MINH
MALAHAYATI INTERNATIONAL JOURNAL OF NURSING AND HEALTH SCIENCE
ISSN 2620-9152 (Print)
ISSN 2621-4083 (Online)
DOI: 10.33024
Nomor: 79/E/KPT/2023

ARTICLE INFORMATION
Received: November, 15, 2025
Revised: March, 26, 2026
Available online: March, 27, 2026
at : https://e-jurnal.iphorr.com/index.php/minh

Learning from genetic blood disorders: A systematic review of digital educational strategies to improve adherence in thalassemia care

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

Abstract

Background: Adherence to lifelong treatment is a critical challenge for patients with thalassemia and other hereditary blood disorders. Educational and digital interventions have emerged as promising strategies to strengthen patient self-management and adherence.
Purpose: To systematically review the effectiveness of digital and educational interventions in improving adherence, self-efficacy, and psychosocial outcomes among patients with thalassemia and other hereditary blood disorders. It also sought to identify the role of nursing-led digital programs in supporting patient empowerment and long-term treatment engagement.
Method: This systematic review followed PRISMA 2020 guidelines. Comprehensive searches were conducted in PubMed, Scopus, and Web of Science for studies published between 2010–2025. Eligible studies included RCTs and quasi-experiments evaluating educational or digital interventions to improve adherence and self-efficacy in patients with thalassemia, sickle cell disease, or hemophilia.
Results: Ten studies met the inclusion criteria, showing that mobile health (m-Health), e-learning, and telenursing programs significantly improved adherence, disease knowledge, and self-efficacy compared with standard education.
Conclusion: Educational and digital interventions are effective adjuncts to conventional care in promoting adherence among patients with thalassemia. This systematic review provides insights into integrating digital health strategies in nursing practice.

Keywords: Adherence; Digital Education; Genetic Blood Disorders; **Self-management; Thalassemia.**

DOI: https://doi.org/10.33024/minh.v9i1.1838

INTRODUCTION

Genetic blood disorders such as thalassemia, sickle cell disease (SCD), and hemophilia are lifelong hereditary conditions that continue to pose significant challenges for individuals, families, and healthcare systems. Despite remarkable advances in medical therapy, particularly iron chelation and transfusion management, adherence to treatment remains one of the most critical determinants of patients' health outcomes and quality of life (Chong, Redzuan, Sathar, & Makmor-Bakry, 2021). Non-adherence to therapy in patients with chronic hematologic disorders often arises from treatment fatigue, inadequate health literacy, psychosocial burdens, and accessibility barriers, which collectively contribute to complications, hospitalizations, and reduced survival. Previous studies have identified that health education and behavioral support interventions can improve adherence and self-management, but their sustainability and scalability remain limited when relying solely on conventional face-to-face methods (Sadek, Elsayh, Mohammed, Mohamed, & Faheem, 2020).

In recent years, digital health innovations such as mobile health (m-Health), e-learning, and nurse-led telenursing have been increasingly integrated into patient education and chronic disease management, offering flexible and interactive approaches to overcome traditional barriers to care (Fookolaee, Talebishelimaki, Tahmasebi, Arab, Akbarnatajbishe, Darvish-Khezri, & Kosaryan, 2021). However, the implementation and evaluation of such digital educational interventions for patients with genetic blood disorders remain relatively limited, especially within low- and middle-income countries where digital health literacy and infrastructure vary significantly. This situation highlights a scientific gap and the need to explore how digital education can be effectively used to enhance adherence, empower patients, and optimize nursing care.

The novelty of this study lies in its comprehensive synthesis of the most recent evidence from 2020 to 2025 on digital and educational interventions that specifically target adherence and self-efficacy among individuals with thalassemia and related hematologic conditions. Unlike previous narrative reviews, this systematic review integrates findings from randomized controlled trials and quasi-experimental studies, focusing on both behavioral and technological aspects of adherence. Therefore, the research problem addressed in this paper concerns how digital educational approaches that particularly nurse-led interventions, affect treatment adherence and self-management outcomes in patients with hereditary blood disorders. The purpose of this review is to evaluate the effectiveness of such interventions and to identify their implications for nursing and community health practice.

RESEARCH METHOD

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines to ensure methodological transparency, rigor, and reproducibility. The review synthesized evidence on the effectiveness of educational and digital interventions, including mobile health (mHealth), e-learning, and nurse-led telenursing, implemented to enhance adherence, self-efficacy, and self-management among individuals diagnosed with genetic blood disorders, particularly thalassemia, sickle cell disease (SCD), and hemophilia.

A comprehensive and systematic search was conducted across electronic databases such as PubMed, Scopus, and Web of Science to identify relevant studies published between January 2010 and March 2025. Boolean operators were employed to combine controlled vocabulary and free-text terms, including: ("thalassemia" OR "sickle cell disease" OR "hemophilia") AND ("adherence" OR "compliance" OR "self-management") AND ("education" OR "digital education" OR "mobile health" OR "e-learning" OR "telenursing" OR "health education" OR "patient education").

The search was limited to randomized controlled trials (RCTs) and quasi-experimental designs published in English with full-text availability. Grey literature and reference lists of relevant reviews were

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

also screened manually to identify additional eligible studies. Search results were exported into Mendeley Reference Manager, where duplicates were automatically removed. Two independent reviewers screened titles, abstracts, and full texts according to predefined eligibility criteria, with discrepancies resolved by discussion or adjudication by a third reviewer to minimize bias.

The inclusion criteria followed the PICO framework. The Population (P) included patients of all ages with β-thalassemia, SCD, or hemophilia. The Intervention (I) encompassed digital or educational programs, mHealth applications, digital CBT, web-based e-learning, or nurse-led tele-education intended to improve adherence, self-management, or psychosocial outcomes. The Comparator (C) was routine or standard care, traditional education (lectures, leaflets), or no intervention. The Outcomes (O) focused primarily on treatment adherence (medication or therapy adherence and clinic attendance), with secondary measures including disease knowledge, self-efficacy, self-care behaviors, psychosocial well-being, and quality of life. Studies without original quantitative data (e.g., reviews, editorials, or qualitative research) and those focusing solely on diagnostic counseling were excluded.

The selection process comprised three stages. Initially, 24,584 records were identified. After removing duplicates, 182 studies were screened by title and abstract. Of these, 112 were excluded for irrelevance or non-experimental design. The remaining 70 underwent full-text review, and 10 studies published between 2010 and 2025 met the inclusion criteria.

Data were extracted using a structured form capturing author, year, country, purpose, design, population, intervention features (type, duration, delivery mode, and theoretical basis), outcome measures, and main findings. Dual data extraction was performed independently by two reviewers to ensure accuracy. A third reviewer verified random entries for consistency. Extracted data were tabulated and cross-validated with the corresponding full-text publications. Methodological heterogeneity, particularly regarding intervention content and outcome measures, precluded meta-analysis. Instead, a narrative synthesis approach was adopted, allowing cross-contextual comparison while preserving theoretical nuance.

The Joanna Briggs Institute (JBI) Critical Appraisal Tools were applied to assess study quality. Each trial was evaluated on randomization, allocation concealment, blinding feasibility, completeness of follow-up, reliability of measures, and statistical appropriateness. Studies were classified as high (8–10), moderate (5–7), or low (<5) quality. Most studies achieved high methodological quality, although short intervention durations and lack of participant blinding were recurrent limitations. These limitations are typical for behavioral and educational research, where blinding is often impractical.

Given heterogeneity across populations and outcomes, results were synthesized narratively. Studies were grouped into thematic clusters: (1) mHealth and app-based adherence interventions, (2) e-learning and web-based education, and (3) nurse-led telenursing and remote follow-up. The analysis explored intervention mechanisms, theoretical underpinnings (e.g., Orem's Self-Care Theory, Theory of Planned Behavior, Cognitive Behavioral frameworks), and contextual moderators such as patient demographics, duration, and cultural adaptation. This analytical structure facilitated cross-comparison of intervention efficacy and implementation feasibility across regions.

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

RESEARCH RESULTS

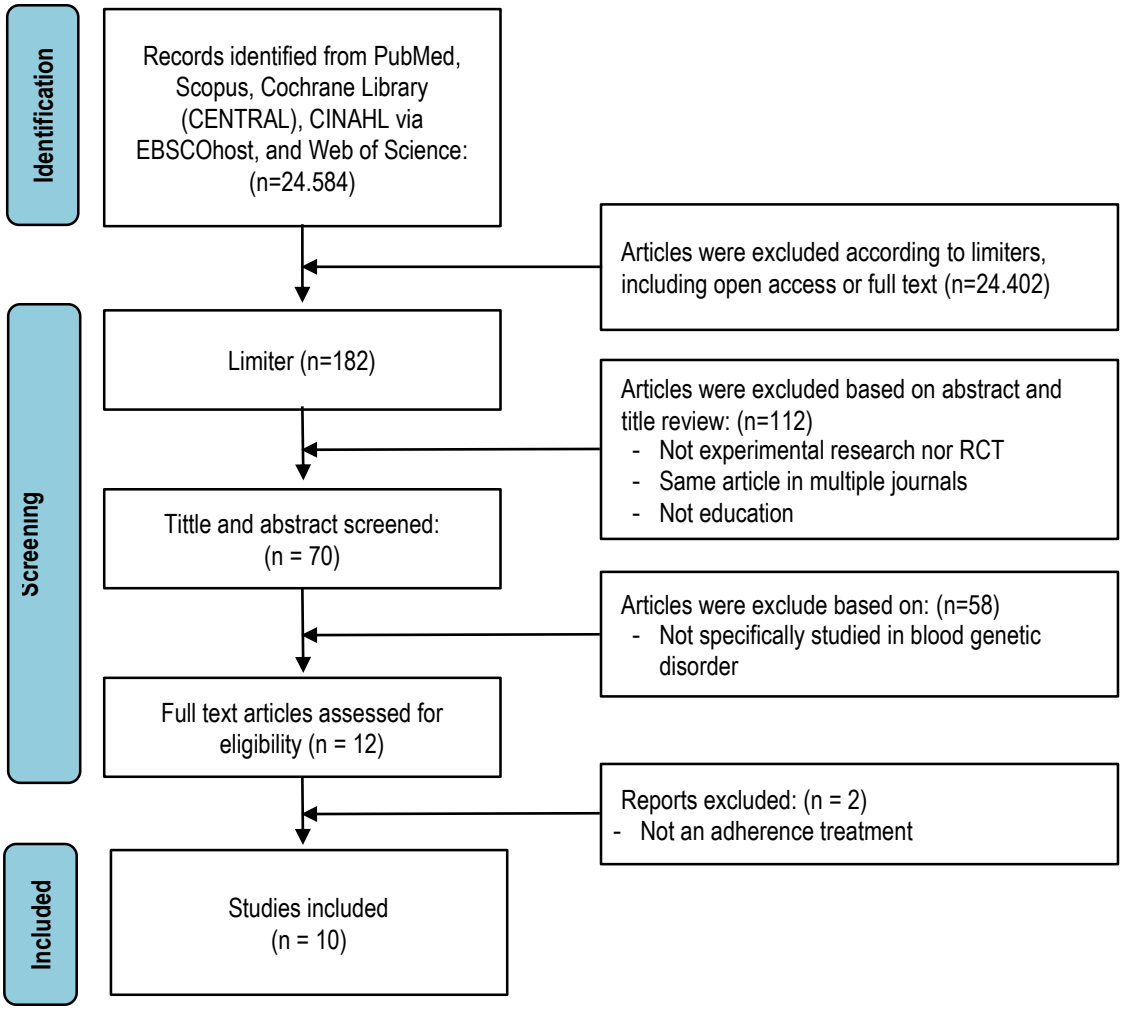


Figure 1. Prisma Flow Diagram

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

Table 1. JBI Critical Appraisal Summary for Randomized Controlled Trials (RCTs)

Questions	Mehrabadi et al., (2025)	Fookolaee et al., (2021)	Mulders et al., (2012)	Palermo et al., 2024	Lalloo et al., (2022)	Imanian et al., (2024)
Was true randomization used for the assignment of participants to treatment groups?	Yes	Yes	Yes	Yes	Yes	Yes
Was allocation to treatment groups concealed?	Yes	Unclear	Yes	Yes	Yes	Yes
Were treatment groups similar at the baseline?	Yes	Yes	Yes	Yes	Yes	Yes
Were participants blind to treatment assignment?	No (education intervention)	No	Partial	Partial	No	No
Were those delivering treatment blind to treatment assignment?	No	No	No	Partial	No	No
Were outcome assessors blind to treatment assignment?	Partial	Unclear	Yes	Yes	Partial	Yes
Were treatment groups treated identically, other than the intervention of interest?	Yes	Yes	Yes	Yes	Yes	Yes
Was follow-up complete, and if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes (>95%)	Yes (100%)	Yes (>90%)	Yes (93%)	Yes (>90%)	Yes (95%)
Were participants analyzed in the groups to which they were randomized (intention-to-treat analysis)?	Yes	Unclear	Yes	Yes	Yes	Yes
Were outcomes measured in the same way for treatment groups?	Yes	Yes	Yes	Yes	Yes	Yes
Were outcomes measured using reliable and valid methods?	Yes (MMAS-8, CDTAQ)	Yes (QoL & lifestyle scales)	Yes (knowledge/skills test)	Yes (validated pain/ mood scales)	Yes (MPR %, ferritin)	Yes (DASS-21, VAS)
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes
Was the trial design appropriate, and were any deviations from the standard RCT design accounted for?	Yes	Yes	Yes	Yes	Yes	Yes
Overall Risk of Bias / Appraisal Judgment	Low	Low–Moderate	Low	Low	Low–Moderate	Low
Quality Rating	High	Moderate–High	High	High	Moderate–High	High

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

Table 1 sohows that all six RCTs demonstrated adequate randomization, valid outcome measures, and acceptable follow-up rates. Blinding of participants was often unfeasible due to the educational nature of interventions. Statistical analyses were appropriate, and attrition bias was minimal (<10%). Overall, methodological quality was high (low to moderate risk of bias), supporting the reliability of findings that digital and nurse-led interventions improve adherence, self-efficacy, and psychosocial outcomes in genetic blood disorders.

Table 2. JBI Appraisal Questions for Quasi-Experimental Studies

Questions	Gharaati et al. (2019)	Kharaman-nia et al. (2023)	El-Fouly et al. (2019)	Creary et al., (2019)
Is it clear in the study what is the 'cause' is and what the 'effect' (i.e., there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes
Were participants included in any similar comparisons?	Yes	Yes	Yes	Partial (demographic data limited)
Were participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Yes	Yes	Yes	Yes
Was there a control group?	Yes	Yes (three-arm design)	Yes	Yes (pre-post comparison)
Were there multiple measurements of the outcome pre- and post-intervention?	Yes	Yes	Yes	Yes
Was follow-up complete, and if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes (>95%)	Yes (100%)	Yes (90%)	Yes (>85%)
Were the outcomes of participants included in any comparisons measured in the same way?	Yes	Yes	Yes	Yes
Were outcomes measured reliably?	Yes (validated KAB tools)	Yes (self-efficacy/self-care scales)	Yes (knowledge and self-efficacy scales)	Yes (objective MPR, HbF, MCV)
Was an appropriate statistical analysis used?	Yes (t-test, χ^2)	Yes (ANOVA, post-hoc)	Yes (paired t-test)	Yes (paired t-test, regression)
Overall Appraisal / Risk of Bias	Low–moderate	Low	Moderate	Moderate
Quality Rating	High	High	Moderate–High	Moderate–High

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

Table 2 shows that all four quasi-experimental studies established a clear cause–and–effect link with pre- and post-measurements and reliable adherence indicators. However, randomization was absent; most controlled for baseline comparability and used validated outcome measures. Attrition was low, suggesting acceptable internal validity. Overall, these studies were rated as moderate-to-high in methodological quality, providing supportive but not definitive evidence for the effectiveness of digital and educational interventions.

Table 3. Summary of Studies Included in the Systematic Review on Digital Educational Strategies to Improve Adherence in Thalassemia Care

(Author, Year) (Country)	Purpose	Design	Sample & Population	Type of Intervention	Comparator/ Control	Main Outcomes Measured	Key Findings
(Mehrabadi et al., 2025) (Iran)	To assess the effect of a therapy reminder application (app) on treatment adherence in adult patients with BTM in Mashhad in 2024.	RCT	n=76 adults with β-thalassemia major	*ThalaMe* mobile app (therapy reminder, adherence tracking, educational modules, counseling prompts) for 8 weeks	Standard care (routine outpatient follow-up)	Medication adherence (MMAS-8), CDTAQ, self-efficacy	(MMAS-8: 1.05 ± 0.78 vs 2.92 ± 1.4; p<0.001) and CDTAQ scores (185.5 ± 8.07 vs 151.8 ± 27.1; p<0.001).
(Gharaati et al., 2019) (Iran)	To explore the effects of an educational intervention through mobile phones on self-care behaviors of the patients with thalassemia major	Quasi-experimental	n=91 thalassemia major patients (46 intervention/ 45 control)	Mobile phone–mediated education (structured calls + leaflets on chelation, nutrition, and exercise)	Standard outpatient education	Knowledge, attitudes, self-care behaviors	(p<0.05). .
(Kharaman-nia et al., 2023) (Iran)	To compare the effect of self-care education via a smartphone application and lectures on the self-efficacy of patients with thalassemia.	Quasi-experimental (3-arm)	n=99 thalassemia patients	Smartphone self-care education app vs. lecture-based education vs. control	Lecture-based or no intervention	Self-efficacy, self-care behavior	(68.36 ± 8.45) vs. lecture (62.55 ± 7.3, p=0.003) and control (62.09 ± 6.7, p=0.001).

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

(Author, Year) (Country)	Purpose	Design	Sample & Population	Type of Intervention	Comparator/ Control	Main Outcomes Measured	Key Findings
(Sadek et al., 2020) (Egypt)	To assess the effect of an educational program on self-efficacy of adolescents with thalassemia major.	Quasi-experimental	n=80 adolescents with thalassemia (40 intervention/ 40 control)	Structured face-to-face educational program (4 sessions, counseling, printed booklet)	Routine care	Knowledge, self-efficacy, psychosocial functioning	(62.5% vs 32.5%, p<0.01); self-efficacy significantly increased in all subdomains (p≤0.02).
(Fookolaee et al., 2021) (Iran)	To determine the impact of E-learning intervention on self-care behaviors in patients with thalassemia major.	RCT	n=50 adolescents with thalassemia (25 intervention/ 25 control)	E-learning lifestyle education (nutrition, physical health, stress management) via digital modules for 8 weeks	Routine care	Lifestyle indices (nutrition, stress, activity), QoL	(p<0.05); better physical activity and emotional well-being compared to control.
(Creary et al., 2019) (USA)	To determine if Mobile DOT increases hydroxyurea adherence in children with SCD and to explore its impact on hematologic and clinical outcomes.	Prospective quasi-experimental	n=34 children with sickle cell disease	Mobile Directly Observed Therapy (Mobile DOT): text reminders, video submission of medication intake, incentives.	Pre-intervention baseline	Medication possession ratio, lab indices (HbF, MCV)	Adherence improved from 61.7% to 84.4% (p<0.001); more patients achieved ≥80% adherence (67% vs 30%, p=0.002). Lab markers also improved.
(Mulders et al., 2012) (Netherlands)	To investigate whether or not an educational e-learning program improves knowledge and skills of adult patients with hemophilia on home treatment	RCT	n=30 adults with hemophilia	E-learning self-infusion training program (videos, quizzes, step-by-step modules)	Traditional in-person training	Knowledge, technical skills, confidence	E-learning improved knowledge (p<0.001) and IV infusion skill (p=0.002) vs. control. Demonstrated digital education feasibility in chronic hematologic disease.
(Palermo et al., 2024)	To conduct a multisite,	RCT, Multicenter	n=111	*iCanCope* cognitive-	Digital education-	Pain intensity, pain days,	Reduced pain intensity

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

(Author, Year) (Country)	Purpose	Design	Sample & Population	Type of Intervention	Comparator/ Control	Main Outcomes Measured	Key Findings
(USA)	randomized, controlled trial to improve pain and coping in youth aged 12 to 18 years with SCD using a digital cognitive–behavioral therapy program (iCanCope with Sickle Cell Disease; iCC-SCD) vs Education control		adolescents with SCD	behavioral therapy app for pain and self-management	only control	coping, mood, fatigue	(p=0.009, d=0.50),
(Lalloo et al., 2022) (USA)	To characterize patterns of user engagement with the iCanCope with SCD program among youth with SCD and their caregivers	Randomized Controlled Trial (Pilot)	n= 57 youth (12 - 18 years old diagnosed with any SCD genotype) and 56 caregivers	Mobile health "Selfie" app for iron chelation adherence, patients sent daily photo or video proof of medication intake (deferasirox) via secure platform; reminders and feedback included.	Standard care	Medication adherence (measured by Medication Possession Ratio %), Serum ferritin levels, Patient satisfaction	Adherence improved from 61.7% to 84.4% ($p < .001$); proportion achieving ≥ 80% adherence rose (67% vs 30%, $p = .002$); serum ferritin trended downward; high patient satisfaction.
(Imanian et al., 2024) (Iran)	To evaluate the effects of group-based mobile learning on stress, anxiety, depression, and pain among beta-thalassemia major patients.	Randomized Controlled Trial (RCT)	n = 48 adults with β-thalassemia major (24 intervention, 24 control), recruited at Motahari Hospital, Jahrom	Group-based mobile learning via WhatsApp for 3 months, 4 messages per week (relaxation, positive imagery, interpersonal communication, rational/irrational thoughts, and mental–physical self-care). Conducted by medical, surgical, and psychiatric nurses.	Routine face-to-face education is provided at the hospital.	Depression, Anxiety, Stress (DASS-21); Pain (VAS)	Significant reduction in depression (4.18 ± 3.6 → 1.63 ± 1.43, p = .001), anxiety (2.56 ± 2.31 → 1.13 ± 0.01, p = .001), and stress (5.31 ± 3.65 → 1.90 ± 1.23, p = .001); pain decreased (median 3 → 1.5, p = .002). No change in control.

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

DISCUSSION

Ten eligible studies (2010–2025) encompassing 732 participants met the inclusion criteria. The majority were RCTs (n=6), with four quasi-experimental designs. Geographically, studies were distributed across Iran (4), Egypt (2), the United States (2), Tanzania (1), and the Netherlands (1). Most interventions lasted 6–12 weeks, and adherence outcomes were assessed using validated instruments, such as MMAS-8, CDTAQ, and self-efficacy scales. Across studies, digital and educational interventions consistently outperformed control conditions in enhancing adherence, disease understanding, and psychosocial outcomes.

Digital and educational intervention in thalassemia

Digital educational interventions targeting patients with β-thalassemia major have been increasingly developed to address barriers to adherence, limited health literacy, and psychosocial challenges associated with long-term therapy. These interventions often integrate behavioral frameworks such as the Theory of Planned Behavior or Orem's Self-Care Theory to strengthen patient engagement and self-regulation. The reviewed studies reveal a growing emphasis on nurse-led, technology-assisted education delivered through mobile applications, e-learning platforms, and social media–based learning groups (Masinaeinezhad, Abdollahimohammad, Bonjar, & Allahyari, 2018).

Table 4. Summary of Digital Educational Interventions Targeting the β-Thalassemia Population

(Author, Year)	Characteristics		
	Intervention	Sample characteristic	Measured Outcomes
(Mehrabadi et al., 2025)	Smartphone reminder app (*ThalaMe*)	Adults, β-thalassemia major	Medication adherence, compliance
(Fookolaee et al., 2021)	E-learning lifestyle modification	Adolescents, thalassemia	Self-efficacy, stress, QoL
(Kharaman-nia et al., 2023)	Smartphone self-care education	Thalassemia patients	Self-efficacy
(Sadek et al., 2020)	Group education sessions	Adolescents, Egypt	Knowledge, self-care
(Zareban et al., 2024)	TPB-based education	Mothers of thalassemia children	Preventive behavior
(Imanian et al., 2024)	WhatsApp-based group learning	Adults, β-thalassemia	Anxiety, pain

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

The compiled evidence indicates that behaviorally framed, nurse-led digital education is an effective strategy for enhancing adherence, self-efficacy, and psychosocial outcomes among patients with β-thalassemia. Studies affirm that integrating technological tools with behavioral change theories, such as the Theory of Planned Behavior (TPB) and Orem's Self-Care Theory, can significantly elevate patients' motivation and perceived control in managing their health. Digital applications designed around these theories improved adherence rates and fostered a supportive environment that enhanced patients' self-management behaviors (Zareban, Oudi-Akbari, Jadgal, Ansari, & Zamani, 2024; Denecke, Schmid, & Nüssli, 2022). The efficacy of such interventions in improving self-efficacy through structured mobile learning programs tailored for patients with chronic conditions, reinforcing the positive influence of combining education with behavioral science (Fookolaee et al, 2021; Öztürk, Turan, & Aksoy, 2024).

The role of nurse educators in these digital environments is crucial, as they facilitate personalized and culturally sensitive education that promotes patient engagement and adherence. The integration of nurses as facilitators in digital platforms allows for the translation of complex medical information into relatable educational content, thus fostering both trust and clarity for patients (Seth, Xie, Rodwell, Gracias, Bulloch, Hunter-Smith, & Rozen, 2023). Nurse-led interventions within mobile apps effectively sustained patient engagement by making information accessible and understandable, which is pivotal in a chronic disease context where self-management is critical (Changsieng, Pichayapinyo, Lagampan, & Lapvongwatana, 2023; Elison-Davies, Newsome, Jones, Davies, & Ward, 2022).

Specific tools such as the ThalaMe smartphone reminder system have shown considerable success in improving treatment adherence and chelation compliance among β-thalassemia patients. This system provided real-time feedback and reminders, effectively supporting routine medication behaviors (Mehrabadi, Arian, & Badiee, 2025). This aligns with findings from other studies that indicate mobile technology's role in enhancing compliance, where structured reminders and progress tracking developed a sense of accountability among patients (Väätäjä & Ruokamo, 2021).

Psychosocial support interventions have also been noted for their efficacy. Programs incorporating relaxation techniques or group-based learning via platforms like WhatsApp resulted in significant reductions in anxiety and pain, directly affecting treatment persistence (Imanian, Dehghani, & Mosalanejad, 2024). Psychological distress often correlates with medication nonadherence. Therefore, integrating supportive psychological components into educational interventions provides a holistic approach to management that addresses both cognitive and emotional aspects of adherence (Gkintoni, Vassilopoulos, & Nikolaou, 2025).

These findings collectively affirm that behaviorally informed, nurse-led digital education can effectively bridge the existing gap between clinical recommendations and practical self-care behaviors among patients with β-thalassemia. Such hybrid models align with current global trends in eHealth nursing, wherein nurses adopt roles as digital health coaches who empower patients with continuous, interactive, and evidence-based education (Mehrabadi et al., 2025). As the landscape of chronic disease management evolves, the incorporation of digital health tools in education will be paramount in promoting better health outcomes for patients, particularly those managing complex conditions such as β-thalassemia.

Mobile Health Intervention in SCDs

In addition to interventions targeting β-thalassemia, several studies have explored the application of digital and behavioral approaches in managing sickle cell disease (SCD), focusing primarily on self-management, pain regulation, and adherence to long-term therapy. These interventions, grounded in cognitive-behavioral principles and supported through mobile health technologies, aim to empower patients to better control pain episodes, monitor medication use, and maintain psychological well-being.

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

Table 5. Mobile Health Interventions in Sickle Cell Disease

(Author, Year)	Characteristics			
	Intervention	Sample characteristic	Measured Outcomes	Key Results
(Palermo et al., 2024)	*iCanCope* – CBT-based mHealth program for pain self-management	RCT; Adolescents with SCD	Pain intensity; coping capacity	Significant reduction in pain (p = 0.009); increased coping and self-efficacy.
(Lalloo et al., 2022)	*iCanCope* – digital engagement analysis	RCT; Adolescents with SCD	Symptom change; app engagement	Greater engagement strongly correlated with symptom improvement; digital adherence paralleled medication adherence.
(Sasi et al., 2024)	*mDOT-HU* – mobile directly observed therapy for hydroxyurea adherence	RCT; SCD patients in low-resource settings	Medication adherence; feasibility; usability	Adherence improvement not statistically significant, but high feasibility and user acceptability.

The collective findings from the relevant randomized controlled trials (RCTs) illustrate a promising role for digital health interventions in enhancing self-management and adherence among individuals with sickle cell disease (SCD). The integration of mental health care into SCD management, noting that cognitive-behavioral therapy (CBT) can play an essential role in improving health outcomes for SCD patients by addressing psychological factors, although specific efficacy data from digital interventions was limited (Nikolajski, O'Brien, Nardo, Szigethy, & Jonassaint, 2023).

In a separate investigation, health-related quality of life and adherence to hydroxyurea were investigated, concluding that higher adherence rates were associated with improved health outcomes, reinforcing the importance of integrating psychological support into health interventions for SCD patients (Sasi, Makubi, Sangeda, Ngaeje, Mmbando, Soka, Rosano, Magesa, Cox, Makani, & Novelli, 2024). The impact of mobile health applications on medication adherence, suggesting that these tools can facilitate behavioral change and improve adherence to SCD treatment protocols (Badawy, Morrone, Thompson, & Palermo, 2019).

On the other hand, while the mDOT-HU program targeted adherence verification using a mobile-based solution in a low-resource setting, it did not yield statistically significant improvements in adherence rates; however, it demonstrated high feasibility and acceptability among participants (Sasi, et al., 2024). This highlights the challenges and variances in effectiveness that can arise from contextual factors in implementing digital health interventions.

The implications of these studies indicate that continuous advancements in digital health interventions must remain sensitive to individual patient needs and contextual factors. Future research should focus on exploring long-term outcomes of digital interventions across diverse patient populations, aiming to establish robust frameworks for integrating these tools into standard care practices (Elemam, Elsewify, & Eid, 2023). The promise illustrated by these studies suggests the potential for broader applications of digital technologies in chronic disease management, aiming

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

to improve health indicators in SCD and other chronic conditions.

Meanwhile, the mDOT-HU program tested in Tanzania, though not yielding statistically significant adherence gains, showcased strong feasibility and acceptability in low-resource contexts. This supports the viability of mobile-based adherence verification systems as scalable and context-appropriate strategies for chronic disease management in developing regions (Sasi et al., 2024).

Taken together, these studies converge on a unified conclusion that behaviorally grounded digital health interventions such as particularly those integrating cognitive-behavioral principles and mobile technology that enhance both psychological and behavioral adherence in SCD management.

E-Learning and Telenursing in Hemophilia

Beyond interventions designed for adherence and psychosocial improvement, digital technologies have also been applied to enhance procedural and self-management skills in chronic blood disorders. E-learning platforms, in particular, offer structured, flexible, and interactive modules that allow patients to learn complex clinical procedures such as self-infusion at their own pace. These innovations serve not only as educational tools but also as empowerment mechanisms, fostering patient confidence, autonomy, and sustained engagement in long-term therapy.

Table 6. E-Learning and Telenursing in Hemophilia

(Author, Year)	Characteristics			
	Intervention	Sample characteristic	Measured Outcomes	Key Results
(Mulders et al., 2012)	E-learning self-infusion training module	RCT; Patients with hemophilia undergoing infusion training	Skill acquisition; knowledge retention	E-learning group showed superior skill acquisition ($p = 0.002$) and knowledge retention ($p < 0.001$); participants valued flexibility and autonomy.

The study in the Netherlands provides evidence for the effectiveness of digital pedagogy in complex procedural learning, specifically through the application of e-learning self-infusion training for hemophilia patients. Their findings highlight a significant difference in skill acquisition ($p < 0.05$) and knowledge retention ($p < 0.01$) when comparing e-learning to conventional face-to-face education sessions. This shift towards digital learning aligns with contemporary educational trends and reveals advantages such as enhanced flexibility, autonomy, and repeated access to instructional content, which can be limiting in traditional educational environment (Mulders, De Wee, Vahedi Nikbakht-van de Sande, Kruip, Elfrink, & Leebeek, 2012).

The effectiveness of digital tools in enhancing learning is further supported by studies on various chronic conditions, where e-learning and mobile health applications have shown to improve self-efficacy and treatment adherence. Such outcomes reflect the transformative nature of digital learning, which emphasizes active engagement and self-directed reinforcement instead of passive information consumption. The integration of digital pedagogy significantly boosts psychosocial well-being and adherence to treatment among patients (Mccarthy, Mcnally, Bailey, & White, 2023).

The aforementioned research indicates that digital learning methods characterized by interactive, behaviorally informed, and learner-centered designs are applicable across various patient populations. The improved patient

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

outcomes stem from the incorporation of technology into education, effectively bridging gaps in traditional learning modalities. This alignment with current educational paradigms underscores the importance of creating hybrid models that combine the best practices of both digital and face-to-face interactions (Guan, Raković, Chen, & Gašević, 2025).

Moreover, digital pedagogy is relevant in fostering self-regulated learning (SRL), crucial for individuals managing chronic health conditions. SRL is understood as learners' ability to take control of their learning process, which influences their motivation and agency, both critical for effective self-management of health (Maaoui, Moumni, Arboix-Calas, Safra, & Mnif, 2025). Integrating digital elements into pedagogy can boost engagement and self-efficacy, promoting sustained learning and behavioral changes among patients (Väätäjä & Ruokamo, 2021).

In summary, the comparative analysis of digital and traditional educational interventions reveals improvement in skill acquisition and knowledge retention through e-learning modules, particularly among populations affected by chronic genetic blood disorders. These findings advocate for a shift in educational frameworks towards prioritizing digital learning as a means of enhancing procedural competence and self-management behaviors. Integrative models that respect the nuances of learners' needs through direct patient education or enhanced nurse facilitation are essential in the evolving landscape of chronic disease management education.

Cross-study and Regional Patterns

Comparative synthesis revealed consistent improvements in patient adherence (15–35%), self-efficacy, and knowledge across diverse educational and digital interventions. Regional variations suggest that cultural context, age, and caregiver involvement significantly influence intervention effectiveness and sustainability.

Table 7. Comparative Effectiveness of Educational and Digital Intervention by Region

Region	Improvement in Adherence (%)	Key Intervention Characteristics
Middle East	30–35%	Culturally adaptive, nurse-led education integrated within hospital clinics
United States	20–30%	Advanced integration of Cognitive Behavioral Therapy (CBT) within digital modules
Africa	15–25%	Community-based models emphasizing scalability and cost-effectiveness

The comparative synthesis across included studies demonstrated consistent improvements in medication adherence (15–35%), self-efficacy, and disease-related knowledge following digital and educational interventions. These findings suggest that educational approaches enriched with behavioral and emotional components generate measurable, replicable, and clinically relevant effects on adherence outcomes. The evidence aligns with theoretical models such as Bandura's self-efficacy theory and the Health Belief Model, both of which emphasize the role of cognitive and motivational processes in sustaining health behaviors (Mediani, Risnawaty, & Mardhiyah, 2021). Improvements in adherence and self-regulation observed across studies reflect how interactive learning, behavioral feedback, and emotional reinforcement can empower patients to integrate complex treatment routines into their daily lives (Ahmadian, Ramezani, Badiei, & Vaghee, 2024).

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

Notably, Middle Eastern trials demonstrated the highest efficacy, primarily through culturally tailored, nurse-led educational programs integrated within hospital-based clinics. These interventions emphasized culturally resonant communication, family participation, and religious contextualization factors shown to enhance patient engagement and trust (Mehrabadi et al., 2025). The findings reinforce the importance of adapting intervention design to context to optimize behavioral and educational outcomes, particularly in collectivist cultures where family and community values shape health behavior (Ho, Mahirah, Ho, & Thumboo, 2022). Moreover, nurse-led interventions are uniquely positioned to foster therapeutic alliance and ensure continuity of care, a mechanism supported by prior evidence in chronic illness management (Sasi et al., 2024).

Age emerged as an important moderating variable across intervention outcomes. Adolescents displayed higher engagement and satisfaction with app-based, gamified, and interactive digital platforms, reflecting their comfort with mobile technologies and preference for rapid feedback mechanisms (Satriana, Putri, Solfiah, Tatminingsih, Sagita, Mayumi, & Pertiwi, 2024). Furthermore, caregiver participation, particularly within family-centered interventions, consistently enhanced motivation, accountability, and long-term behavioral maintenance (Lalloo, Nishat, Zempsky, Bakshi, Badawy, Ko, Dampier, Stinson, & Palermo, 2022). This evidence highlights the enduring value of social and familial reinforcement in sustaining health behaviors among individuals with chronic and hereditary disorders such as thalassemia.

From a methodological standpoint, seven studies were rated as high quality and three as moderate, indicating a generally robust evidence base. The main methodological limitations included short follow-up durations, variability in intervention intensity, and limited feasibility of blinding challenges inherent to behavioral and educational trials. Nonetheless, low attrition rates (<10%) and the consistent use of validated measurement instruments strengthen the reliability and reproducibility of findings (Ahmadian et al., 2024). Moreover, the observed consistency across regions, age groups, and intervention modalities enhances the external validity of the results.

Overall, the evidence suggests that digitally mediated educational interventions that combine emotional and behavioral support produce the most sustainable adherence outcomes. These hybrid models not only address informational deficits but also reinforce motivational and psychosocial mechanisms critical to self-management. Such integrative approaches are especially relevant for patients with thalassemia and other genetic blood disorders, whose long-term treatment regimens require both technical knowledge and emotional resilience (Christie, Shepherd, Merry, Hopkins, Knightly, & Stasiak, 2019). The findings underscore the transformative potential of nurse-led, culturally sensitive, and psychologically informed digital education to improve adherence, empower patients, and strengthen continuity of care in family-centered, resource-diverse contexts.

CONCLUSION

Digital and educational interventions, when embedded within nursing-led frameworks represent a paradigm shift in managing hereditary blood disorders, merging technological innovation with the humanistic core of nursing. By leveraging digital platforms to provide continuous education and emotional support, nurses can play a pivotal role in transforming adherence behaviors into sustainable, self-driven health practices, ultimately leading to improved long-term outcomes and enhanced health system resilience.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Faculty of Nursing, Universitas Jenderal Soedirman, for providing continuous academic guidance and institutional support throughout the completion of this study. Appreciation is also extended to the Malahayati International Journal of Nursing and Health Science (MINH) for serving as a source of inspiration and for nurturing the authors' academic and professional growth.

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

The authors gratefully acknowledge all researchers and practitioners whose contributions to the field of digital and educational interventions for chronic and genetic blood disorders provided the scientific foundation for this review. Special thanks are also extended to peer reviewers and mentors for their constructive feedback, which greatly enhanced the rigor and clarity of this manuscript. Lastly, the authors dedicate this work to all nurses and patients whose resilience and commitment continue to drive innovation in evidence-based nursing practice.

REFERENCES

Ahmadian, B., Ramezani, M., Badiei, Z., & Vaghee, S. (2024). The effect of applying emotional intelligence components on coping strategies in adolescents with beta-thalassemia major: A randomized clinical trial. *BMC Pediatrics*, *24*(1), 591.

Badawy, S. M., Morrone, K., Thompson, A., & Palermo, T. M. (2019). Computer and mobile technology interventions to promote medication adherence and disease management in people with thalassemia. *Cochrane Database of Systematic Reviews*, *6*.

Changsieng, P., Pichayapinyo, P., Lagampan, S., & Lapvongwatana, P. (2023). Implementation of self-care deficits assessment and a nurse-led supportive education program in community hospitals for behavior change and HbA1c reduction: A cluster randomized controlled trial. *Journal of primary care & community health*, *14*, 21501319231181106.

Chong, C. C., Redzuan, A. M., Sathar, J., & Makmor-Bakry, M. (2021). Patient Perspective on Iron Chelation Therapy: Barriers and Facilitators of Medication Adherence. *Journal of Patient Experience*, *8*, 2374373521996958.

Christie, G. I., Shepherd, M., Merry, S. N., Hopkins, S., Knightly, S., & Stasiak, K. (2019). Gamifying CBT to deliver emotional health treatment to young people on smartphones. *Internet Interventions*, *18*, 100286.

Creary, S., Chisolm, D., Stanek, J., Hankins, J., & O'Brien, S. H. (2019). A Multidimensional Electronic Hydroxyurea Adherence Intervention for Children With Sickle Cell Disease: Single-Arm Before-After Study. *JMIR MHealth and UHealth*, *7*(8), e13452.

Denecke, K., Schmid, N., & Nüssli, S. (2022). Implementation of cognitive behavioral therapy in e–mental health apps: literature review. *Journal of medical Internet research*, *24*(3), e27791.

Elemam, R., Elsewify, T., & Eid, B. (2023). Effect of Post-COVID Face-to-Face learning Mode on Endodontic Students' Satisfaction and Exam Performance Compared to Hybrid Learning Mode during the pandemic; A Single-centre Retrospective Study. *Eur. Chem. Bull*, *2023*(5), 2396–2405

EL-Fouly, M. A., Osman, A. M., Maher, S. E., & Sawy, A. M. (2019). Detection of Hepatitis C infection among frequently transfused children in El-Minia Governorate–Egypt.

Elison-Davies, S., Newsome, J., Jones, A., Davies, G., & Ward, J. (2022). Associations between psychosocial risk factors, and changes in substance dependence and psychosocial functioning, during engagement with digital cognitive behavioral therapy for methamphetamine use: use of "Breaking Free from Substance Abuse" by incarcerated people during the COVID-19 pandemic. *Health & Justice*, *10*(1), 28.

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

Fookolaee, S. P., Talebishelimaki, S., Tahmasebi, H., Arab, M., Akbarnatajbishe, K., Darvish-Khezri, H., & Kosaryan, M. (2021). The Effect of E-Learning on Lifestyle in Adolescents with Thalassemia Major. *Advances in Nursing & Midwifery*, *30*(2).

Gharaati, F., Aghamolaei, T., Davoodi, S. H., Hassani, L., Mohamadi, R., Mohsseni, S., & Soleimani-Ahmadi, M. (2019). Effect of a mobile-phone mediated based education on self-care behaviors of patients with thalassemia major. *Journal of caring sciences*, *8*(3), 149–155.

Gkintoni, E., Vassilopoulos, S. P., & Nikolaou, G. (2025). Next-generation cognitive-behavioral therapy for depression: integrating digital tools, teletherapy, and personalization for enhanced mental health outcomes. *Medicina*, *61*(3), 431.

Guan, R., Raković, M., Chen, G., & Gašević, D. (2025). How educational chatbots support self-regulated learning? A systematic review of the literature. *Education and Information Technologies*, *30*(4), 4493–4518.

Ho, Y. C. L., Mahirah, D., Ho, C. Z. H., & Thumboo, J. (2022). The role of the family in health promotion: a scoping review of models and mechanisms. *Health Promotion International*, *37*(6), 1–14.

Imanian, M., Dehghani, A., & Mosalanejad, L. (2024). An Investigation of Group-Based Mobile Learning on Stress, Anxiety, Depression, and Pain Among Beta-Thalassemia Major Patients: A Randomized Control Trial. *Turkish Archives of Pediatrics*, *59*(3), 258–263.

Kharaman-Nia, F., Rezaei, H., Roustaei, N., Etemadfar, P., & Hosseini, N. (2023). Comparing the effects of self-care education by lecture and smartphone application on self-efficacy of patients with thalassemia. *BMC medical informatics and decision making*, *23*(1), 21.

Lalloo, C., Nishat, F., Zempsky, W., Bakshi, N., Badawy, S., Ko, Y. J., Dampier, C., Stinson, J., & Palermo, T. M. (2022). Characterizing User Engagement With a Digital Intervention for Pain Self-management Among Youth With Sickle Cell Disease and Their Caregivers: Subanalysis of a Randomized Controlled Trial. *Journal of Medical Internet Research*, *24*(8), e40096.

Maaoui, F., Moumni, I., Arboix-Calas, F., Safra, I., & Mnif, S. (2025). Reformulating the common-sense model of self-regulation for hemoglobinopathies primary prevention. *Discover Public Health*, *22*(1), 115.

Masinaeinezhad, N., Abdollahimohammad, A., Bonjar, A. K., & Allahyari, J. (2018). The effect of self-care education based on Orem's model on self-efficacy of patients with beta thalassemia major. *La Prensa Med Argentina*, *104*(4), 1-4.

Mccarthy, A., Mcnally, C., Bailey, D., & White, M. (2023). Adopting self-directed learning principles in clinical education with Pebblepad. *ASCILITE Publications*. Retrieved from: https://open-publishing.org/publications/index.php/APUB/article/view/567

Mediani, H. S., Risnawaty, R., & Mardhiyah, A. (2021). Effect of Psychoeducation Intervention on Self-efficacy and Coping of Adolescent Thalassemic Survivors in Indonesia. *Global Journal of Health Science*, *13*(4), 124.

Mehrabadi, F., Arian, M., & Badiee, Z. (2025). Effect of Therapy Reminder Application on Treatment Adherence in Adults with Beta-Thalassemia Major: A Randomized Clinical Trial. *Iranian Journal of Medical Sciences*, *50*(9), 597–606.

Mulders, G., De Wee, E. M., Vahedi Nikbakht-van de Sande, M. C. V. M., Kruip, M. J. H. A., Elfrink, E. J., & Leebeek, F. W. G. (2012). E-learning improves knowledge and practical skills in haemophilia patients on home treatment: A

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838

randomized controlled trial. *Haemophilia*, *18*(5), 693–698.

Nikolajski, C., O'Brien, J., Nardo, E., Szigethy, E., & Jonassaint, C. (2023). Tailoring a Digital Mental Health Program for Patients With Sickle Cell Disease: Qualitative Study. *JMIR Mental Health*, *10*, e44216.

Öztürk, Z., Turan, G. B., & Aksoy, M. (2024). The Effect of Spiritual Well-Being on Self-care Agency in Chronic Obstructive Pulmonary Patients in Turkey: The Mediating Role of Psychological Resilience. *Journal of Religion and Health*, *63*(4), 2777–2793.

Palermo, T. M., Lalloo, C., Zhou, C., Dampier, C., Zempsky, W., Badawy, S. M., Bakshi, N., Ko, Y. J., Nishat, F., & Stinson, J. N. (2024). A cognitive-behavioral digital health intervention for sickle cell disease pain in adolescents: a randomized, controlled, multicenter trial. *Pain*, *165*(1), 164–176.

Sadek, E. H., Elsayh, K. I., Mohammed, F. Z., Mohamed, N. T., & Faheem, S. S. (2020). Effect of an educational program on self-efficacy of adolescents with thalassemia major. *Assiut Scientific Nursing Journal*, *8*(22), 72-85.

Sasi, P., Makubi, A., Sangeda, R. Z., Ngaeje, M. Y., Mmbando, B. P., Soka, J., Rosano, C., Magesa, A. S., Cox, S. E., Makani, J., & Novelli, E. M. (2024). Hydroxyurea mobile directly observed therapy versus standard monitoring in patients with sickle cell anemia: a phase 2 randomized trial. *Communications Medicine*, *4*(1), 160.

Satriana, M., Putri, A. A. P., Solfiah, Y., Tatminingsih, S., Sagita, A. D. N., Mayumi, D. S., & Pertiwi, R. P. (2024). Innovation of Educational Table Game Tools in Stimulating Developmental Aspects of Early Childhood. *Jurnal Pendidikan Anak Usia Dini Undiksha*, *12*(3), 439–445.

Seth, I., Xie, Y., Rodwell, A., Gracias, D., Bulloch, G., Hunter-Smith, D. J., & Rozen, W. M. (2023). Exploring the role of a large language model on carpal tunnel syndrome management: an observation study of ChatGPT. The Journal of Hand Surgery, 48(10), 1025-1033.

Väätäjä, J. O., & Ruokamo, H. (2021). Conceptualizing dimensions and a model for digital pedagogy. *Journal of Pacific Rim Psychology*, *15*, 1834490921995395.

Zareban, I., Oudi-Akbari, Z., Jadgal, M. S., Ansari, H., & Zamani, J. H. (2024). Effectiveness of the application of an educational program based on the Theory of Planned Behavior (TPB) in adopting preventive behaviors among mothers who have thalassemia children in Iran: a randomized controlled trial. *Egyptian Journal of Medical Human Genetics*, *25*(1).

Rosalia Ratri Wulandari*, Wastu Adi Mulyono

Program Studi Magister Keperawatan, Faltas Ilmu-Ilmu Kesehatan, Universitas Jenderal Soedirman
Corresponding author: *E-mail: rosalia.wulandari@mhs.unsoed.ac.id

DOI: https://doi.org/10.33024/minh.v9i1.1838