management effectively, informing the next steps in refining the application for widespread use [21,25,26]. Additionally, the study examined the impact of gender and age on improvements in HbA1c levels using a two-way ANOVA.

Qualitative Analysis: The qualitative data were analyzed using a structured six-step approach (Figure 3). Thematic analysis was conducted for interviews with 55 participants (mean age 50 ± x years). This analysis aimed to identify key themes related to the utility of the Swayam Diabetes mHealth application [13,14].

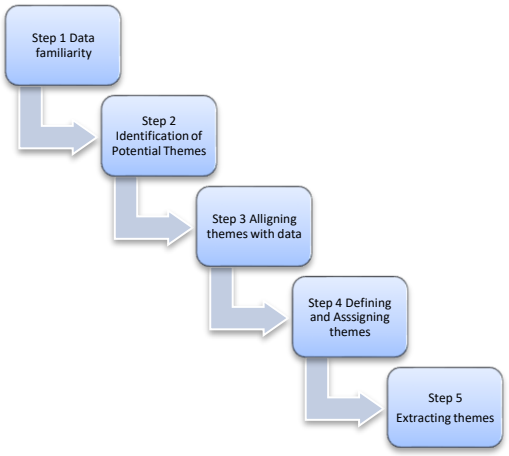

Figure 3: Steps in qualitative analysis of data

Study Design and Framework

The study design follows a systematic approach involving conceptualization, definition of necessity, design and development of an informatics app, implementation, and user evaluation.

1. **Conceptualize**: Identify the need for an mHealth intervention, define the objectives, and ideate key features of the app, including informatics and self-care management functionalities.
2. **Design (User-Centered)**: Develop a prototype based on user consultation, incorporating human-centered design principles. This phase includes pretesting the app, mapping out the user journey, and ensuring ease of use.
3. **Implement**: Deploy the app for use, with continuous user consultation and feedback. This phase also involves modifications, completion, customization, and visualization of data, alongside providing users with the necessary informatics for effective self-care management.
4. **User Evaluation**: Assess the app's utility through user feedback, utilizing globally tested evaluation tools. Evaluate

the outcomes of the app and implement further improvements. Periodic evaluations with users are conducted to refine and enhance the application [12,13,14].

Ethical Considerations

The study protocol was approved by the DIT University Research Ethics Committee (Protocol No. UREC/2021/07/10). The investigation adhered to the principles outlined in the Declaration of Helsinki, as it did not involve human research subjects. Informed consent was obtained from all participants, and data protection protocols were strictly followed, as detailed in the study protocol published in the *Journal of Positive School Psychology*, 2022, Vol. 6, No. 12 [15].

3. RESULTS

Pretesting: During the pretesting phase, 18 users provided feedback on the Swayam Diabetes mobile application. Their input contributed to refining the application's interface, features, and usability. The collected data provided insights into diabetes management behaviors, user engagement with the application, and baseline measures of self-care practices. Key areas of self-care, including nutrition, exercise, medication tracking, and diabetes-related information, were particularly identified as beneficial [13,14,15]. Furthermore, 83% of participants expressed a preference for an FAQ section to clarify common misconceptions regarding diabetes management. Several respondents suggested that offering the application in Hindi would enhance accessibility and usability.

Testing: The results of this phase study demonstrated that 78% of respondents experienced notable improvements in self-care management, facilitated by the features of the Swayam Diabetes app, such as daily and weekly diaries. A significant 88% of users favored using a digital diary for daily tracking, highlighting its role in promoting adherence to self-care routines. These findings underscore the importance of developing mHealth applications that are both user-friendly and culturally relevant to diverse populations. This study illustrates the potential of personalized digital tools to enhance diabetes management.

Follow-up Phase: Usability assessment using the System Usability Scale (SUS) was conducted with 55 participants. The mean SUS score indicated 80% suggesting e.g., high usability, moderate usability, or need for improvement]. Participants reported [summarize key feedback, e.g., ease of use, effectiveness, challenges]. The follow-up evaluation highlighted the application's potential to support diabetes self-management, with recommendations for further improvements. Overall, a 14.1% improvement in HbA1c was reported over the six-month period, with a 5.1% overall improvement in self-care management among the 55 users of the Swayam Diabetes app [14, 15]. Additionally, a 5.1% increase in health knowledge and positive attitudes toward self-care was observed, contributing to enhanced self-care outcomes. Language preference had a minimal impact on these results.

Notably, 93.8% of respondents reported adherence to a healthy diet, suggesting a positive influence of the mobile health application on diabetes management behaviors.Two-way ANOVA analysis assessed HbA1c improvement based on gender and intervention, revealing a significant mean square (MS = 428.2) with a p-value < 0.05, indicating substantial variance. The intercept also showed significant variance (MS = 5412, $p < 0.05$). While gender had a small but statistically significant effect on HbA1c improvement ($p = 0.05$, MS = 1250), the interaction between gender and HbA1c improvement was also significant ($p < 0.05$, MS = 732). The portion of the model related to HbA1c improvement showed significant changes ($p < 0.05$, MS = 64.5), further supporting the effectiveness of the intervention. The System Usability Scale (SUS) assessment of the Swayam Diabetes app yielded a total score of 84.25, corresponding to a Grade A rating, indicating excellent usability. This high score suggests that participants found the app both useful and easy to use [14, 16]. The residual mean square for the model was 29.70342, with a total sum of squares of 18, 208 and 274 degrees of freedom. These findings affirm the positive impact of the Swayam Diabetes app in improving self-care management and diabetes-related health outcomes [15,16].

4. DISCUSSION

The study highlights the importance of diabetes self-management education and continuous support for individuals with type 2 diabetes. It emphasizes that treatment, adherence, attitudes, and prior knowledge significantly influence self-care behaviors. While some users expressed a need for more advanced resources, it was noted that individuals with shorter-term diabetes often utilize basic tools to track daily routines, while those with longer-term diabetes are more likely to leverage technology for enhancing self-care behaviors [15,16].

Themes from the qualitative study: Three major themes emerged from the qualitative investigation [Figure 4].

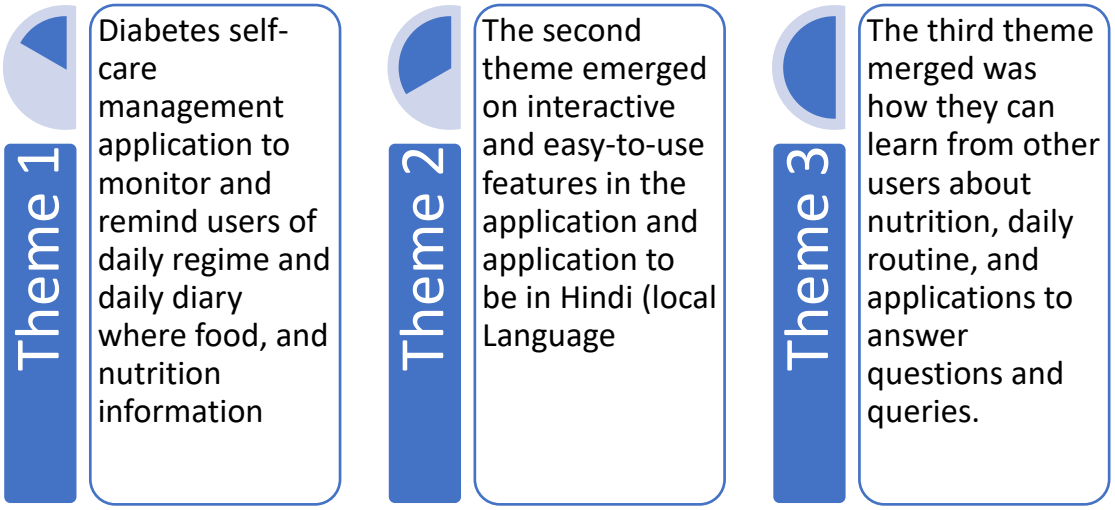

Figure 4: The qualitative themes from the study

Despite the importance of diabetes education for effective self-management, most current programs do not adequately address it. Mobile applications, however, can fill this gap by providing educational content, nutritional guidance, and professional support [13,14]. Moreover, fostering two-way communication and collaboration between healthcare providers and app developers can enhance app usage and support ongoing patient engagement [16, 17, 18].

Self-care Management at Home Using Mobile Health to Improve Patient-Level Diabetes Management

The study found that patients' ability to manage their diabetes effectively at home significantly influences their health outcomes. Therefore, education on the proper use of mobile health applications is essential for enhancing self-care management and improving disease control [18, 19, 20]. The self-management programs, including patient follow-up and support for improved healthcare service utilization, have been tested across diverse groups with promising results [21,22].

Human-Centered Design: Placing the User at the Core of mobile health application Development

A human-centered design approach to developing mobile applications for self-care management can effectively address the challenges associated with type 2 diabetes [21, 23]. By designing mobile applications with the user's needs in mind, the utility of these tools is greatly enhanced. Features like daily diaries for tracking food intake, physical activity, and medication adherence provide valuable support in managing diabetes and promoting healthier lifestyles [23,26].

Expanding the Reach of mobile health applications: Testing in Diverse Populations

The utility of mobile health applications should be evaluated in broader and more diverse populations, including rural areas, to gain a comprehensive understanding of their effectiveness in diabetes self-care management [22, 23]. Artificial intelligence (AI)-enabled systems can further support this by generating evidence-based treatment recommendations based on user experiences, feedback, and interactions, ensuring that the application meets the diverse needs of users [25,26].

5. LIMITATION

The study includes challenges related to digital literacy, connectivity barriers and varying levels of healthcare provider engagement. These factors may impact on the usability and effectiveness of the mobile health intervention. Furthermore, the success of mobile health applications is influenced by factors such as user demographics, socioeconomic status, cultural norms, and the existing healthcare infrastructure. Addressing these issues is crucial to improving the generalizability and applicability of the findings across different populations and healthcare settings.

6. CONCLUSION

Mobile health application possess significant potential to reach underserved populations, thereby improving healthcare access within communities. Education and awareness regarding the use of mobile health applications are essential for effective self-care management. The Swayam Diabetes mobile application has shown itself to be a valuable tool for self-care management in home settings. The results of this study highlight the utility of features such as the daily diary and other self-monitoring tools in enhancing the self-care management of individuals with T2DM. Future research should investigate the effectiveness of mobile health interventions across diverse populations, aiming to validate and build upon these findings. Additionally, a more comprehensive study design would help to further explore the potential of mobile health applications in T2DM.

Additional Information: Disclosures

- ***UREC approval****; The Study was approved DIT University Research Ethics Committee UREC 2021/07/10. Global DBMS and SUS tools were approved and informed consent forms in local language were obtained from all participants signed by the participants to take part in this study.*
- ***Human subjects:*** *All authors have confirmed that this study did not involve human participants or tissue. DIT University Research Ethics Committee (UREC) accepted the protocol number study. The Helsinki Declaration (Protocol number UREC/2021/07/10) has govern the investigation.*
- ***Animal subjects:*** *All authors have confirmed that this study did not involve animal subjects or tissue.*
- ***Conflicts of interest:*** *In compliance with the ICMJE uniform disclosure form, all authors declare the following:*
- ***Payment/services info:*** *All authors have declared that no financial support was received from any organization for the submitted work.*
- ***Financial relationships:*** *All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.*
- ***Intellectual property info:*** *I have submitted a patent of integrated diabetes management system in Indian Government patent application in January 2023, it is due for approval.*
- ***Other relationships:*** *All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.*
- ***Data-****The dataset generated or analyzed during the study are available from the corresponding author on reasonable requests.*

Abbreviations

- APL- Above poverty line
- BPL- Below poverty line
- CDIU- Concept, Design, Implementation and user testing
- DBMS- Diabetes based management system
- SUS- System usability scale
- T2DM- Type 2 diabetes management

QIMA- Quality improvement and management framework

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