

Honoring Heritage, Managing Health: A Mobile Diabetes Self-Management App for Native Americans with Cultural Sensitivity and Local Factors

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Abstract— Diabetes has a disproportionate impact on Native Americans (NAs) as a chronic health condition, yet there is a dearth of mobile apps specifically designed for this population. In this paper, we present the design and development of a culturally tailored mobile app for NAs, taking into account their cultural traditions. Our app incorporates NA's traditional foods, food availability, the importance of family and community, cultural practices and beliefs, local resources, and heritage heroes into the app interface and self-management design. The app includes personalized nutrition guidance, family and community-based support, seamless connection to tribal health providers, access to local resources, and integration of cultural elements. By considering the cultural context of NAs, the developed app has the potential to provide culturally sensitive and relevant features that address the unique needs and preferences of NA users, facilitating effective self-management of diabetes.

Keywords— *diabetes, self-management system, Native American, cultural sensitivity*

I. INTRODUCTION

Native Americans (NA) are among the populations disproportionately affected by diabetes, facing significant health disparities compared to the general population. According to the American Diabetes Association, NAs have the highest age-adjusted prevalence of diabetes among all racial and ethnic groups in the United States, with rates nearly double that of non-Hispanic whites[1].

Managing diabetes among NA populations presents unique challenges due to several factors. Limited access to medical resources is a prevalent issue in many NA communities, with healthcare facilities often located far away or lacking the necessary resources to effectively manage diabetes [2]. Rural locations of many NA reservations further exacerbate this challenge, with limited transportation options and distance barriers to healthcare facilities [3]. Additionally, socioeconomic disparities, including poverty and lower health literacy rates, can further hinder effective diabetes self-management among NA patients [4]. Furthermore, NA patients face distinct cultural and traditional factors that can impact diabetes management [5]. Tribal cultures and traditions play a crucial role in the daily lives of many NA individuals, influencing their food choices, lifestyle practices, and health beliefs. Existing diabetes self-care apps often do not consider these cultural factors, leading to recommendations that may be irrelevant or incompatible with NA patients' unique cultural practices and beliefs. Language gaps and education gaps between NA patients and healthcare providers can also create barriers in understanding and implementing diabetes self-management recommendations.

To effectively manage diabetes among NA populations, it is crucial to address these challenges and consider the special needs and cultural context of NA patients. Culturally tailored approaches that respect the unique socio-economic, cultural, ethnic, and geographical status of NA communities can hold promise in improving diabetes self-management outcomes in this population.

Our paper proposes a culturally tailored diabetes self-management system for NA patients, incorporating their cultural traditions, local resources, and socio-economic context. We actively involve the NA community, specifically the Lower Sioux Indian Community in Morton, MN, in requirement analysis, design iterations, and prototype feedback. We incorporate NA factors in ontology design, interface design, nutrition recommendations, social networking, and local resources. Our approach aims to create a user-friendly app that resonates with NA cultural traditions, provides culturally appropriate nutrition and lifestyle recommendations, fosters community support, and improves access to local resources for diabetes care in NA communities.

II. RELATED WORK

Cultural appropriateness in healthcare interventions has been explored by different researchers. Researchers have consistently emphasized the importance of incorporating cultural elements to achieve positive and sustainable health outcomes. For instance, Airhihenbuwa [6] suggests that cultural elements should be prioritized over behavior. In their study [7] Kreuter highlights the potential benefits of cultural tailoring in health promotion programs for specific cultural groups. Also, Barrera [8] proposed a framework for developing culturally enhanced interventions, which have been shown to be more effective in improving health outcomes compared to traditional care or other control conditions. On the other hand, Asad [9] offers a tripartite definition of culture as knowledge, practice, and change, emphasizing its crucial role in the success or failure of health interventions. Collectively, these studies suggest that incorporating cultural traditions and practices can improve the effectiveness of health interventions and help reduce health disparities.

Prior studies show that there are limited options for diabetes management apps, with varying levels of quality. For example, Rodríguez [10] discovered that only a few free diabetes management apps were available in Local language, and most of them lacked proper certification and scientific references while Brzan [11] analyzed 65 self-management mobile apps for diabetes and found only nine to be versatile and useful for successful diabetes management. Furthermore, Sneha [12] draws the need for regulation, standardization, and quality control of diabetes management apps, as the unregulated market is witnessing a surge in development. However, on the other hand, Kebede [13] found that popular apps like mySugr and continuous glucose monitoring apps helped improve self-care behavior in both type 1 and type 2 diabetes patients. While some diabetes management apps are popular, studies suggest that more high-quality apps need to be developed that are regulated and standardized to meet the needs of diabetes patients. One significant gap in the current diabetes management apps is the lack of incorporation of cultural and traditional factors.

Some studies suggest that incorporating cultural and traditional factors into diabetes management apps could improve their effectiveness. Petersen [14] found that culture has a significant impact on diabetes self-management activities, even more than the adoption of mobile applications. Millan-Ferro [15] emphasized the importance of creating culturally relevant interventions for vulnerable populations, like the Latino

community in the United States. Chacko [16] discovered that patients with Type 2 diabetes in Kerala, India, relied on both biomedicine and complementary therapies, such as Ayurvedic medicine and folk herbal remedies, to manage their condition. Lastly, Goody [17] argued that understanding cultural food practices is critical to diabetes care and education, and that applying the Campinha-Bacote Model of cultural competency could help healthcare professionals better comprehend the relationship between cultural food practices and diabetes. Overall, these papers suggest that incorporating cultural and traditional factors into diabetes management apps can help improve their effectiveness, and better serve diverse populations.

In summary, consideration of culture and tradition while designing a healthcare intervention are important. However very few interventions could adequately and properly incorporate these factors. In our study we aim to cater these needs for the Native American communities.

III. METHODS

A. NA Community-based Participatory Research

To ensure that our app meets the unique needs and preferences of the NA community, we actively involve the Lower Sioux Indian Community in various sate of the system development cycle:

- Requirement analysis: The research team actively engaged with the community members to gather their perspectives, needs, and preferences related to diabetes self-management. This involved conducting focus groups, interviews, and discussions with community members to understand their cultural traditions, local resources, socio-economic context, and challenges related to diabetes management in their community.
- System design: Based on the input received from the community, the research team used a participatory design approach to develop the system interface, functionality, and features that were tailored to the specific needs of the NA population. This included incorporating tribal logos, utilizing NA celebrity voices, and integrating cultural elements in the design to ensure it resonated with the community's cultural traditions and preferences.
- System implementation: The system was implemented based on the design decisions made in collaboration with the community. The research team worked closely with the community to ensure that the system was deployed in a manner that aligned with their local resources, language, and other contextual factors. This included integrating local restaurants, game food, and other community-specific factors into the system.
- Testing: The system will be tested in the Lower Sioux Indian Community, Morton MN, to evaluate its usability, effectiveness, and acceptability among NA patients. Feedback and input from community members will be actively sought and incorporated into further iterations of the system to ensure its relevance and appropriateness for the NA community.

Throughout the entire CBPR research process, the Lower Sioux Indian Community was actively engaged, and their input and feedback were invaluable in shaping the culturally-tailored diabetes self-management system to better meet the unique needs of the NA population. This collaborative approach ensured that the system was culturally sensitive, relevant, and effective in addressing the diabetes management challenges faced by the community.

B. NA Biocultural Profile Ontology Design

In the context of self-management solutions for diabetes in NA populations, it is crucial to consider the unique characteristics of these individuals. To address this, we propose a biocultural user profile ontology that models the biological, cultural, socio-economic, and environmental aspects of NA diabetes patients. This ontology includes information such as cultural influences, geographical locations, health beliefs and attitudes, literacy levels (including health literacy and numeracy), physical limitations, family support, and financial status, which collectively contribute to a NA patient's well-being. The biocultural approach allows for a comprehensive understanding of AI patients from both biological and cultural perspectives, enabling customized self-management strategies that account for their specific biocultural context.

The ontology development process follows six work phases, namely scope definition, knowledge acquisition, specification, conceptualization, implementation, and evaluation. This process involves collaboration among ontology engineers, developers, and domain experts, including the NA community, who actively participate in planning, development, implementation, evaluation, and delivery of the ontology. The ontology development is iterative and cyclical, with each work phase being repeated incrementally, allowing for continuous refinement and revision of the ontology with each new cycle. Fig. 1 presents a partial view of the NAOnto, which is the ontology defined for this research. Detailed information about NAOnto can be found in the referenced publication [18], [19].



Fig. 1. Partial view of ontology NAOnto

C. Cultural-User-Centered Interface Design

We propose a Cultural-User-Centered Design methods to create an interface that is tailored for NA users. The interface design incorporates various cultural elements that are relevant to NA communities. These may include:

- **Tribal Logos:** Incorporating tribal logos that is significant to the NA community in the interface design. This can help create a sense of familiarity and identity for NA users and reflect their cultural heritage.
- **Native American Celebrities' Voices:** Using voice recordings of Native American celebrities or respected community members to provide voice prompts or feedback in the interface. This adds a culturally relevant and authentic touch to the user experience, and help users feel more connected to the interface. We collaborated with Evan Adams, a well-known NA actor famous for his role in the critically acclaimed Native American comedy-drama film "Smoke Signals" (1998), to record voice clips for our app. These voice clips are designed to help users feel more connected to the interface. In "Smoke Signals," Evan Adams portrayed the lead character of Thomas Builds-the-Fire, a storyteller representing the modern Native American experience. Directed by Chris Eyre, the film is considered a landmark in Native American cinema, and Evan Adams' authentic performance has received praise for its representation of Native American culture.
- **Language Proficiency:** Customizing the language used in the interface based on the user's language proficiency. This involved providing options for users to choose their preferred language, and using appropriate language based on their language proficiency level, such as using simplified language for users with lower literacy levels. For more detailed information, please refer to our previous research publication [20].
- **Multi-Modal Input:** Allowing for multi-modal input options, such as voice and finger-based input, based on user preferences. This can accommodate diverse user preferences and provide flexibility in how users interact with the interface, depending on their cultural norms and preferences.
- **Cultural Contextualization:** Incorporating cultural elements, such as stories, traditions, or cultural practices, into the interface to make it more meaningful and relevant to NA users. This can help create a sense of belonging and cultural resonance, and enhance the overall user experience.

By incorporating these cultural elements into the design process, the interface can be more effectively tailored to the needs, preferences, and cultural background of NA users, resulting in a more culturally sensitive and user-friendly interface.

D. Culturally Tailored System Design

In our system functionality design, we go beyond general requirements and consider specific factors related to NA users.

- **Personalized nutrition guidance.** This personalized nutrition guidance is designed to address the specific dietary needs and preferences of NA users, taking into consideration the availability of local foods that are culturally relevant and traditional to their communities. The affordability of food is also a crucial factor, considering the socioeconomic context of NA communities. Additionally, game food, which holds cultural significance in many NA communities, is taken into account in the nutrition guidance provided by the app. Local restaurant menus are analyzed and screened to ensure that the recommended options align with the dietary requirements and cultural practices of NA users, making the app's nutrition guidance practical and feasible for their daily lives. By incorporating these factors into the app's functionality, it aims to provide a culturally sensitive and relevant approach to nutrition guidance for NA users, supporting their self-management of diabetes in a way that respects their cultural traditions and practices.
- **Culturally tailored lifestyle suggestion.** Changes that are meaningful and feasible for the NA community. The app considers the unique preferences and traditions of tribal members, acknowledging their cultural practices and beliefs, and tailoring the lifestyle recommendations accordingly. For example, the app may provide suggestions for physical activities that are culturally relevant and enjoyable, such as traditional dancing or walking on traditional trails. It may also consider the importance of family and community connections in NA culture, and encourage social activities that foster community support, such as family-based support or participation in cultural events. By respecting the cultural practices and beliefs of tribal members, the app aims to promote lifestyle changes that are not only relevant but also meaningful to NA users, increasing the likelihood of sustained engagement and positive health outcomes.
- **Community-based social networking.** The social network feature is designed with cultural relevance in mind, taking into consideration the importance of community connections in NA. It enables community members and family members to communicate and provide mutual encouragement, fostering a sense of community support among app users. This feature allows NA users to connect with each other, share experiences, and provide support on their diabetes self-management journey. Through this social network, users can form virtual communities where they can exchange ideas, share cultural practices related to diabetes management, and offer emotional support, creating a supportive environment that promotes positive health behaviors. This feature promotes social engagement, fosters a sense of belonging, and provides a platform for users to motivate and encourage each other in their diabetes self-management efforts. Seamless communication with tribal health providers. We create a platform for users to connect with healthcare professionals who understand their cultural context and provide relevant healthcare information and services. This feature ensures culturally competent healthcare delivery, taking into consideration the unique needs and preferences

of NA users. Also, through the app, users can receive education content that is tailored to their specific needs. This education content is designed to address the cultural considerations and sensitivities of NA users, providing information and guidance in a way that is relevant and relatable. It covers various aspects of diabetes management, including dietary recommendations, physical activity, medication management, and self-monitoring, among others. By incorporating features that facilitate communication with tribal health providers and tailored education content, our app recognizes the importance of culturally competent healthcare delivery for NA users. It acknowledges the significance of cultural context in shaping health beliefs and behaviors, and aims to bridge the gap between healthcare providers and users by promoting effective communication and education. This feature enhances the user experience, promotes self-management of diabetes, and contributes to improved health outcomes in the NA community.

Overall, our culturally tailored system functionality design ensures that the app provides a relevant and inclusive user experience for NA users, promoting healthy lifestyle changes and fostering community support for improved health outcomes in the NA community.

IV. RESULTS

The diabetes self-management mobile app was implemented using the Ionic framework and Javalin server. Ionic was chosen for its ability to build one codebase that can be used to develop both iOS and Android apps. The Javalin server was used to handle HTTP requests between the app and the backend server, as well as to route those requests to the appropriate handlers. To ensure data security and privacy, data transmitted and received between the mobile app and the Javalin server was encrypted using HTTPS, and data stored in the SQL server was encrypted using RSA encryption. Overall, the combination of Ionic and Javalin provided a fast, lightweight, and secure platform for the development and deployment of the diabetes self-management mobile app.

Fig. 2 showcases several interfaces of our app, each serving a unique function. In Fig. 2 (a), we have integrated the Lower Sioux tribal logo into our diabetes management system. The four parts of the wheel in the logo correspond to important concerns for NA diabetes patients and their healthcare providers, including blood sugar levels, general health, stress levels, and daily diet. This allows them to easily input and track their data through the health wheel, providing a culturally relevant and user-friendly interface. Fig. 2 (b) displays the function menu of the app, which includes meal recommendations and screening, health data recording and visualization, social networking, education, and seamless connection to healthcare providers. This menu provides a comprehensive range of features aimed at supporting diabetes self-management. Fig. 2 (c) showcases a family group communication feature, allowing family members to conveniently work together to communicate and encourage each other in managing diabetes. This feature recognizes the importance of family support in NA culture and promotes a collaborative approach to diabetes care. Fig. 2 (d) demonstrates how the app propagates culturally tailored education and community events to users. This feature ensures that users are

informed about relevant cultural events and educational resources that are specific to their community, fostering engagement and participation.

Overall, our app's interfaces and functions are designed to be culturally sensitive, user-friendly, and aligned with the unique needs and preferences of Native American diabetes patients. Through incorporating cultural elements and addressing the specific concerns of this population, our app aims to promote effective self-management of diabetes among Native Americans.

We have systematically tested each function of the app to ensure its functionality and usability. Additionally, we have conducted multiple use case studies to evaluate the feasibility and effectiveness of various features, such as meal planning, restaurant menu recommendations, and other components. These studies have provided valuable insights into the performance and user experience of the app, helping us refine and improve its functionality.

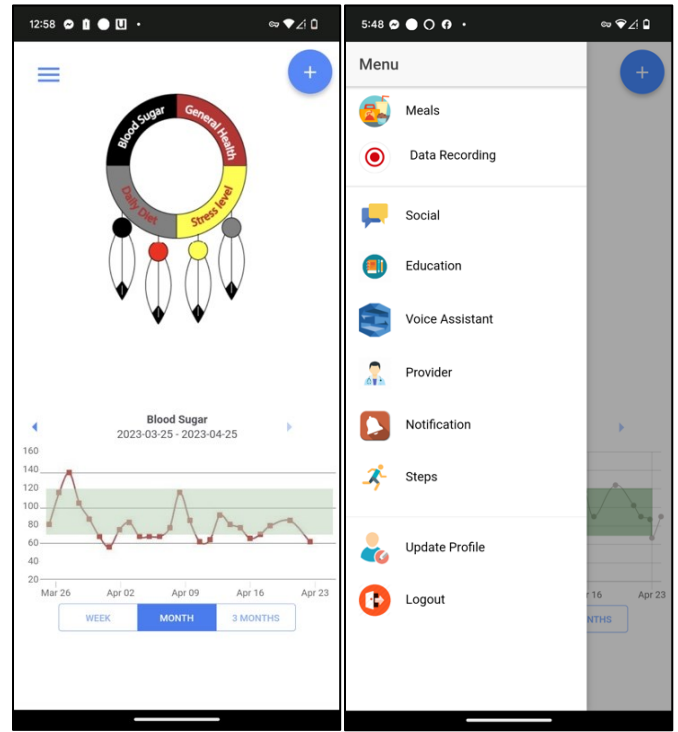
In particular, we have conducted user studies to evaluate specific functions of the app, such as personalized meal planning that takes into consideration local foods, traditional foods, affordability, and game food availability [9], [10]. We have also examined the effectiveness of restaurant menu recommendations, which are analyzed and screened for user suitability [11]. These user studies have helped us understand the usability, relevance, and impact of these features on diabetes self-management among Native American users.

However, while we have conducted user studies to evaluate specific functions, the app as a whole has not been evaluated by the tribal community yet. Therefore, we are planning to evaluate the entire system with the tribal community of Lower Sioux to gather feedback and assess its overall effectiveness. This community-based evaluation will provide us with important insights into the real-world impact of the app, including its acceptability, feasibility, and effectiveness in improving health outcomes among Native Americans with diabetes.

V. CONCLUSION

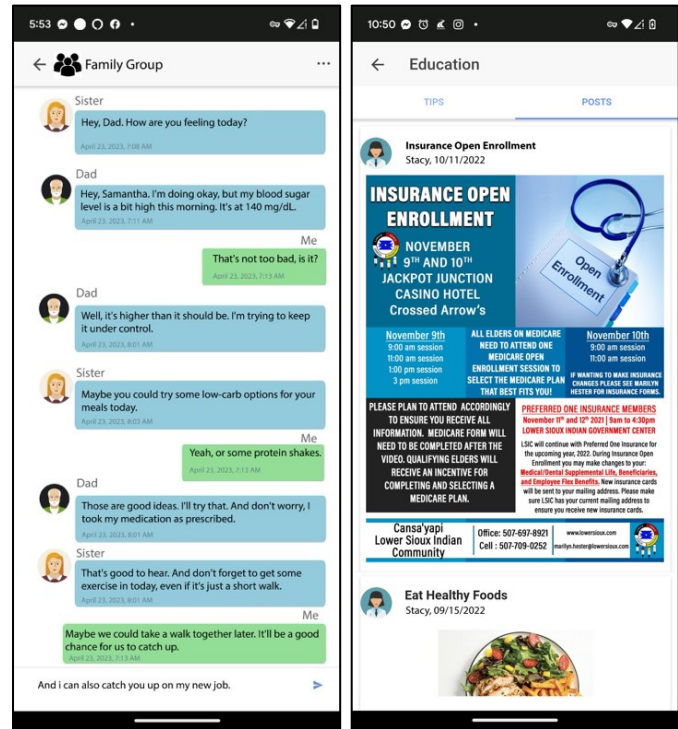
In conclusion, our paper presents the design and development of a culturally tailored mobile app for NAs with diabetes. Through an iterative design process involving input from the Lower Sioux Indian Community, we have created an app that takes into consideration the unique cultural traditions, local resources, and socio-economic context of NAs. The app features personalized nutrition guidance, family-based support, access to local resources, and integration of cultural elements, making it culturally sensitive and relevant for NA users.

Moving forward, we plan to conduct more comprehensive user studies in the Lower Sioux community, involving a larger sample size and assessing the impact of the app on improving health outcomes among NA with diabetes. This feedback will be crucial in further refining and enhancing the app to better meet the needs of the users and contribute to improved health outcomes.



(a)

(b)



(c)

(d)

Fig. 2. Screenshots of the mobile app

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