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Evaluating telemedicine diabetes mellitus: a mobile health app for type-2 diabetes

Muhammad Zakwan Abdul Karim[1], Norashikin M. Thamrin[1], Ruhizan Liza Ahmad Shauri[1], Rozita Jailani[1], Mohd Haidzir Abd Manaf[2], Nurul Amirah Mustapa[2,3]
[1]Department of System Engineering, School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia
[2]Centre for Physiotherapy Studies, Faculty of Health Sciences, Universiti Teknologi MARA Cawangan Selangor, Bandar Puncak Alam, Malaysia
[3]Department of Physical Rehabilitation Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, Kuantan, Malaysia

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ABSTRACT

Telemedicine diabetes mellitus (Tele-DM) mobile health (mHealth) tool functionality, usefulness, and user feedback were examined in this study. Data from nine distinct users of type-2 diabetes (T2D) patients, healthcare professionals (HCPs), and administrators was analyzed to determine functionality. Data retrieval times increased with database user data amount, according to the study. A 3-month program with five T2D patients reduced weight (0.98 kg) and Hemoglobin A1c (HbA1c) (0.34%). This shows that Tele-DM helps manage diabetes, but more participants are needed to confirm. Nine Tele-DM customers were satisfied with the app's reception, according to 14 online questionnaires. Overall, Tele-DM simplifies diabetic self-management in a novel way. This study shows its potential to transform diabetes management and address major healthcare issues.

Corresponding Author:

Norashikin M. Thamrin
Department of System Engineering, School of Electrical Engineering, College of Engineering
Universiti Teknologi MARA
40450 Shah Alam, Selangor, Malaysia
Email: norashikin@uitm.edu.my

1. INTRODUCTION

Diabetes care has changed significantly due to healthcare and exercise technology. Patient outcomes have improved with current technology, showing a shift towards proactive and customized treatment [1]. Even though technology makes health care easier, diabetes treatment is expensive. Diabetes treatment in Malaysia costs RM42K (USD 9.9 K) per year, burdening patients and healthcare providers [2]. Mobile health (mHealth) apps can help patients manage their condition through diet and exercise [3]–[5]. Digital platforms improve diabetic patients' health and enable healthcare professionals (HCPs) to advanced monitoring and therapy [6]. Despite its potential, mHealth solutions struggle. User engagement, data reliability, and healthcare infrastructure digital tool integration are priorities. The long-term health effects of mHealth apps across demographics are unknown. Eleven mHealth apps use self-reported physical activity, studies suggest. These apps rarely employ objective measures like pedometers [7]–[16], [17]. Lack of accurate physical activity monitoring hinders diabetes management. Mobile app database size and hypertext transfer protocol (HTTP) application programming interface (API) response time are rarely studied. This problem could severely impact program performance and user experience [18]. This study evaluates the telemedicine diabetes mellitus (Tele-DM) mobile app's operation, efficacy, and user feedback to address these discrepancies. Database size and API response time are its main metrics. The app's effect on type-2 diabetes (T2D) patients' weight and Hemoglobin A1c (HbA1c) will be assessed [19]. User feedback will be examined to make the app easier to use, especially for T2D-afflicted elders [20], [21]. Three areas are studied to show how mHealth apps can save treatment costs and improve diabetes results. Discovering mHealth solution restrictions and adoption challenges will help offer new ways to increase user participation and smoothly integrate these technologies into healthcare operations. Show that mHealth reduces diabetes' economic and health costs, helping to digital chronic disease management.

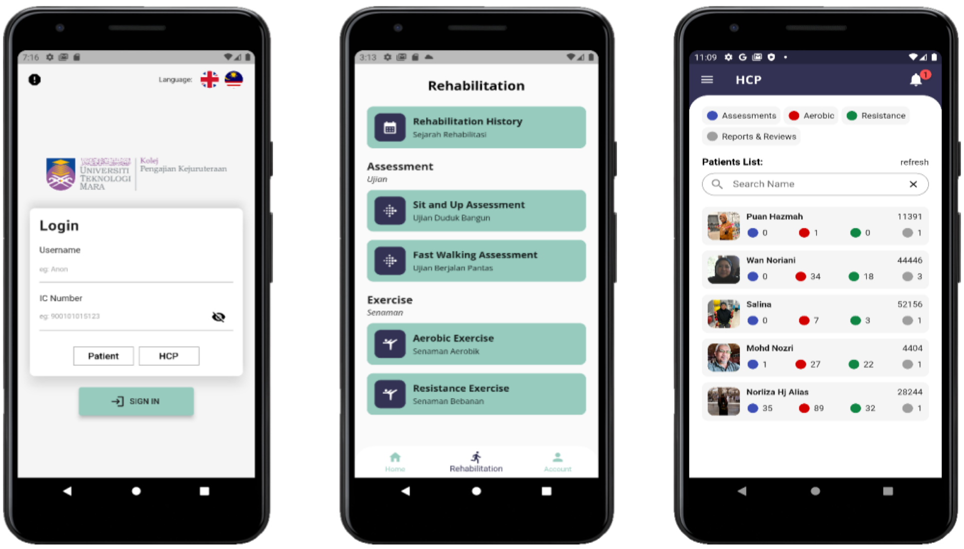
2. RESEARCH METHOD

2.1. mHealth applications benchmark analysis

Eleven mHealth tools were assessed for their potential impact on diabetes treatment. This study examined each application's pros and cons. Tele-DM was the typical smartphone app for this investigation. Tele-DM and eleven mHealth systems were tested for usability [22]. We examined each program's pros and cons to assess its efficacy, user engagement, and diabetes control potential. This comprehensive comparison examined user interface (UI) design, usability, evidence-based methods, and personalization. The study examines how well these tools motivate users, particularly diabetics, and help HCPs provide personalized care. This detailed study displays each mHealth tool's features. This includes assessing how well these technologies control diabetes, expand, and integrate into healthcare systems. The analysis assesses each tool's Tele-DM position and highlights gaps and innovation opportunities to increase mHealth solutions' healthcare ecosystem influence. A comprehensive comparison review expands diabetes management mHealth technology understanding. Current tools are compared to Tele-DM to determine their strengths and cons. To guide digital health advancements for patients and HCPs, this research prioritizes user demands, clinical importance, and ease of integration into healthcare systems.

2.2. Telemedicine diabetes mellitus

Figure 1 shows Tele-DM's mobile app user interface features and capabilities. Patients and HCPs can log in separately (Figure 1(a)). Dual-entry meets each group's data access needs. The patient interface's rehabilitation module assesses and prescribes physical activities (Figure 1(b)). Diabetics benefit from aerobic and resistance training. Figure 1(c) shows the HCP homepage's patient list, which lets visitors rapidly obtain patient information by clicking on the patient's name. These interfaces show how this study will compare health apps to Tele-DM. against identifying strengths and weaknesses, this comparison compares the Tele-DM app's functionality, usability, and design against other diabetes management mHealth apps. This study explores Tele-DM's digital health ecosystem role. Tele-DM's user-centric design, functionality, and healthcare integration will shine. This comparison will show how Tele-DM and related apps increase patient care and HCP help, leading to mHealth technology development.



(a) (b) (c)

Figure 1. UI design of Tele-DM mobile application for (a) login page, (b) rehabilitation page, and (c) home page for HCP system.

2.3. Functionality analysis
The Tele-DM mobile app's operation is vital to our study. We ensure app navigation and operation to boost user engagement [23]. Due to its robust backend database, Tele-DM requires an internet connection on Android handsets to access user data. When an Android smartphone opens Tele-DM, it sends an API request to retrieve user data from the database. To do this, the user must click on the Tele-DM icon on their smartphone to launch the app. The startup screen, where the API call to retrieve user data is made. Afterwards, the application switches to the main page after retrieving data. The home page shows the transaction's millisecond length, indicating the app's efficiency. As Tele-DM users add rehabilitative exercises to the database or schedule, user data grows. Increasing data necessitated a careful analysis of the application's functionality to identify its impact on starting reaction time. The study examined if database user data affects app startup time. This study used data from five T2D patients, two HCPs, and two administrators. This diverse group was chosen to cover all use cases and data volumes. To ensure reliability, the app's reaction time was measured five times for each user to establish an average. Unifi 5 GHz, a fast-cellular technology, eliminated external variables on reaction time in the study. This detailed functionality analysis emphasizes the importance of app performance to user happiness and the technological hurdles of managing and retrieving data in mHealth apps. Database size and app responsiveness are studied to improve Tele-DM. This will help the app control diabetes smoothly and engagingly.

2.4. Effectiveness analysis
The Tele-DM mobile app's ability to supplement T2D clinical therapy was widely studied. This study explored how Tele-DM, a mHealth device, benefited T2D patients' self-management. This study relied on a well-organized 3-month T2D therapy strategy. The Tele-DM app was promoted for everyday diabetes management. Participants were closely supervised by a Tele-DM diabetes management specialist during rehabilitation. This approach taught patients how to manage their diabetes through participatory activities, not just app use. Regular data collection was used to assess the program's impact. The participants' baseline health was evaluated on day 1. Progress was compared against initial data. After three months, weight and HbA1c were measured on day 90. These indicators show how diabetes care improves participants' health and disease control, indicating program performance. The study will assess Tele-DM's self-management benefits using these health markers. This study should demonstrate Tele-DM's advantages to T2D patients and its ability to transform diabetes self-care.

2.5. Effectiveness analysis
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2.6. Users' feedback analysis
The online application evaluation questionnaires were created using Google Forms. User feedback improves app functionality and data trust [25]. HCP and patient evaluation forms exist. Patients utilized the patient system assessment form to score and remark on the Tele-DM mobile app. Participants were encouraged to test Tele-DM's mobile app and submit feedback in both ways. The evaluation uses consumer feedback. Feedback can improve the software to reach more people. Patient system evaluation Google form questions are flowcharted in Figure 2. Four sections of this evaluation form assess the Tele-DM mobile app's impact. The first part covers app operation. Participants discuss app features, navigation, and difficulties, revealing its usefulness and practicality. Section 2 assesses user satisfaction with the app's UI, font style and size, and English and Bahasa readability. Third, application rehab. To assess health benefits, participants should evaluate rehabilitation, including exams and activities. “Workout mode” and “search and upload” request vitals. Finally, Tele-DM referrals are measured by net promoter score (NPS). It measures the app's word-of-mouth and adoption potential. The patient system evaluation form has 14 well-written questions in four key sections. The Tele-DM mobile app's impact and potential advantages to diabetic self-management can be assessed using this comprehensive approach. Organized flowcharts assessing HCP systems Google Form inquiry setup in Figure 3. Q1, Q2, Q3, Q4, and Q5 of this brief form analyze the patient list tab user

interface, monitoring process, charts, user data settings, and HCP system user interface. This simplified approach collects HCP and public app usability and functionality comments.

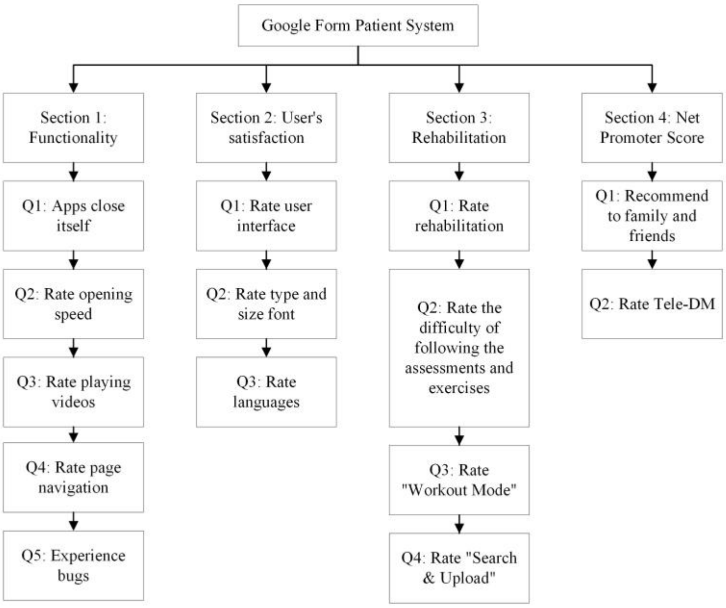

Figure 2. Flowcharts of questions in Google Forms for patient system

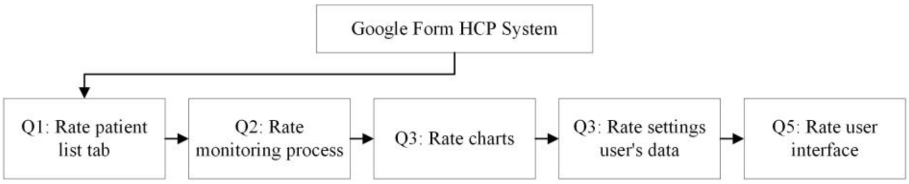

Figure 3. Flowcharts of questions in Google Forms for the HCP system

3. RESULTS AND DISCUSSION

3.1. Comparison of Tele-DM with previous mobile health

Table 1 compares Tele-DM to other diabetes mHealth apps and shows its benefits. Critique of this comparison highlights Tele-DM's innovative platform for T2D patients, HCPs, and administrators. Tele-DM tracks aerobic and resistance exercise, unlike most mHealth solutions that use self-reported data. Enhanced physical activity tracking and tailored training adherence may improve patient outcomes. Tele-DM has patient, HCP, and administrator components. With this connectivity, patients may update HCPs and administrators can manage care. In contrast, prior mHealth systems focused on patients and overlooked HCP-administrator collaboration in treatment and management. Tele-DM connects to wearable devices to track steps, calories, and heart rate better than smartphone pedometers. By directly connecting wearable technologies, health monitoring and intervention can obtain more accurate and objective physical activity data. Although advantageous, Tele-DM's approach has drawbacks. Innovative wearable vital signs monitors may struggle with availability, cost, and comfort. Patients without proper wearable gear may not benefit from the app. Patient outcomes improve with user engagement and Tele-DM tasks and monitoring compliance. Work and imagination are needed for high engagement. Integration of patient, HCP, and administrator systems improves coordinated therapy but requires robust data privacy and security to protect sensitive health information. For user trust, healthcare rules and standards must be upheld. Finally, the comparison study shows that Tele-DM's unique mHealth diabetes management strategy improves patient care through personalized activities, integrated systems, and wearable device connectivity. Although beneficial, the app's effectiveness hinges on technology accessibility, user engagement, and data security. These must be considered in future Tele-DM and mHealth technologies to improve diabetes control and patient health.

Table 1. Tele-DM versus the previous mHealth

No.	Name of mHealth	Physical activity	Available systems	Vital signs monitoring	Other significant features
1	Tele-DM	Aerobic (22 activity) and resistance (27 activity) exercise	Patient, HCP, and administrator	Monitor steps, calories burned, and heart rate during physical activity using a wearable device	SR weight and blood glucose, and daily tasks calendar
2	Time2Focus	SR	Patient	None	Glucose monitoring, Education video on eating healthy
3	DiaSocial	SR, walking	Patient	Monitor steps using the phone’s pedometer	SR food intake
4	Health2Sync	SR	Patient	None	SR's diet and medication
5	GlycoLeap	SR, walking	Patient	Monitor steps using the phone’s pedometer	Online health lessons, Blood glucose, and weight monitoring
6	D’LITE	SR, walking	Patient	Monitor steps using the phone’s pedometer	Blood glucose and weight monitoring, and chat function
7	DSMES	SR	Patient	None	Medication reminders
8	Triabetes	SR	Patient	None	Sets individual goals for blood glucose and weight
9	LIBIT	SR	Patient	None	Blood glucose and weight monitoring
10	BlueStar	SR	Patient	None	Medication reminders, diabetes, and diet videos
11	iCareD	SR	Patient	None	Healthy diet videos
12	mDiab	Brisk walking	Patient	None	Weight tracker

3.2. Functionality analysis

Table 2 illustrates that user data amount influences the Tele-DM mobile app's mean reaction time. A correlation was found in nine users' 1.50 to 106 KB data. App reaction time increases with data. The average response time is 1,332 milliseconds for the smallest data and 2,925 for the largest. It appears that processing additional data impacts application performance. This scatter graph shows the relationship between data size and reaction time. The x and y-axes show data size and response time. A positive trendline shows data size and reaction time are positively connected. User data volume increases the Tele-DM program opening processing time, according to the trendline. This has important implications for performance-focused app developers and system administrators. This site gives crucial app performance data and exposes underlying constraints and challenges. Application scalability is limited. As users and data per user rise owing to more detailed tracking of physical activities, health measurements, or personal entries, the application's performance may decrease, resulting in longer wait times that annoy and reduce user interest. This approach overlooks network speed variations and device processing capabilities, which can greatly alter reaction times regardless of data quantity. Additional criteria could improve future research by providing a fuller view of the application's efficacy under diverse usage scenarios. The experiment quantifies how data size impairs performance and stresses the need to enhance application data management and storage. Compressing data, selectively loading data, and improving server response times can improve performance. It keeps the app responsive as it grows. Overall, the experiment shows how data amount affects app performance. It emphasizes improving the program to handle more data while maintaining a good user experience. Maintaining and increasing the Tele-DM program's performance and user satisfaction requires addressing the restrictions.

Table 2. Results of average response time for each user

#	Data size, kilobytes (KB)	Average response time, milliseconds (ms)
1	1.50	1,332
2	5.21	1,352
3	6.51	1,411
4	22.8	1,897
5	23.2	1,912
6	24.8	1,936
7	57.3	2,387
8	74.5	2,717
9	106	2,925

3.3. Effectiveness analysis

Over 90 days, the Tele-DM mobile app reduced weight and HbA1c levels in T2D patients. In Table 3, the data shows a significant weight loss of 0.98 kg from 67.5 to 66.52 kg ($P<.001$) within the specified confidence interval (CI). One individual, who exercised more, lost 3.4 kg, or 4.44% of their baseline body weight. This shows that the app promotes physical exercise and weight loss. Also, long-term HbA1c improved. The average HbA1c drop was 0.34% (5.31%), from 7.72 to 7.38% ($P<.001$). Top weight loser's HbA1c dropped 0.8%. The Tele-DM app's weight and HbA1c effects suggest diabetes self-management. This intriguing study has drawbacks. First, the five-person sample restricts generalization. Larger cohort data would help determine the app's demographic relevance. User involvement may affect results, as more exercisers saw significant gains. Variable engagement requires user participation solutions. Customers need individualized exercise routines and therapies to maximize Tele-DM app use for weight reduction, HbA1c lowering, and app utilization. Future research should examine these health outcomes' long-term sustainability to evaluate Tele-DM's diabetes treatment efficacy beyond 90 days. Initial findings suggest the Tele-DM smartphone app helps T2D patients lose weight and lower HbA1c. A larger and more diverse participant community must evaluate these outcomes, engagement techniques, and long-term advantages to prove the Tele-DM mobile app's impact on diabetic self-management.

Table 3. Results of the effectiveness analysis

Outcomes	Day 1		Day 90		Mean difference
	Mean [95% CI]	Standard deviation (SD)	Mean [95% CI]	Standard deviation (SD)	
Weight	67.5 (60.3 to 74.7)	8.23	66.52 (60.3 to 72.7)	7.06	0.98
HbA1c levels	7.72 (7.1 to 8.3)	0.73	7.38 (6.5 to 8.2)	0.94	0.34

3.4. Users' feedback analysis: evaluation form

3.4.1. For patient system

The first question in section one questioned if the Tele-DM mobile app closed unexpectedly while using it. The findings showed that 13 of 14 respondents had never had the app close for no apparent reason. The software appears to work properly and gives a solid user experience. The third question in section one asked respondents to rate the app's video playback feature. The findings showed that 7 of 14 respondents gave the videos five stars, indicating that they play on all mobile platforms. In the fifth question of section one, respondents were asked if they had any issues with the Tele-DM mobile app, such as missing text, video not playing, buttons not working, or text out of sync. The question responses suggest that Tele-DM has handled technical issues and bugs well. All 14 respondents said the app never had severe issues. This is good because technical faults can ruin the user experience and cause irritation. The first section two questions rate the Tele-DM mobile app's user interface. Survey respondents rated the app's user interface 4.1 out of 5. While most respondents appreciated the Tele-DM app's interface, the results imply it could be better. The Tele-DM mobile application's language is good in conveying information and does not hamper user experience, as the third question in section two received a 4.9-star average rating for readability and comprehension.

The second question in section three asked respondents to rank the difficulty of following evaluation and exercise steps. Most participants (10 out of 14) rated 5 stars, indicating they found the directions easy to follow. Most respondents had little trouble with the exercise instructions, therefore they likely were clear. Next, for questions 3 and 4, the respondents imply that clearer instructions are needed to navigate the vital signs data-gathering tool. The fourth section's first question questioned if respondents would recommend Tele-DM to family and friends. Twelve of fourteen survey respondents agreed. Tele-DM appears to be user-friendly and effective for diabetes treatment. Results show users like and operate well with the product. The second question ranked the Tele-DM mobile app on a 10-point scale. The average rating is 8.5 stars, indicating high satisfaction with the app.

3.4.2. For healthcare professional system

Figure 1(c) shows the first HCP system question: grade the patient list tab user interface. In the HCP system poll, 14 people gave 4 or 5 stars. Average rating: 4.64 stars. These consistently high results show that the patient list tab's user interface meets HCP needs. Second question: rank Tele-DM mobile app monitoring. The responses were positive, with 4 participants rating 3 stars, 10 rating 4 to 5 stars, and the average rating 4.14 stars. The monitoring approach should include real-time monitoring. Fifth question: HCP system user interface rating. One person gave 1 star; however, the average rating is 4.50. Data demonstrates that most respondents enjoyed the user interface's usefulness and experience. The healthcare system's user interface guides HCPs. Participants in the Google Form HCP system evaluation showed excellent satisfaction in all five areas. Data suggests the HCP system is popular. The patient list tab's monitoring procedure, user interface charts, data settings, and general user interface have been well appreciated. These findings prove the Tele-DM mobile app's HCP system works and meets HCP needs.

4. CONCLUSION

Finally, the Tele-DM mobile app study reveals its functionality, efficacy, and user feedback. Functionality research shows that data size affects response time, emphasizing the need for optimization as data quantity increases. The effectiveness analysis of a 3-month program for five T2D patients shows weight and HbA1c reductions of 0.98 kg and 0.34%, respectively. These findings suggest that the application may have a positive impact, but more HCPs could manage a bigger participant pool. Doing so would strengthen the effectiveness assessment and validate the application's diabetes management efficacy. User feedback confirms the app's popularity and ability to meet user needs. Triangulating these data shows that Tele-DM could be a useful diabetes self-management tool.

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REFERENCES

[1] W. Choi, S. Wang, Y. Lee, H. Oh, and Z. Zheng, "A systematic review of mobile health technologies to support self-management of concurrent diabetes and hypertension," *Journal of the American Medical Informatics Association*, vol. 27, no. 6, pp. 939–945, Jun. 2020, doi: 10.1093/jamia/ocaa029.

[2] A. A. Shafie and C. H. Ng, "Estimating the costs of managing complications of type 2 diabetes mellitus in Malaysia," *Malaysian Journal of Pharmaceutical Sciences*, vol. 18, no. 2, pp. 15–32, Nov. 2020, doi: 10.21315/mjps2020.18.2.2.

[3] G. Rinaldi, A. Hijazi, and H. Haghparast-Bidgoli, "Cost and cost-effectiveness of mhealth interventions for the prevention and control of type 2 diabetes mellitus: a protocol for a systematic review," *BMJ Open*, vol. 9, no. 4, p. e027490, Apr. 2019, doi: 10.1136/bmjopen-2018-027490.

[4] S. Akhtar, J. A. Nasir, A. Ali, M. Asghar, R. Majeed, and A. Sarwar, "Prevalence of type-2 diabetes and prediabetes in Malaysia: a systematic review and meta-analysis," *PLOS ONE*, vol. 17, no. 1, p. e0263139, Jan. 2022, doi: 10.1371/journal.pone.0263139.

[5] I. Lora-Pozo, D. Lucena-Anton, A. Salazar, A. Galán-Mercant, and J. A. Moral-Munoz, "Anthropometric, cardiopulmonary and metabolic benefits of the high-intensity interval training versus moderate, low-intensity or control for type 2 diabetes: systematic review and meta-analysis," *International Journal of Environmental Research and Public Health*, vol. 16, no. 22, p. 4524, Nov. 2019, doi: 10.3390/ijerph16224524.

[6] M. Z. A. Karim, R. Jailani, R. L. A. Shauri, and N. M. Thamrin, "IoT framework of telerehabilitation system with wearable sensors for diabetes mellitus patients," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 31, no. 2, p. 1023, Aug. 2023, doi: 10.11591/ijeecs.v31.i2.pp1023-1031.

[7] B. C. Batch *et al.*, "General behavioral engagement and changes in clinical and cognitive outcomes of patients with type 2 diabetes using the time2focus mobile app for diabetes education: pilot evaluation," *Journal of Medical Internet Research*, vol. 23, no. 1, p. e17537, Jan. 2021, doi: 10.2196/17537.

[8] J. Su, M. Dugas, X. Guo, and G. (Gordon) Gao, "Influence of personality on mhealth use in patients with diabetes: prospective pilot study," *JMIR mHealth and uHealth*, vol. 8, no. 8, p. e17709, Aug. 2020, doi: 10.2196/17709.

[9] Y.-Z. Tu, Y.-T. Chang, H.-Y. Chiou, and K. Lai, "The effects of continuous usage of a diabetes management app on glycemic control in real-world clinical practice: retrospective analysis," *Journal of Medical Internet Research*, vol. 23, no. 7, p. e23227, Jul. 2021, doi: 10.2196/23227.

[10] D. Koot *et al.*, "A mobile lifestyle management program (glycoleap) for people with type 2 diabetes: single-arm feasibility study," *JMIR mHealth and uHealth*, vol. 7, no. 5, p. e12965, May 2019, doi: 10.2196/12965.

[11] S. L. Lim *et al.*, "A smartphone app-based lifestyle change program for prediabetes (d'lite study) in a multiethnic Asian population: a randomized controlled trial," *Frontiers in Nutrition*, vol. 8, Jan. 2022, doi: 10.3389/fnut.2021.780567.

[12] D. E. Nkhoma, C. J. Soko, K. J. Banda, D. Greenfield, Y.-C. (Jack) Li, and U. Iqbal, "Impact of dsmes app interventions on medication adherence in type 2 diabetes mellitus: systematic review and meta-analysis," *BMJ Health & Care Informatics*, vol. 28, no. 1, p. e100291, Apr. 2021, doi: 10.1136/bmjhci-2020-100291.

[13] M. Taloyan, M. Kia, F. Lamian, M. Peterson, and E. Rydwik, "Web-based support for individuals with type 2 diabetes - a feasibility study," *BMC Health Services Research*, vol. 21, no. 1, p. 721, Dec. 2021, doi: 10.1186/s12913-021-06707-7.

[14] S. W. Oh, K.-K. Kim, S. S. Kim, S. K. Park, and S. Park, "Effect of an integrative mobile health intervention in patients with hypertension and diabetes: crossover study," *JMIR mHealth and uHealth*, vol. 10, no. 1, p. e27192, Jan. 2022, doi: 10.2196/27192.

[15] P. Agarwal *et al.*, "Mobile app for improved self-management of type 2 diabetes: multicenter pragmatic randomized controlled trial," *JMIR mHealth and uHealth*, vol. 7, no. 1, p. e10321, Jan. 2019, doi: 10.2196/10321.

[16] E. Y. Lee *et al.*, "Efficacy of personalized diabetes self-care using an electronic medical record–integrated mobile app in patients with type 2 diabetes: 6-month randomized controlled trial," *Journal of Medical Internet Research*, vol. 24, no. 7, p. e37430, Jul. 2022, doi: 10.2196/37430.

[17] S. Muralidharan *et al.*, "Engagement and weight loss: results from the mobile health and diabetes trial," *Diabetes Technology & Therapeutics*, vol. 21, no. 9, pp. 507–513, Sep. 2019, doi: 10.1089/dia.2019.0134.

[18] A. A. Prayogi, M. Niswar, Indrabayu, and M. Rijal, "Design and implementation of rest API for academic information system," *IOP Conference Series: Materials Science and Engineering*, vol. 875, no. 1, p. 012047, Jun. 2020, doi: 10.1088/1757-899X/875/1/012047.

[19] C. C. Quinn *et al.*, "An mhealth diabetes intervention for glucose control: health care utilization analysis," *JMIR mHealth and uHealth*, vol. 6, no. 10, p. e10776, Oct. 2018, doi: 10.2196/10776.

[20] I. Gremyr, A. Birch-Jensen, M. Kumar, and N. Löfberg, "Quality functions' use of customer feedback as activation triggers for absorptive capacity and value co-creation," *International Journal of Operations & Production Management*, vol. 42, no. 13, pp. 218–242, Dec. 2022, doi: 10.1108/IJOPM-11-2021-0692.

[21] P. Parmar, J. Ryu, S. Pandya, J. Sedoc, and S. Agarwal, "Health-focused conversational agents in person-centered care: a review of apps," *npj Digital Medicine*, vol. 5, no. 1, p. 21, Feb. 2022, doi: 10.1038/s41746-022-00560-6.

[22] A. S. Mustafa, N. Ali, J. S. Dhillon, G. Alkawsi, and Y. Baashar, "User engagement and abandonment of mhealth: a cross-sectional survey," *Healthcare*, vol. 10, no. 2, p. 221, Jan. 2022, doi: 10.3390/healthcare10020221.

[23] D. Chakraborty and J. Paul, "Healthcare apps' purchase intention: a consumption values perspective," *Technovation*, vol. 120, 2023, doi: 10.1016/j.technovation.2022.102481.

[24] Z. C. *et al.*, "The effectiveness of mhealth interventions on postpartum depression: a systematic review and meta-analysis," *Journal of telemedicine and telecare*, p. 1357633X20917816, 2020, doi: 10.1177/1357633X20917.

[25] S. R. Joshua, W. Abbas, J.-H. Lee, and S. K. Kim, "Trust components: an analysis in the development of type 2 diabetic mellitus mobile application," *Applied Sciences*, vol. 13, no. 3, p. 1251, Jan. 2023, doi: 10.3390/app13031251.

BIOGRAPHIES OF AUTHORS

Muhammad Zakwan Abdul Karim is a postgraduate student at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM), Selangor, Malaysia. He holds a bachelor's degree in Electrical Engineering and he graduated from Universiti Teknologi MARA (UiTM) in 2021. His interests are mobile application development, UI/UX design, and robotic arm. Currently working on projects involving mobile applications. He can be contacted at email: mzakwankarim@gmail.com.

Norashikin M. Thamrin an Associate Professor at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM), Malaysia, since 2008. She earned her bachelor's (Honours) in electrical-electronic engineering and master's in engineering from Universiti Teknologi Malaysia in 2005 and 2007. In 2017, she earned her Ph.D. in automation and robotics from UiTM. Her research focuses on automated system development, water security, agribusiness, and educational robots. She has written/co-written 50+ publications. She can be contacted at email: norashikin@uitm.edu.my.

Ruhizan Liza Ahmad Shauri is a senior lecturer in System Engineering Studies, at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM), Malaysia. She obtained his Ph.D. degree from the University of Chiba, Japan in Systems Artificial Science under the Faculty of Mechanical Engineering. Her research focuses on robotic design, control systems, and image processing. She can be contacted at email: ruhizan@uitm.edu.my.

Rozita Jailani received her Ph.D. in Automatic Control and System Engineering from Sheffield University, UK. She is currently an Associate Professor at the School of Electrical Engineering, College of Engineering, and a research fellow at the Integrative Pharmacogenomics Institute (iPROMISE), Universiti Teknologi MARA (UiTM), Malaysia. Her research interests include intelligent control systems, rehabilitation engineering, assistive technology, instrumentation, artificial intelligence, and advanced signal and image processing techniques. She can be contacted at email: rozitaj@uitm.edu.my or rozita@ieee.org.

Mohd Haidzir Abd Manaf is an Associate Professor in the Faculty of Health Sciences, Universiti Teknologi MARA. He is head of the Clinical Rehabilitation and Exercise Research Group and is extensively involved in the field of research with an accumulation of international and national grants. He has authored 43 publications in various international, national, and specialized journals in his field of research. He can be contacted at email: haidzir5894@uitm.edu.my.

Nurul Amirah Mustapa obtained a Degree (Physiotherapy) and Master of Health Sciences (Physiotherapy) qualification from Universiti Teknologi Mara (UiTM). Presently, she is a physiotherapy lecturer at the Department of Physical Rehabilitation Sciences, Kulliyyah of Allied Health Sciences, IIUM. She can be contacted at email: nurulamirah@iium.edu.my.