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Management of type 1 diabetes mellitus in children: Integrating technology and family-centered care

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ABSTRACT

This review examines the clinical and family challenges of caring for children with type 1 diabetes mellitus. We updated the literature and professional guidance, focusing on pediatric glycemic targets, continuous glucose monitoring (CGM), automated insulin delivery (AID), nutrition, exercise, psychosocial care, and school support. Current care combines individualized insulin treatment and education with CGM-derived measures, including time in range, rather than relying on glycated hemoglobin alone. Randomized trials show that hybrid closed-loop systems, which automatically adjust insulin delivery based on glucose sensor readings, improve time in range in children, although access, training, alarm burden, and device management remain important concerns. Earlier observational studies describe mealtime difficulties, fear of hypoglycemia, parental stress, and disrupted sleep, but many predate widespread CGM and AID use and may not reflect present-day experiences. Coordinated support among families, diabetes teams, and schools, together with age-appropriate psychosocial assessment, is an established component of care. Research is still needed on access to technology, long-term child and family outcomes, and the effects of planned behavioral interventions. Clinical trials provide strong evidence that AID improves time in target range. Evidence for lasting psychosocial and glycemic benefits from specific family interventions is less certain.

Keywords: Automated insulin delivery; children; continuous glucose monitoring; family-centered care; type 1 diabetes

INTRODUCTION

Type 1 diabetes mellitus (T1DM) results from autoimmune destruction of pancreatic beta cells and requires lifelong exogenous insulin treatment. In childhood, daily care is shared by the child, family, medical team, and school or preschool staff during the day. Treatment must adapt to growth, variable food intake, spontaneous activity, and a growing ability to manage the condition. Glycemic outcomes alone do not capture the emotional and practical burden of care (1,2). Advances in continuous glucose monitoring (CGM) and automated insulin delivery (AID) have altered how glucose excursions are detected and treated, while creating new demands for device education, data interpretation, and coordination across settings (2,3). This review integrates contemporary clinical guidance with evidence on nutrition, activity, child and parent well-being, interventions, and school support. Its focus is the practical relationship between current treatment and family life, with particular attention to young children.

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METHODS

The literature for this review was identified through PubMed searches conducted by the authors before the original submission on May 15, 2026, and continued during the subsequent months. The authors performed a further PubMed check on September 25, 2026, to identify additional relevant publications and consulted current American Diabetes Association (ADA) and International Society for Pediatric and Adolescent Diabetes (ISPAD) guidance. Searches combined pediatric type 1 diabetes with glycemic targets, CGM, AID, exercise, nutrition, parental distress, sleep, family interventions, and school care. We prioritized pediatric guidance, clinical trials, and studies directly relevant to children and families. Older studies were retained when they provided relevant context. This was a targeted search, without a registered protocol, exhaustive retrieval, duplicate independent screening, or formal risk-of-bias assessment.

CHARACTERISTICS OF T1DM IN CHILDREN

Children with T1DM require insulin replacement, glucose monitoring, education, and repeated adjustment of care as they grow. The immediate safety priorities include preventing severe hypoglycemia and diabetic ketoacidosis, while long-term care also aims to reduce microvascular and cardiovascular risk. Glycemic targets should be individualized around safety, well-being, and the resources available

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to the child and caregivers (2,4). Current ADA guidance generally recommends a glycated hemoglobin (HbA1c) goal below 7.0% for many children, with a lower goal, such as below 6.5%, considered for selected children when safely achievable without excessive treatment burden (2). ISPAD 2024 recommends an HbA1c target of 6.5% or lower when advanced technology allows it to be reached safely and 7.0% or lower in other settings (4). These goals replace the older age-specific values cited in the previous version of this review. HbA1c should be interpreted alongside CGM metrics, particularly time in the 70–180 mg/dL (3.9–10.0 mmol/L) range, time below range, time above range, and glycemic variability (2,4). Numerical targets should guide shared decisions while accounting for hypoglycemia risk and the child's quality of life.

MANAGEMENT OF T1DM IN CHILDREN: CLINICAL AND EVERYDAY CHALLENGES

The demands of treatment differ across developmental stages and care settings. Preschool children depend on adults to interpret glucose changes and administer insulin. On the other hand, adolescents gradually assume more tasks while facing changes in insulin sensitivity, peer relationships, and routine. Neither physical complications nor psychological difficulties follow a simple age-related pattern. Clinical visits should address acute safety, longer-term risk, treatment feasibility, and the child's and family's daily functioning (2,5).

Contemporary glucose monitoring and insulin delivery

CGM provides frequent glucose measurements, trends, and alerts that can help families anticipate hypoglycemia, assess meals and activity, and review overnight patterns. Some systems let caregivers view glucose data remotely. Alerts can offer reassurance but may also interrupt sleep or increase vigilance. Families need training in sensor limitations, confirmatory finger-stick measurement when readings and symptoms do not match, data sharing, and realistic alarm settings (2,3). Multiple daily injections and pump therapy remain valid modes of insulin delivery. AID systems integrate CGM with an insulin pump and an algorithm that adjusts insulin delivery, and most hybrid closed-loop systems, which automatically adjust insulin delivery based on glucose sensor readings, still require user input for meals and attention to device failures. Education and access to backup insulin and glucose testing remain essential (3,6). A 2025 synthesis of outpatient trials confirms that AID generally improves time in range compared with conventional care, although the included systems and comparators differ (7). In a trial involving young children, caregiver questionnaires and interviews captured experiences with AID that glucose measures alone cannot describe (8). Unequal access to CGM has also been documented, so recommendations must consider availability and support as well as device performance (9). Randomized pediatric trials provide stronger evidence for glycemic benefit than older descriptive reports. In a trial involving children aged two to under 6 years, time in range improved by 12.4% points more with closed-loop treatment than with standard care over 13 weeks (10). Trials in other pediatric age groups likewise found greater time in range with hybrid closed-loop systems (11,12). These findings do not show that technology resolves every psychosocial difficulty. Wearing a device, dealing with alarms or connectivity problems, and meeting the cost and time demands may affect whether families use these systems and how they experience care. Psychosocial outcomes require direct evaluation rather than inference from time in range (3,12).

Psychological challenges

Young children may be unable to recognize or communicate hypoglycemia reliably, and parents may struggle to distinguish symptoms from ordinary behavior. Some children resist injections, sensor insertion, or mealtime routines. These observations remain clinically relevant, although many early studies were performed before widespread CGM and AID use (13,14). Neuroimaging and cognitive studies have reported associations between dysglycemia and differences in brain structure or cognitive performance. Because these studies are observational and differ in how they measured glucose exposure, they cannot establish causation for an individual child (15,16). Psychological distress and diabetes-specific worries also vary across developmental stages. Assessment should be individualized and should ask how treatment, school, peers, and family relationships affect daily life rather than assuming a uniform response to diagnosis (5,17). A later review of young children discusses possible links among glucose exposure, cognition, and brain development, while noting how difficult it is to separate diabetes-related effects from other influences (18). An earlier meta-analysis likewise reported small average differences in cognitive performance across studies, which do not predict an individual child's development (19).

Nutritional challenges

Medical nutrition therapy should support adequate growth, dietary variety, and predictable insulin dosing without turning every meal into a conflict. Carbohydrate estimation, insulin timing, and meal composition affect postprandial glucose, and the appropriate plan depends on age, appetite, insulin regimen, and family circumstances (2,6). Young children may eat unpredictably, which complicates premeal dosing. CGM patterns can inform individualized adjustment, whereas caregivers need practical advice on missed or partially eaten meals and on avoiding coercive feeding. Older observational work documented mealtime stress and selective eating, but small samples and changes in insulin technology limit direct application of its estimates to current care (13,20). Reviewing food records and CGM data together can help clinicians address both nutrition and the way meals affect family life. Observational studies of young children describe disrupted mealtime behavior in families using intensive insulin therapy (21). Other studies have raised concerns about dietary composition (22) and linked food neophobia and selective eating with less varied diets in young people with T1DM (23). These findings merit discussion with families, but observational designs cannot show that mealtime behavior causes later glycemic or cardiovascular problems.

Challenges of physical activity

Physical activity should be encouraged as part of ordinary childhood and planned with the family and diabetes team.

Glucose responses vary with the activity's duration and intensity, recent insulin, food intake, and time of day, and delayed hypoglycemia may occur after exercise (24). CGM trends can help guide decisions, but sensor readings may lag behind blood glucose during rapid change. Carbohydrate availability, insulin adjustment, monitoring, and an individualized plan for school, sport, and unexpected play improve safety. AID exercise settings can be useful but require knowledge of their timing and limitations (3,24). Earlier small studies suggested that children with T1DM might be less active than peers, but their findings should not be generalized to all children or used to discourage participation. The practical priority is to reduce avoidable barriers to activity while monitoring for both hypoglycemia and hyperglycemia (24). A small accelerometer study found less activity among children younger than 7 years with T1DM than among controls (25). Its small sample and the changes in diabetes care since publication limit how widely the findings can be applied.

IMPACT OF T1DM ON PARENTS OF AFFECTED CHILDREN

Diagnosis requires parents and other caregivers to learn insulin administration, glucose interpretation, hypoglycemia treatment, and responses to illness while maintaining ordinary family routines (2,26). Early qualitative and observational studies describe fear, uncertainty, and social isolation after diagnosis; their estimates should be read in the context of the periods and settings in which they were obtained (13,27). Caregiver demands change as a child gains autonomy and begins preschool or school. Social circumstances, language, access to technology, and available support may affect a family's capacity to use recommended care. Education therefore needs to be repeated and adapted to the household rather than delivered only at diagnosis (17,26). Parents of newly diagnosed children have described anxiety and depressive symptoms in an observational study, underscoring the value of timely education and counseling (28). Parents use different coping strategies and have different support needs; one program will not fit every family (29).

Stress in parents of children with T1DM

Fear of hypoglycemia, diabetes distress, anxiety, and family conflict can affect care decisions and well-being. Earlier studies of parents of young children described substantial worry, especially when children were asleep or outside parental supervision (13,30). These associations do not establish that worry causes poorer glycemia or that a single prevalence estimate applies across current treatment settings. CGM and AID may reduce uncertainty but can also bring frequent alerts, repeated data checking, or concern about device failure (3,17). Routine care should include developmentally appropriate discussion of the child's and caregivers' well-being, screening with suitable measures when indicated, and access to psychological assessment or referral for persistent or severe difficulties. Shared decisions should respect the child's growing autonomy and avoid placing all responsibility on one caregiver (2,17). One study linked maternal fear of hypoglycemia with aspects of treatment adherence, but its observational design cannot establish the direction of the relationship (31). Care teams should ask what parents fear and which tasks they find difficult before interpreting glucose data as a measure of family coping.

Sleep patterns of parents of children with T1DM

Overnight management can interrupt both child and caregiver sleep. Reports from the period before current technology describe waking for glucose checks and fear of nocturnal hypoglycemia, but their frequencies cannot be assumed to characterize families using present-day CGM and AID (32). Sensor alerts and remote monitoring may reduce the need for some scheduled checks while also causing awakenings and repeated checking. Clinicians should ask specifically about sleep, alarm settings, overnight glucose patterns, and the family's response plan (3,17). In older studies, parental sleep quality and hypoglycemia worry were associated with perceived self-efficacy (33), while nighttime caregiving was associated with parent functioning (34). Because both studies predate widespread AID use, their findings should be reassessed in families receiving current care. When parental vigilance is excessive, or sleep disruption persists, the care team can review whether alert thresholds, education, insulin settings, or additional psychological support might help. The effects of a device on sleep and distress vary across families and should be evaluated directly alongside glycemic outcomes.

INTERVENTIONS IN THE FIELD OF T1DM IN CHILDREN

Education, coping-skills training, peer support, and family-focused counseling address different needs. Older parent-focused programs reported improvements in perceived support, coping, and mealtime stress, whereas consistent benefits for child glycemic outcomes have been less clear (35,36). Many studies had small samples, short follow-up, or were conducted before current technology became common; effects should not be generalized to all age groups or care systems. A family newly adjusting to diagnosis may benefit most from structured education and practical support; a family facing persistent distress or conflict may require a tailored psychological intervention (17,26). Clinical care should integrate these approaches with insulin and device education and measure psychosocial and glycemic outcomes to assess their benefits. Future trials should compare well-specified interventions, report engagement and equity of access, and follow children and families long enough to test sustained effects. Early work on parent-to-parent support offers one model for helping newly diagnosed families (37). More recently, a systematic review and meta-analysis reported short-term reductions in distress after family psychological interventions; there is less evidence that these benefits persist across different families and intervention types (38). These findings support offering targeted help while evaluating child and caregiver outcomes separately.

DIABETES CARE AT SCHOOL AND PRESCHOOL

Care plans should specify who monitors glucose, gives insulin, responds to hypoglycemia or hyperglycemia, manages

meals and activity, and contacts caregivers or clinicians. Staff need appropriate training, access to supplies, and a clear emergency plan; the child's participation should match age and ability (2,39). CGM data sharing and AID use need agreed roles so that alerts prompt a timely response without placing unrealistic responsibility on the child or teacher. Transitions into preschool, school, and extracurricular activities require renewed coordination among family, diabetes team, and educational staff. These are components of current care, not merely future recommendations (3,39). A 2024 systematic review of school nursing and diabetes devices found that staff training and organization are central to safe technology use at school, although the available studies varied in design and setting (40). Care plans should reflect the resources and staff available in each school.

FUTURE RECOMMENDATIONS

Current practice should combine individualized insulin treatment, CGM when available and appropriate, education for children and caregivers, assessment of psychosocial needs, and a workable school care plan (2-4,17,39). These measures should be adapted to access, safety, development, and family preferences. Research should identify which family interventions have lasting benefits, measure sleep and quality of life alongside glycemic outcomes, and examine how technology access and school resources affect disparities. Longitudinal studies should examine developmental outcomes without attributing observed associations to glucose exposure alone. Studies should also report the age, technology, and social context of participating families so that findings can be applied appropriately.

CONCLUSION

Care for children with T1DM now combines insulin treatment with CGM-based assessment and, for many, AID. Contemporary guidance supports individualized HbA1c and time-in-range goals, whereas pediatric trials demonstrate improved time in range with hybrid closed-loop systems. Families still face mealtime decisions, exercise planning, sleep disruption, and emotional strain that technology does not automatically remove. Effective care therefore includes practical education, psychosocial assessment, and explicit coordination with schools. Evidence for the lasting effects of specific family interventions on well-being and glycemia remains limited. Future studies should address these outcomes, equitable access, and the changing needs of children across development.

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DECLARATION OF GENERATIVE AI USE

During revision of this manuscript, the authors used ChatGPT to assist with English expression, organization, revision of existing text, drafting of proposed additions, and suggestions concerning relevant literature. Both authors checked the references and scientific statements against the original publications, reviewed and approved the complete manuscript, and accept full responsibility for its content.

DECLARATION OF INTEREST

Authors declare no conflict of interests.

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