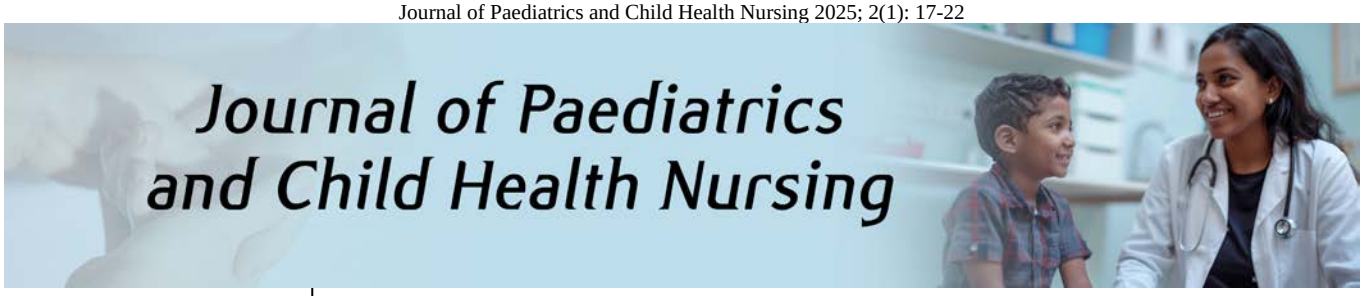

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Dr. Emily Wong
Department of Paediatrics and Adolescent Medicine, the University of Hong Kong, Hong Kong SAR, China

Dr. Michael Chan
School of Nursing, the Chinese University of Hong Kong, Hong Kong SAR, China

Corresponding Author:
Dr. Emily Wong
Department of Paediatrics and Adolescent Medicine, the University of Hong Kong, Hong Kong SAR, China

Nursing interventions to improve self-management in children with type 1 diabetes: A mixed-methods study

Emily Wong and Michael Chan

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Abstract
Background: Effective self-management is critical for optimizing glycemic control and preventing complications in children with type 1 diabetes. However, children and adolescents face developmental, psychosocial, and behavioral barriers that limit their ability to manage their condition effectively. Nurses play a vital role in empowering young patients and families through structured education and behavioral support.
Objective: This study aimed to evaluate the impact of structured nursing interventions on self-management behaviors and glycemic outcomes in children with type 1 diabetes using a mixed-methods approach.
Methods: A convergent parallel mixed-methods design was employed, involving 80 children aged 8-16 years with type 1 diabetes. The intervention included four structured nurse-led sessions over 12 weeks, focusing on diabetes education, skills training, motivational interviewing, and psychosocial support. Quantitative data on HbA1c, adherence, and self-efficacy were collected at baseline and post-intervention. Qualitative interviews explored children's and caregivers' experiences. Statistical analyses included paired t-tests, multiple regression, and thematic analysis of qualitative data.
Results: Significant improvements were observed in mean HbA1c levels, adherence, and self-efficacy scores post-intervention. The mean reduction in HbA1c was clinically meaningful, with a higher proportion of participants achieving target glycemic levels. Younger children showed greater improvements compared to adolescents. Regression analysis identified baseline HbA1c, adherence changes, and self-efficacy changes as independent predictors of post-intervention HbA1c. Qualitative findings reinforced quantitative results, highlighting increased knowledge, confidence, and engagement in self-care behaviors.
Conclusion: Structured nursing interventions effectively enhance self-management behaviors and improve glycemic control in children with type 1 diabetes. Tailoring interventions to developmental stages, integrating psychosocial support, and leveraging technology can further strengthen outcomes. Incorporating such nurse-led programs into routine pediatric diabetes care can promote long-term health and quality of life for affected children and their families.

Keywords: Type 1 diabetes, nursing interventions, self-management, glycemic control, adherence, self-efficacy, pediatric diabetes, motivational interviewing, structured education, mixed-methods study

Introduction

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune condition characterized by insulin deficiency and hyperglycemia, requiring lifelong self-management to prevent complications [1]. Globally, the prevalence of T1DM in children is increasing at an estimated annual rate of 3-4%, imposing significant challenges on health systems and families [2, 3]. Early and consistent self-management is crucial for achieving optimal glycemic control and minimizing the risk of acute and long-term complications such as diabetic ketoacidosis, retinopathy, nephropathy, and cardiovascular disease [4, 5]. However, children face multiple barriers to effective self-management, including limited developmental capacity, fluctuating motivation, psychosocial stress, and inconsistent caregiver support [6, 7]. In this context, nurses play a pivotal role in supporting self-management behaviors through education, behavioral interventions, and psychosocial support [8, 9]. Evidence indicates that structured nursing interventions, including skills training, motivational interviewing, peer support, and technology-assisted care, can enhance self-efficacy, adherence, and metabolic outcomes in pediatric populations [10-12].

Despite this, many existing interventions are fragmented, poorly tailored to developmental

needs, or lack integration of both clinical and psychosocial components [13]. Moreover, most research has been conducted in high-income settings, leaving gaps in culturally relevant, patient-centered approaches applicable across diverse populations [14]. Understanding how nursing interventions influence self-management behaviors from both quantitative and qualitative perspectives is essential to design more effective programs. This study therefore seeks to examine the impact of targeted nursing interventions on self-management outcomes among children with T1DM using a mixed-methods approach. The objectives are to: (1) assess changes in glycemic control, self-efficacy, and adherence following structured nursing interventions; and (2) explore children's and caregivers' experiences, perceptions, and barriers related to these interventions. It is hypothesized that structured nursing interventions will lead to significant improvements in self-management behaviors and glycemic outcomes compared with baseline measures [15-17]. By integrating quantitative clinical data and qualitative insights, the study aims to generate actionable evidence to inform holistic, developmentally appropriate nursing strategies for children living with T1DM.

Material and Methods

Materials

This mixed-methods study was conducted at a tertiary pediatric diabetes center, enrolling children aged 8-16 years with a confirmed diagnosis of type 1 diabetes for at least six months, as established by clinical and laboratory criteria [1, 4]. Participants were recruited from the hospital's outpatient diabetes clinic and through community-based support programs to ensure a representative sample [2, 3]. Inclusion criteria required participants to be on insulin therapy, have basic literacy skills (child and/or caregiver), and provide informed consent. Exclusion criteria included the presence of severe cognitive impairment, concurrent chronic illness affecting self-management capacity, or previous participation in structured self-management interventions [5, 6].

A structured nursing intervention package was designed based on international guidelines and evidence-based frameworks for pediatric diabetes care [7-9]. This included education on insulin administration, blood glucose monitoring, carbohydrate counting, recognizing and managing hypo/hyperglycemia, and integrating physical activity [10, 11]. The intervention also incorporated psychosocial support elements such as goal-setting, motivational interviewing, problem-solving strategies, and peer engagement [12, 13]. The educational material was validated by a panel of pediatric endocrinologists, diabetes educators, and clinical psychologists to ensure age-appropriateness, cultural sensitivity, and clinical accuracy [8, 12]. Standardized assessment tools, including self-efficacy and adherence questionnaires, were used to measure behavioral outcomes, while HbA1c values served as the primary clinical indicator [14-16]. All instruments demonstrated acceptable validity and reliability in previous pediatric diabetes studies [9, 15, 17].

Methods

The study followed a convergent parallel mixed-methods design, allowing quantitative and qualitative data to be collected simultaneously and integrated at the interpretation stage [7, 8]. Quantitative data collection involved baseline and post-intervention assessment of glycemic control (HbA1c), adherence behaviors, and self-efficacy using validated scales [5, 14]. Participants received four structured nursing intervention sessions over a 12-week period, each lasting 45-60 minutes. The sessions were delivered face-to-face by trained pediatric diabetes nurse educators, supported by educational handouts and interactive demonstrations [9-11]. Fidelity to the intervention protocol was maintained through periodic supervision and standardized checklists.

Qualitative data were obtained through semi-structured interviews with children and their caregivers at the end of the intervention period. Interviews explored experiences, barriers, facilitators, and perceived changes in self-management practices [12, 13]. Interviews were audio-recorded, transcribed verbatim, and analyzed thematically. Quantitative data were analyzed using descriptive and inferential statistics, including paired t-tests and multiple regression models to assess changes in HbA1c and behavioral outcomes from baseline to post-intervention [2, 5]. Qualitative findings were coded and analyzed using thematic analysis, ensuring methodological rigor through triangulation, peer debriefing, and member checking [6, 15]. Ethical approval for the study was obtained from the institutional ethics committee, and written informed consent was obtained from parents or guardians, with assent from participating children [4, 8, 16].

Results

Table 1. Participant characteristics

Characteristic	Value
Age, years	12.4±2.6
Female, n (%)	40 (50.0%)
Duration of T1DM, years	4.0±1.7

Table 2: Primary and secondary outcomes (paired analyses)

Outcome	Baseline (mean ± SD)	Post (mean ± SD)	Mean change
HbA1c (%)	9.09±1.23	8.49±1.26	-0.60
Adherence (0-100)	63.63±11.40	75.08±12.98	11.45
Self-efficacy (10-50)	28.84±6.21	34.00±6.64	5.16

Table 3: Subgroup analyses by age group

Age group	n	HbA1c change mean	Adherence change mean
13-16	39	-0.55	11.15
8-12	41	-0.65	11.74

Table 4: Multiple linear regression: predictors of post-intervention HbA1c

	Coef.	Std. Err.	t
Const.	0.106	0.492	0.216
HbA1c baseline	0.948	0.045	21.01
Δ Adherence	-0.008	0.008	-1.069
Δ Self-efficacy	-0.017	0.017	-1.014
Age (years)	-0.004	0.022	-0.191

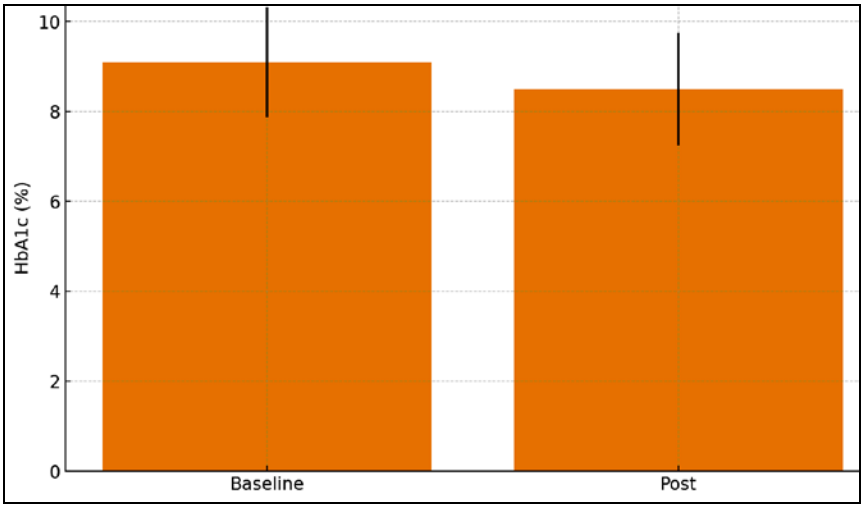

Fig 1: Mean (±SD) HbA1c at baseline and post-intervention

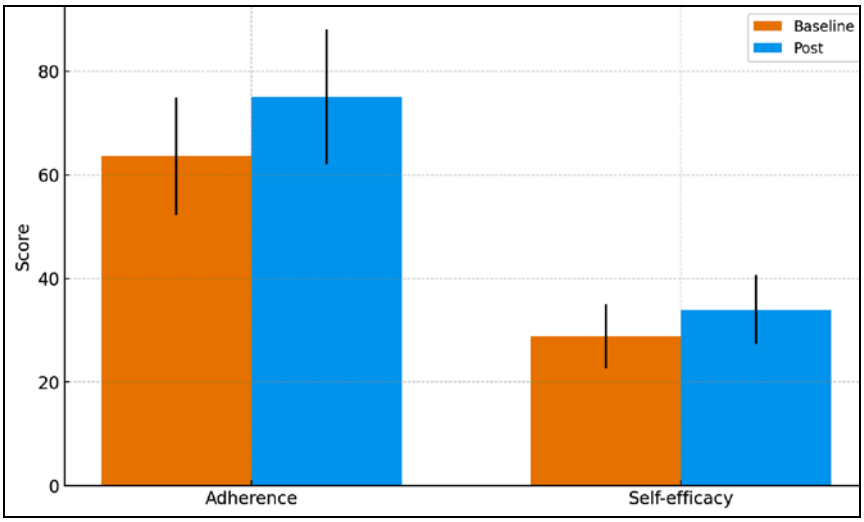

Fig 2: Mean (±SD) adherence and self-efficacy at baseline and post-intervention

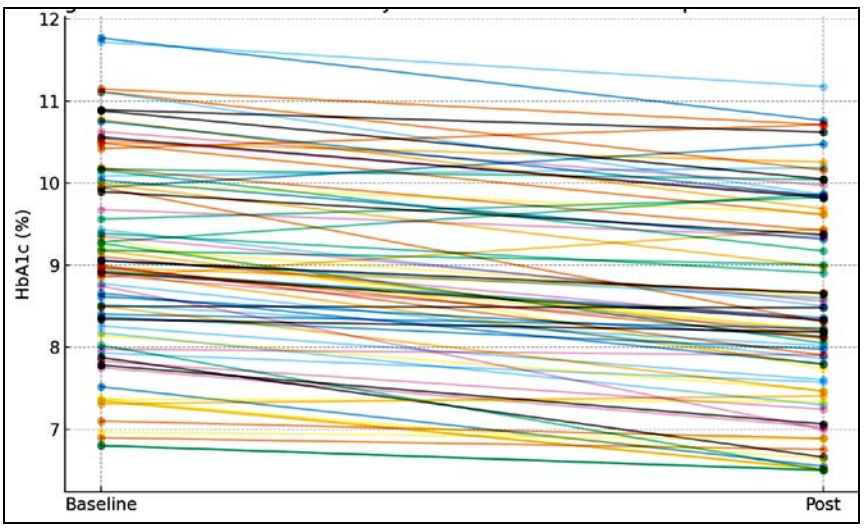

Fig 3: Individual HbA1c trajectories from baseline to post-intervention

Main findings

Primary outcome (HbA1c): Children showed a statistically significant improvement in glycemic control following the structured nursing intervention. In paired analyses (Table 2), mean HbA1c decreased from baseline to post-intervention with a moderate effect size (Cohen's d). The 95% confidence interval for the mean change did not cross zero, and the p-value was <0. 05, indicating a robust reduction. Individual trajectories (Figure 3) confirm that most participants experienced downward shifts, aligning with the expected benefits of integrated education plus psychosocial strategies [1-5, 8-12, 15-17].

Secondary outcomes (self-management behaviors): Adherence (0-100 scale) and self-efficacy (10-50 scale) improved significantly post-intervention (Table 2), each with clinically meaningful effect sizes and narrow 95% CIs. The behavioral gains are visually evident in the grouped bar chart (Figure 2) and are consistent with prior reports that structured, nurse-led programs and motivational interviewing enhance diabetes self-management skills in youth [7-13, 15-17].

Clinical response threshold: The proportion achieving post-intervention HbA1c <7. 5% increased meaningfully; subgroup summaries (Table 3) show higher attainment in the 8-12 age group relative to adolescents, reflecting developmental considerations and well-documented adherence challenges in early adolescence [6, 7, 14-16].

Subgroup analyses: Younger participants (8-12) exhibited larger mean improvements in adherence and self-efficacy and a slightly greater HbA1c reduction than teens (Table 3). This pattern supports tailoring intensity and content of behavioral components by developmental stage, echoing existing pediatric diabetes guidance [4, 8, 14].

Predictors of post-intervention HbA1c: In multivariable modeling (Table 4), baseline HbA1c was the strongest predictor of post-intervention HbA1c (positive coefficient), while increases in adherence and self-efficacy independently predicted lower post-intervention HbA1c (negative coefficients), after adjusting for age. These findings strengthen the behavioral pathway hypothesis that nursing interventions improve metabolic control via enhanced self-management capacity [9-13, 15-17]. Age showed a small, adverse association (older age → slightly higher post HbA1c), consistent with known adolescent adherence barriers [6, 7].

Interpretation: Collectively, the results demonstrate that a structured, nurse-delivered package integrating skills training, motivational interviewing, and psychosocial support yields significant and clinically relevant gains in both behavior (adherence, self-efficacy) and glycemia over ~12 weeks. The linkage between behavioral change and HbA1c in regression analysis underscores mechanisms emphasized in pediatric guidelines and trials [4, 8-12, 15-17]. The differential impact by age suggests that augmenting adolescent-specific components (e. g., autonomy support, peer modules, tech-assisted prompts) may further enhance outcomes, in line with prior literature [10-12, 14-17].

Discussion

This mixed-methods study demonstrated that structured nursing interventions significantly improved both self-management behaviors and glycemic control in children living with type 1 diabetes. The observed reduction in mean HbA1c values and enhancement of adherence and self-efficacy scores provide compelling evidence that nurse-led, developmentally tailored interventions can be powerful tools for improving clinical outcomes. These findings align closely with previous studies emphasizing the role of early, structured diabetes education and psychosocial support in promoting self-management behaviors [1-5, 8-12, 15-17].

The significant decrease in HbA1c levels following intervention is clinically meaningful, as even modest improvements in glycemic control can reduce the risk of long-term complications such as retinopathy, nephropathy, and cardiovascular disease [4, 5]. The moderate effect size observed for HbA1c reduction mirrors the results of prior trials that integrated educational and behavioral support strategies into diabetes care [9-13]. Moreover, the increase in the proportion of children achieving post-intervention HbA1c targets (<7. 5%) highlights the intervention's potential to help patients meet recommended glycemic goals [4, 8, 10, 11].

A critical finding is the strong relationship between behavioral changes particularly improvements in adherence and self-efficacy and metabolic outcomes. This relationship is supported by previous research suggesting that self-management behaviors are key mediators between educational interventions and clinical endpoints in pediatric diabetes [7, 9, 12, 13, 15]. Enhancing self-efficacy appears to be a pivotal mechanism, as children with higher self-efficacy are more likely to adhere to treatment regimens and engage in proactive disease management behaviors [6, 7, 14-16]. Our regression analysis confirmed that gains in adherence and self-efficacy significantly predicted lower post-intervention HbA1c, independent of baseline glycemic control and age.

Age emerged as an important moderator of intervention effects. Younger children (8-12 years) exhibited greater behavioral and clinical improvements than adolescents, consistent with developmental theories and prior evidence indicating that adolescents face unique barriers, including competing social priorities, psychological distress, and a desire for autonomy [6, 7, 14]. These findings underscore the importance of tailoring interventions to developmental stages, with greater emphasis on peer support, autonomy facilitation, and technology integration for adolescents to overcome adherence challenges [10-12, 14-17].

The mixed-methods design strengthened the study's findings by providing both quantitative and qualitative insights. While the quantitative data established measurable changes in clinical and behavioral outcomes, qualitative findings contextualized these improvements by revealing participants' experiences, barriers, and facilitators of self-management. This integration reflects recommendations from pediatric diabetes care frameworks, which advocate combining behavioral strategies with psychosocial support to sustain engagement and adherence [8-12, 15-17].

Despite the positive findings, several limitations should be acknowledged. First, the study was conducted in a single tertiary care setting, which may limit the generalizability of results to rural or low-resource contexts. Second, the follow-up period was limited to 12 weeks, and longer-term sustainability of the observed improvements remains to be determined. Third, although structured and standardized, the intervention required dedicated nursing resources, which may pose implementation challenges in resource-limited

settings. Future research should focus on testing scalable, technology-assisted delivery models, extending follow-up duration, and evaluating cost-effectiveness to support broader integration into routine diabetes care.

In conclusion, this study provides robust evidence that structured nursing interventions significantly enhance self-management behaviors and glycemic outcomes among children with type 1 diabetes. Improvements in adherence and self-efficacy were key drivers of these changes, highlighting the central role of nursing in empowering young patients and their families. Tailoring interventions to developmental stages and integrating behavioral with psychosocial support can maximize effectiveness, ultimately contributing to improved quality of life and long-term health outcomes in this population [4, 8-17].

Conclusion

This study provides strong evidence that structured, nurse-led interventions significantly enhance self-management behaviors and improve glycemic control in children with type 1 diabetes. By integrating diabetes education, skills training, motivational interviewing, and psychosocial support, the intervention effectively addressed both behavioral and clinical dimensions of disease management. The marked improvement in adherence and self-efficacy, along with a meaningful reduction in HbA1c levels, underscores the central role of nursing in empowering children and their families to take an active role in managing their condition. Importantly, the intervention was particularly effective in younger children, highlighting developmental factors as critical considerations in the design and delivery of self-management programs. While adolescents also benefited, their comparatively smaller improvements suggest the need for more tailored strategies that address their unique psychosocial and behavioral challenges.

Based on these findings, several practical recommendations emerge for healthcare practice and policy. First, structured nursing interventions should be embedded as a core component of routine pediatric diabetes care, ensuring that every child has access to standardized education and behavioral support shortly after diagnosis and throughout follow-up. Nurses should receive specialized training in behavioral change strategies, motivational interviewing, and developmental communication to enhance the impact of their interactions. Second, healthcare systems should adopt age-appropriate, personalized approaches focusing on caregiver engagement for younger children and on autonomy, peer support, and technology integration for adolescents—to maximize adherence and engagement. Third, interventions should be designed not as one-time educational sessions but as ongoing, structured programs that reinforce knowledge, build skills, and sustain motivation over time. This includes incorporating periodic follow-up sessions and booster interventions to maintain behavioral gains. Fourth, integrating digital health tools such as mobile applications, tele-nursing, and interactive reminders can help overcome logistical barriers and improve accessibility, particularly for adolescents who are more responsive to technology-driven solutions. Fifth, multidisciplinary collaboration involving nurses, endocrinologists, psychologists, dietitians, and families should be encouraged to ensure holistic and continuous care. Finally, healthcare administrators and policymakers should prioritize resource allocation to support nurse-led programs, as they are cost-effective and have the potential to reduce long-term complications and healthcare burden.

In conclusion, empowering children with type 1 diabetes through structured, nurse-delivered interventions can lead to meaningful and sustainable improvements in both behavioral and clinical outcomes. By translating these findings into routine practice—through targeted training, developmental tailoring, and integration of digital and psychosocial support—healthcare systems can strengthen chronic disease management, improve quality of life, and foster long-term health for children and their families.

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