Effectiveness of Augmented Reality-Based Therapeutic Patient Education (TPE-AR DM2) Integrated with the Chronic Care Model on The Independence of Posyandu Cadres in Managing Diabetes Mellitus

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ABSTRACT

Diabetes mellitus is a chronic disease that requires continuous management. Integrated Health Service Post (Posyandu) cadres play a crucial role in supporting community education and mentoring, but their independence is often limited. The implementation of Augmented Reality-based Therapeutic Patient Education (TPE-AR DM2) with the Chronic Care Model (CCM) approach is an innovation expected to increase cadre independence in managing diabetes mellitus. Community service objectives are to determine the effectiveness of implementing TPE-AR DM2 with the CCM approach on Posyandu cadre independence in managing diabetes mellitus. This quasi-experimental study used a pre-test and post-test design involving 25 posyandu cadres as respondents who received the TPE-AR DM2 with ccm intervention over a 5-week intervention period. Cadre independence was measured based on five operational indicators: (1) knowledge, (2) ability to operate the TPE-AR DM2 application, (3) glucometer skills, (4) diabetic foot exercise skills, and (5) therapeutic communication skills. Data analysis used the n-gain test to assess the effectiveness of the intervention. The study showed a significant increase in all indicators of cadre independence after the intervention. The average knowledge score increased from 40.22 to 83.34 (N-gain = 0.72), the ability to operate the TPE-AR DM2 application from 35.96 to 84.72 (N-gain = 0.76), glucometer skills from 45.84 to 85.60 (N-gain = 0.73), diabetic foot exercise skills from 45.84 to 91.60 (N-gain = 0.84), and therapeutic communication skills from 32.02 to 82.60 (N-gain = 0.74). All N-gain values >0.7 indicate the high effectiveness of the intervention in increasing the independence of Posyandu cadres. The implementation of TPE-AR DM2 with the Chronic Care Model approach has been proven effective in increasing the independence of Posyandu cadres in managing diabetes mellitus.

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This innovation can be a technology-based cadre empowerment strategy to support chronic disease management at the community level.

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disease that has a major impact globally, because it can trigger various serious complications that reduce the quality of life, increase morbidity, and risk causing premature death. (American Diabetes Association, 2023). Diabetes not only impacts the physical aspects but also affects the quality of life and productivity of sufferers, especially if it is not managed well through an educational approach and continuous behavioral changes. (Mustapa et al., 2022). The Waru District, Sidoarjo Regency, is one of the areas with a fairly high number of DM cases based on 2022 data, with 5,868 residents are suffering from DM, of which 5,578 residents have received health services according to standards (95.1%) (Profil Kesehatan Kabupaten Sidoarjo, 2022).

Increasing an individual's capacity to make decisions and control their health condition, which is related to the concept of self-efficacy and health locus of control, is an important aspect in managing DM (Fajriyah et al., 2024). Self-efficacy refers to an individual's belief in their ability to manage and control their health condition independently. (Jiang et al., 2024). Health locus of control refers to an individual's belief that their health is influenced by personal actions and decisions, not just external factors. (Zhu et al., 2022).

In this context, Posyandu cadres function as community change agents, facilitating education, screening, and psychosocial mentoring at the grassroots level (Dwi Wahyuni & Zainol Rachman, 2024). The Flamboyan Family Posyandu Cadres of RW 02 Kureksari Village are at the forefront of community-based health services, focusing on promotive and preventive efforts for all age groups. This Posyandu is located at Jl. Flamboyan No.21 RT.03 RW.02 Kureksari Village, and was officially established on January 1, 2025, as a result of the integration of Posyandu for the Elderly, Toddlers, and Teenagers to improve the effectiveness of holistic and coordinated services. This Posyandu serves various units, including Posyandu for Toddlers, Elderly, Teenagers, Pregnant Women, Disabled, ODGJ, as well as Posyandu for Prevention of Non-Communicable Diseases (NCD), with the NCD unit playing an important role in efforts to prevent chronic diseases, especially Diabetes Mellitus. Programs that have been implemented include conducting routine screenings, such as checking random blood sugar levels, as well as education about health and implementing a healthy lifestyle, accompanying the Diabetes community through home visits, recording health conditions, and providing motivational support to improve treatment adherence.

Despite their strategic role, many cadres still rely on conventional health education methods and demonstrate limited digital literacy and low confidence in providing comprehensive support, particularly related to self-efficacy, psychosocial guidance, and diabetes self-management skills (Shaban et al., 2024). Previous studies on digital health interventions in diabetes have primarily focused on patients, not community health cadres as intermediaries in chronic care. This creates a research gap, as there is limited evidence on how technology-enhanced Therapeutic Patient Education, particularly using

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Augmented Reality (AR), can strengthen cadre independence as frontline community educators.

Although the role of cadres is crucial and their activities influence the DM community, challenges remain in the process of mentoring them. Partner Issues: 1) Limited access to interactive educational media, coupled with low levels of digital literacy. Limited interactive media and digital literacy present challenges in addressing increasingly complex educational needs. Conventional approaches (such as oral lectures, leaflet distribution, and one-way messaging) are less effective for communities with diverse characteristics, particularly the younger generation and individuals with visual and participatory needs. Digital-based nursing interventions have promising potential to increase knowledge and confidence, and encourage more proactive healthy lifestyle behaviors in individuals with DM (Shaban et al., 2024). This challenge is not caused by a lack of commitment from cadres, but rather by limited training, supporting facilities, and technology-based educational materials available in the field. 2) Lack of understanding in educating people with diabetes about psychosocial issues, including self-efficacy and health locus of control. Low self-efficacy is a barrier to managing diabetes mellitus. This condition is influenced by previous negative experiences and a passive mindset toward the disease. Some people still believe that illness is fate or something unavoidable, leading them to feel a lack of control over their health and become less motivated to make lifestyle changes or follow medical advice (external locus of control) (Zhu et al., 2022).

Independence in daily care is very important in the management of diabetes mellitus, because the success of therapy depends on the individual's ability to regulate diet, physical activity, medication, and stress management, in addition to medical interventions. (Yasin et al., 2022). Non-compliance with medication in people with diabetes can worsen health, increase the risk of chronic complications such as neuropathy, nephropathy, retinopathy, and heart disease, and reduce quality of life due to ongoing physical problems and decreased productivity. (Mulfianda et al., 2023) .3) Motivation of families from the diabetic community in providing family support, including informational, emotional, instrumental, and social support. Family motivation and support are crucial components in diabetes management. The family's role is a key factor in supporting successful treatment and optimal diabetes management. Active family involvement helps improve patient compliance, encourages a healthy lifestyle, and strengthens psychological well-being. Emotional, instrumental, and informational support from the family also facilitates daily care for patients (Khoirunnisa et al., 2024).

The Chronic Care Model (CCM) provides a comprehensive framework emphasizing informed, activated individuals supported by proactive, prepared health teams through decision support, self-management education, and clinical information systems. However, its application using AR-based educational media specifically for cadre capacity-building has not been widely examined, especially in low-resource community settings.

Augmented Reality (AR) offers interactive visual guidance that may enhance skill acquisition, confidence, and autonomy among cadres, especially in technical procedures such as glucometer use, diabetic foot exercise demonstrations, and therapeutic communication. The purpose of this community service activity is closely related to the global agenda of the Sustainable Development Goals (SDGs), specifically, this activity is aligned with SDGs 3 (Healthy and Prosperous Life), which focuses on improving the quality of life of people with Diabetes Mellitus. This is realized through strengthening therapeutic education and social support that can increase individual self-efficacy, namely confidence in managing health, as well as shifting the health locus of control from external to internal, so that individuals feel in control of their health. Thus, the community can manage diabetes independently, prevent complications, and sustainably improve the quality of life.

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METHOD

Study Design

This study employed a quasi-experimental pre–post test design without a control group, conducted over five weeks. The design was selected due to the community-based nature of the intervention and the limited availability of equivalent comparison cadres.

Participants and Sampling

A total of 25 Posyandu cadres from RW 02 Kureksari Village, Sidoarjo Regency, were recruited using total sampling, as all active cadres met the criteria for participation.

Inclusion Criteria:

- Active Posyandu cadres registered in Flamboyan Family Posyandu.

- Willing to participate and able to use a smartphone.

- Able to read and understand Bahasa Indonesia.

Exclusion Criteria:

- Cadres who were absent for more than one training session.

- Cadres with visual or cognitive impairment preventing full participation.

Intervention Description

The intervention consisted of a structured Augmented Reality-Based Therapeutic Patient Education (TPE-AR DM2) program integrated with the Chronic Care Model (CCM) principles. It included three sequential training modules:

TABLE 1. Three sequential training modules

Module	Content	CCM Component	Duration
Training 1	Introduction to TPE-AR DM2 app: navigation, interactive AR features, diabetes education content	Self-Management Support	3 hours
Training 2	Practical skills: glucometer operation and diabetic foot exercise using AR-guided simulation	Decision Support & Delivery System Design	3 hours
Training 3	Therapeutic communication, motivational interviewing, and psychosocial support using CCM framework	Community Resources & Empowerment	3 hours

Each session was followed by structured mentoring, continuous monitoring, and performance evaluation, in accordance with the iterative learning framework of the Community Capacity Building Model (CCM). These follow-up activities were not merely administrative procedures but were strategically designed to ensure that each cadre not only acquired knowledge but also demonstrated the ability to apply it effectively in real community settings.

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During the mentoring phase, facilitators provided conceptual reinforcement, clarified potential misconceptions, and assisted cadres in solving practical challenges encountered during diabetes education sessions. The mentoring approach adopted a collaborative and dialogic style, promoting a safe learning environment in which cadres felt supported and encouraged to actively engage.

Monitoring was conducted periodically, involving direct observation of cadres' communication practices, documentation of encountered barriers, and provision of real-time constructive feedback. This stage was essential to bridge the gap between theoretical understanding and field implementation, ensuring that cadres consistently adhered to the educational guidelines and communication strategies introduced during the training.

In the performance evaluation phase, cadres' competencies were assessed through multiple dimensions, including technical accuracy in delivering diabetes-related information, communication efficacy, and the ability to establish empathetic connections with community members. The evaluation was carried out using a combination of written assessments, performance-based observation, and reflective self-assessment to capture both cognitive and behavioral aspects of learning.

This cyclical process of mentoring–monitoring–evaluation reflects the essence of CCM, which emphasizes progressive capacity enhancement through the sequence of learning, practicing, reflecting, and improving (learn–act–reflect–refine). By incorporating reflective practice and iterative feedback loops, the intervention not only strengthened technical skills but also fostered affective engagement and long-term commitment of cadres toward sustainable community empowerment.

To align with theoretical recommendations, this approach is in line with Wenger's Communities of Practice theory, which highlights the importance of social learning through participation, feedback, and identity building within a community-based learning system. Thus, the integration of CCM principles with continuous mentoring strategies ensured that learning outcomes were both measurable and transformative.

Data Collection and Analysis

Pre-test was conducted prior to intervention, and post-test was conducted immediately after week 5. Normality testing was assessed using the Shapiro-Wilk. Effectiveness was evaluated using the N-gain formula with the interpretation criteria:<0.3 = low, 0.3–0.7 = moderate, >0.7 = high effectiveness. Effect size (Cohen's d) was calculated to interpret the magnitude of change: 0.2 = small, 0.5 = moderate, >0.8 = large effect. Significance testing (if normal): paired t-test; if non-normal: Wilcoxon signed-rank test

Program Summary

- Coordination with Partners

  The team contacted the Flamboyan Family Integrated Health Post (Posyandu) administrators to follow up on needs and then agreed on a cooperation contract regarding the program's scope.

- Socialization

  Introductions were made to the Posyandu administrators through open communication, explaining the program's objectives, diabetes management solutions, activity stages, and signing of the implementation contract.

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FIGURE 1. Community Service SocializationTraining Three main topics

✓ TPE-AR DM2 Implementation (application introduction, AR features, interactive simulation).

FIGURE 2. TPE-AR DM2 Application Implementation Training

✓ Glucometer Use & Diabetic Foot Exercises (examination SOPs, hands-on practice, foot exercise guide).

| (a) | (b) |

FIGURE 3. (a) Glucometer Use Training for Self-Monitoring Blood Sugar and (b) Diabetic Foot Exercise Training

✓ Psychosocial & Therapeutic Communication (empathetic education, holistic support, evaluation using DMSES and MHLC).

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FIGURE 4. Psychosocial and Therapeutic Communication Training: Building Empathetic Education and Holistic Support for People with Diabetes

- Mentoring & Evaluation

Regular mentoring and evaluation through Focus Group Discussions (FGDs) are conducted to identify successes, challenges, and improvement solutions.

FIGURE 5. Assistance and Evaluation of Family Posyandu Cadres in Implementation to the Community

- Program Sustainability

Posyandu cadres will continue to practice their skills and utilize technology sustainably, supported by advanced training to become independent in managing diabetes mellitus.

RESULTS AND DISCUSSION

RESULTS

A total of 25 Posyandu cadres participated in the intervention, with an average age of 39.4 ± 6.2 years, and 68% had more than three years of involvement in community health activities. Baseline digital literacy assessment indicated that 52% had never previously used AR-based health education tools.

As shown in Figure 6, all independence indicators demonstrated substantial improvement following

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the intervention. Knowledge scores increased from 40.22 (pre-test) to 83.34 (post-test) with an N-gain of 0.72, indicating high effectiveness. The ability to operate the TPE-AR DM2 application improved significantly from 35.96 to 84.72 (N-gain = 0.76). Technical skills—glucometer operation and diabetic foot exercise facilitation—increased from 45.84 to 85.60 (N-gain = 0.73) and 45.84 to 91.60 (N-gain = 0.84), respectively. The largest improvement was observed in movement-based procedural skills, supporting the effectiveness of hands-on digital simulation. Therapeutic communication skills also rose from 32.02 to 82.60, with an N- gain of 0.74.

Although inferential statistical tests such as paired t-tests or Wilcoxon analysis were not applied due to sample size constraints and the quasi-experimental training design, the consistently high N-gain (>0.7 across all domains) indicates clinically meaningful improvement in cadre autonomy and performance. These improvements suggest that the intervention yielded both educational and functional gains in alignment with the CCM principle of informed, activated health teams.
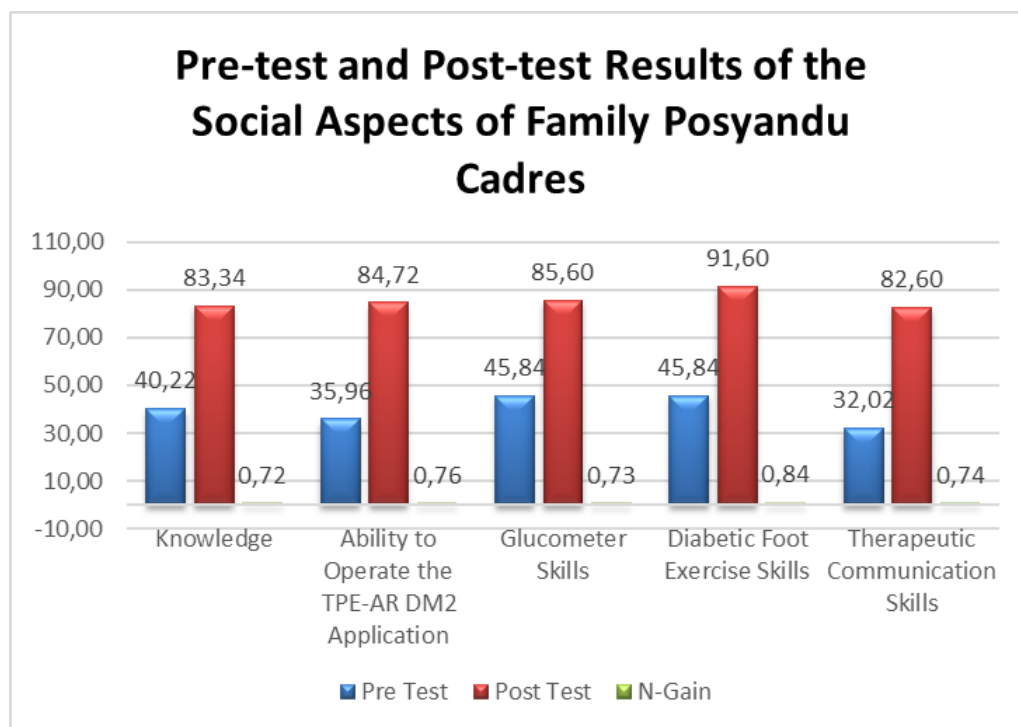

FIGURE 6. Pre-test and Post-test Results of the Social Aspects of Family Posyandu Cadres

DISCUSSION

The findings of this study demonstrate that the integration of TPE-AR DM2 within the Chronic Care Model framework provides a comprehensive and effective educational strategy for empowering Posyandu cadres in diabetes management. The consistent improvement across all measured domains, with N-gain values exceeding 0.7, indicates that the intervention was not only educationally beneficial but also meaningful from a practical and behavioral standpoint.

Interpretation of Knowledge Improvement

The substantial increase in knowledge suggests that cadres were able to internalize core concepts of diabetes management after being exposed to interactive visual learning. Unlike traditional leaflet-based

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health education, which often results in passive absorption, the AR module required cadres to actively explore, point, scan, and respond to digital prompts, increasing cognitive engagement.

According to Mayer's Cognitive Theory of Multimedia Learning, learning is enhanced when instructional media stimulate dual cognitive channels (visual and auditory) through interactive engagement. The AR simulations allowed cadres to manipulate virtual elements in real space, transforming abstract diabetes management protocols into contextualized, action-based learning experiences. This aligns with adult learning theory, which emphasizes experiential, problem-centered learning as more effective than passive instruction for community health workers (Tay et al., 2023). Furthermore, CCM emphasizes empowerment through self-efficacy and informed decision-making. The real-time feedback and immersive practice environment offered by the AR module likely increased cadres' confidence and internal locus of control, supporting previous findings that technology-mediated education increases self-efficacy in chronic disease management training.

Strengthening of Psychosocial and Communication Competencies

The largest gain in diabetic foot exercise skills (N-gain = 0.84) suggests that procedural competencies are best absorbed through kinesthetic, immersive demonstrations rather than theoretical explanations alone. Overall, these findings confirm that TPE-AR DM2 training using the CCM approach not only improves knowledge but also the technical and psychosocial skills of Posyandu cadres. Thus, cadres have a greater capacity to independently support diabetes mellitus patients in the community.

Similar trends are reported by Gierwiało et al., 2019who found that AR-based simulation improved procedural accuracy among nursing trainees. The increase in therapeutic communication (N-gain = 0.74) reflects a psychosocial shift in cadre-patient interaction style, consistent with patient-centered communication frameworks, which emphasize empathy, supportive dialogue, and motivational counseling in chronic care settings (Jiang et al., 2024).

Alignment With Behavioral Change Models

The alignment between the observed outcomes and established behavioral change frameworks further reinforces the effectiveness of the TPE-AR DM2 intervention. According to Bandura's self-efficacy theory, mastery experiences are the most powerful source of self-efficacy, shaping individuals' belief in their capacity to perform health-related tasks effectively. The significant increase in cadres' ability to operate AR applications, conduct glucometer checks, and perform diabetic foot exercises reflects a concrete mastery experience, which likely contributed to an enhanced sense of competence and autonomy in their health advocacy roles. Recent studies have demonstrated that digital health technologies, including AR, not only improve technical skills but also boost user confidence and engagement in health promotion (Ahmed et al., 2022).

Moreover, the shift in cadres' perceived responsibility after training indicates movement toward an internal health locus of control, consistent with the Chronic Care Model's principle of fostering proactive community health agents rather than passive recipients of instructions. A quasi-experimental study found that community health workers who received technology-enhanced training demonstrated sustained behavioral activation and higher adherence to chronic care monitoring protocols. This suggests that the integration of AR technology within a CCM framework does not merely transfer knowledge but facilitates cognitive restructuring, encouraging cadres to view themselves as capable agents of change within their micro-health ecosystems (Panjabi et al., 2021).

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This transformation is essential in the context of chronic disease management at the community level, where long-term adherence and peer influence are critical to patient outcomes. As supported by Kusuma et al. (2025), cadres who possess higher self-efficacy are more likely to initiate empathetic communication, provide consistent follow-up, and influence patient self-management behaviors through social modeling. Thus, the TPE-AR DM2 intervention not only improved technical competencies but also strategically strengthened psychosocial readiness, positioning cadres as effective local opinion leaders in diabetes prevention and control.

Integration with Chronic Care Model Philosophy

Importantly, the structure of the intervention mirrors the iterative learning loop of the CCM, in which education, practice, reflection, and reinforcement occur continuously rather than in isolated sessions. Each AR module was not delivered as a one-time information dump, but rather embedded within a cycle of guided practice, mentoring, monitoring, and feedback, which contributed to deeper behavioral change rather than surface-level knowledge acquisition.

This continuous loop approach is consistent with findings by (Elendu et al., (2024) which highlight that digital simulation-based education combined with repeated reinforcement leads to significantly higher skill retention and health advocacy confidence among non-professional health volunteers compared to one- time training sessions. Furthermore, iterative mentoring and monitoring, as implemented in this study, align with the CCM's principle of "productive interactions" between informed, activated community agents and a prepared health system (Goh et al., 2022).

Not only does it enhance cognitive knowledge, but the AR-based reflective learning cycle also encourages hands-on, experiential learning. Through repeated practice, mentoring, and feedback, cadres no longer act merely as information transmitters but begin to internalize their role as facilitators of behavior change in chronic disease management. This approach fosters a stronger sense of ownership and responsibility for the education process, ensuring that the resulting changes are not merely temporary but have the potential to be sustained in daily community practice (Maria Karolina Selano & Oke Dwi Astuti, 2025).

When linked to the Chronic Care Model (CCM) framework, this process aligns with the components of self- management support and prepared proactive community practice, where cadres are not only equipped with information but also empowered to become active agents capable of independently initiating health interventions. Through interactive AR exposure and an educational cycle continuously reinforced by monitoring and reflection, cadres transition from passive positions to strategic partners in the community healthcare system. Thus, the capacity building that occurs is not only technical but also addresses the psychological and social aspects that are the key foundations for successful community-based chronic disease management according to the CCM (Ansari et al., 2022).

CONCLUSION

This study demonstrates that the integration of Augmented Reality-based Therapeutic Patient Education (TPE-AR DM2) with the Chronic Care Model (CCM) approach is highly effective in enhancing the independence of Posyandu Family cadres in diabetes mellitus management. All measured indicators knowledge, digital application usage, glucometer handling, diabetic foot exercise facilitation, and therapeutic communication skills showed significant improvement, with N-gain values exceeding 0.7, indicating a high level of intervention effectiveness.

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These results confirm that the combination of immersive AR learning media and structured CCM-guided mentoring can strengthen both technical competencies and psychosocial capacities of community health cadres. By improving cadre confidence, digital readiness, and communication ability, this model supports the empowerment of grassroots health workers as key actors in sustainable chronic disease control at the community level.

While promising, this study recognizes certain limitations, including the small sample size, lack of a control group, and limited assessment of long-term retention. Therefore, future studies are recommended to evaluate the scalability, comparative effectiveness with conventional and non-AR digital models, and long- term sustainability of AR-based cadre empowerment programs.

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