

CELIAC DISEASE IN CHILDREN AND ADOLESCENTS WITH TYPE 1 DIABETES MELLITUS: PREVALENCE, TIME TO DIAGNOSIS, AND METABOLIC CHARACTERISTICS IN A TERTIARY CARE CENTER

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Pediatric Endocrinology Unit (P2), Children's Hospital, Ibn Sina University Hospital, Mohammed V University, Rabat, Morocco. DOI: <https://doi.org/10.5281/zenodo.23314921>

How to cite this Article: *Samiha Kitani, Houda Bella, Hind Lachraf, Asmaa Mdaghri Alaoui, Zineb Imane. (2026). Celiac Disease in Children and Adolescents with Type 1 Diabetes Mellitus: Prevalence, Time to Diagnosis, and Metabolic Characteristics in a Tertiary Care Center. World Journal of Pharmaceutical and Life Sciences, 12(10), 236–241.

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Article Received on 05/09/2026

Article Revised on 25/09/2026

Article Published on 01/10/2026

ABSTRACT

Background: Celiac disease (CD) is one of the most common autoimmune disorders associated with type 1 diabetes mellitus (T1D). Owing to shared genetic susceptibility and immunological mechanisms, children with T1D are at increased risk of developing CD. Early identification is essential to prevent long-term complications and optimize metabolic outcomes. **Objective:** To determine the prevalence of celiac disease among children and adolescents with type 1 diabetes mellitus and to describe the metabolic characteristics of patients with coexisting celiac disease and type 1 diabetes mellitus. **Methods:** A retrospective descriptive and analytical study was conducted at a tertiary pediatric referral center specializing in endocrinology and diabetology. Medical records of patients with T1D followed between January 2015 and December 2024 were reviewed. Screening for CD was systematically performed using anti-tissue transglutaminase IgA antibodies and total serum IgA levels, with histological confirmation by duodenal biopsy in positive cases. Glycemic control was assessed using glycated hemoglobin (HbA1c). **Results:** A total of 1,728 children and adolescents with T1D were included. Celiac disease was diagnosed in 71 patients, corresponding to a prevalence of 4.1%. CD was the most frequent autoimmune comorbidity identified in the study population. The mean age at diagnosis of CD was 8.7 years. Most cases (77.5%) were diagnosed within the first five years following T1D onset. Assessment of glycemic control showed that only 14.1% of patients achieved the recommended HbA1c target ($\leq 7.0\%$), whereas 52.1% had HbA1c levels between 7% and 9%, and 33.8% had HbA1c levels $>9\%$. **Conclusions:** Celiac disease is a frequent autoimmune comorbidity among children and adolescents with T1D. The majority of cases occur during the first years following diabetes onset, supporting the relevance of systematic screening in children and adolescents with T1D. The high proportion of patients with suboptimal glycemic control underscores the importance of early diagnosis and multidisciplinary management to optimize long-term outcomes.

KEYWORDS: Type 1 diabetes mellitus; Celiac disease; Autoimmune comorbidity; Glycemic control; HbA1c; Pediatrics.

INTRODUCTION

Type 1 diabetes mellitus (T1D) is one of the most common chronic autoimmune diseases of childhood and adolescence. Its incidence has been steadily increasing worldwide, with an estimated annual rise of 2–3%, making it a major public health concern. The disease results from autoimmune destruction of pancreatic β -cells, leading to absolute insulin deficiency and lifelong

dependence on exogenous insulin therapy. The pathogenesis of T1D involves a complex interaction between genetic susceptibility, particularly HLA-DQ2 and HLA-DQ8 haplotypes, and environmental factors such as viral infections, alterations in gut microbiota, and dietary exposures.

Celiac disease (CD) is a chronic immune-mediated enteropathy triggered by gluten ingestion in genetically predisposed individuals. Similar to T1D, CD is strongly associated with HLA-DQ2 and HLA-DQ8 haplotypes, which explains the frequent coexistence of these two autoimmune disorders. The prevalence of CD among children and adolescents with T1D is considerably higher than in the general population, ranging from 4% to 16% according to international studies.

The coexistence of T1D and CD has important clinical implications. Although many patients remain asymptomatic at diagnosis, untreated CD may lead to impaired growth, nutritional deficiencies, gastrointestinal symptoms, reduced quality of life, and difficulties in achieving optimal metabolic control. Furthermore, intestinal malabsorption may contribute to increased glycemic variability and unpredictable hypoglycemic episodes, complicating diabetes management.

Several international organizations, including the International Society for Pediatric and Adolescent Diabetes (ISPAD) and the American Diabetes Association (ADA), recommend systematic screening for CD at the time of T1D diagnosis and periodic reassessment during follow-up, even in asymptomatic patients. Early identification of CD allows timely initiation of a gluten-free diet and may improve both clinical and metabolic outcomes.

Despite the recognized association between T1D and CD, epidemiological data from North African countries remain limited. Regional variations in genetic background, environmental exposures, and healthcare access may influence the prevalence and clinical presentation of CD among children with T1D. Therefore, local data are essential to optimize screening strategies and improve patient care.

The present study aimed to determine the prevalence of celiac disease among children and adolescents with type 1 diabetes mellitus followed at a tertiary pediatric endocrinology center and to describe their metabolic characteristics.

MATERIALS AND METHODS

Study Design and Setting

This retrospective descriptive and analytical study was conducted at a tertiary pediatric referral center specializing in endocrinology and diabetology. The center provides comprehensive care for children and adolescents with type 1 diabetes mellitus (T1D) and serves a large referral population.

Study Period

The study was carried out over a 10-year period, from January 1, 2015, to December 31, 2024.

Study Population

During the study period, 1,728 children and adolescents diagnosed with T1D were followed at the study center.

INCLUSION CRITERIA

Patients were eligible for inclusion if they met the following criteria:

- Confirmed diagnosis of type 1 diabetes mellitus;
- Age below 18 years at diagnosis;
- Regular follow-up at the Pediatric Endocrinology and Diabetology Unit;
- Availability of at least one glycated hemoglobin (HbA1c) measurement during follow-up;
- Screening for celiac disease according to the institutional protocol.

EXCLUSION CRITERIA

Patients were excluded if they:

- Had a form of diabetes other than T1D (monogenic, secondary, pancreatic, or drug-induced diabetes);
- Had incomplete medical records;
- Were lost to follow-up.

Screening and Diagnosis of Celiac Disease

Screening for celiac disease was systematically performed in all patients with T1D according to current clinical practice guidelines.

The screening strategy included measurement of serum anti-tissue transglutaminase immunoglobulin A antibodies (tTG-IgA) together with total serum IgA levels to exclude selective IgA deficiency.

Patients with positive serological results underwent upper gastrointestinal endoscopy with duodenal biopsy for histopathological confirmation. The diagnosis of celiac disease was established based on positive serological findings and compatible histological features.

Data Collection

Clinical, demographic, and laboratory data were retrospectively collected from medical records.

The following variables were analyzed:

Demographic Characteristics

- Age at diagnosis of T1D;
- Sex;
- Geographic origin;
- Family history of diabetes mellitus;
- Family history of autoimmune diseases.

Celiac Disease Characteristics

For patients diagnosed with celiac disease, the following variables were recorded:

- Age at diagnosis of celiac disease;
- Time interval between diagnosis of T1D and diagnosis of celiac disease;
- Clinical presentation;
- Presence of associated autoimmune disorders.

Assessment of Glycemic Control

Metabolic control was evaluated using glycated hemoglobin (HbA1c).

For each patient, the mean HbA1c value during the last year of follow-up was recorded. Patients were categorized into three groups according to glycemic control:

- HbA1c $\leq$ 7%;
- HbA1c between 7% and 9%;
- HbA1c $>$ 9%.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics software version 29.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median and interquartile range (IQR), according to data distribution. Categorical variables were expressed as frequencies and percentages.

The prevalence of celiac disease was calculated by dividing the number of confirmed cases by the total number of patients with T1D followed during the study period.

Given the descriptive nature of the study, results were primarily summarized using descriptive statistics.

RESULTS

Study Population

During the study period, a total of 1,728 children and adolescents with type 1 diabetes mellitus (T1D) were followed at a tertiary pediatric endocrinology and diabetology referral center.

Among these patients, 100 were identified as having at least one associated autoimmune disease. Celiac disease (CD) was the most frequent autoimmune comorbidity, affecting 71 patients. The remaining patients presented other autoimmune disorders, including autoimmune thyroid disease and less frequent autoimmune conditions.

The overall prevalence of celiac disease among children and adolescents with T1D was therefore 4.1% (71/1,728).

Table 1: Characteristics of patients with celiac disease.

Characteristic	Value
Total T1D patients	1,728
Patients with celiac disease	71
Prevalence of celiac disease	4.1%
Mean age at CD diagnosis	8.7 years
Diagnosis within 5 years after T1D onset	77.5%
HbA1c $\leq$ 7%	10 (14.1%)
HbA1c 7–9%	37 (52.1%)
HbA1c $>$ 9%	24 (33.8%)

Characteristics of Patients with Celiac Disease

The mean age at diagnosis of celiac disease was 8.7 years.

Celiac disease was diagnosed predominantly during childhood and occurred mainly within the first years following the diagnosis of T1D.

Analysis of the time interval between T1D diagnosis and the onset of celiac disease showed that 77.5% of patients were diagnosed with celiac disease within the first five years after diabetes onset, highlighting the increased risk

of developing celiac disease during the early stages of diabetes follow-up.

Glycemic Control

Glycemic control was assessed using the mean glycated hemoglobin (HbA1c) during follow-up.

Among the 71 patients with celiac disease:

- 10 patients (14.1%) had an HbA1c $\leq$ 7%;
- 37 patients (52.1%) had an HbA1c between 7% and 9%;
- 24 patients (33.8%) had an HbA1c $>$ 9%.

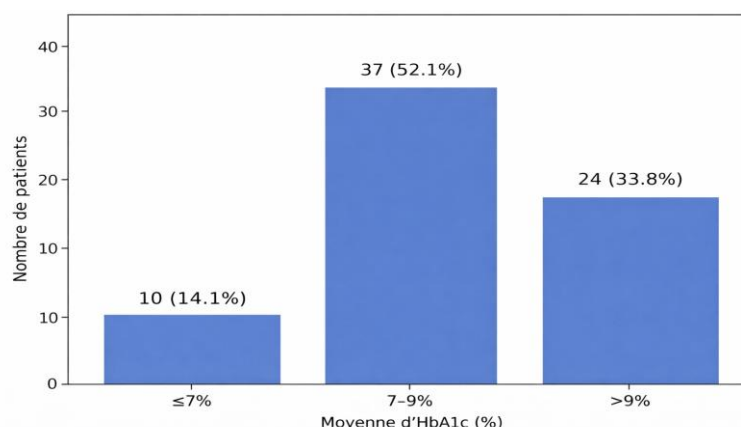


Figure 1: Distribution of HbA1c levels among patients with celiac disease.

Overall, 61 patients (85.9%) had HbA1c levels above the recommended target of 7%, indicating suboptimal metabolic control in the majority of patients.

These findings suggest that achieving optimal glycemic control remains challenging in children and adolescents with coexisting T1D and celiac disease.

Main Findings

The present study demonstrated that celiac disease is the most frequent autoimmune disorder associated with T1D in our cohort. The prevalence of celiac disease was 4.1%, and most cases were diagnosed within five years after diabetes onset. Furthermore, the majority of patients with celiac disease exhibited suboptimal glycemic control, with HbA1c values exceeding recommended targets.

DISCUSSION

The present study evaluated the prevalence of celiac disease (CD) among children and adolescents with type 1 diabetes mellitus (T1D) followed at a tertiary pediatric endocrinology center over a 10-year period. Our findings demonstrate that CD is the most frequent autoimmune disorder associated with T1D in our cohort, with an overall prevalence of 4.1%.

The prevalence observed in our study is consistent with the lower range reported in international literature, where the prevalence of CD among patients with T1D varies from 4% to 16%, depending on the population studied, screening strategies, and diagnostic criteria used. Several European studies have reported prevalence rates ranging between 5% and 10%, while higher rates have been described in selected populations. The prevalence identified in our cohort therefore confirms the increased susceptibility of children with T1D to develop CD compared with the general pediatric population.

A recent global systematic review and meta-analysis published in 2025, including data from more than 65,000 individuals with type 1 diabetes across 40 countries, reported a pooled prevalence of celiac disease of approximately 6% worldwide, with even higher rates observed in Asia and the Middle East. The prevalence observed in our cohort (4.1%) is slightly lower than the global estimate but remains within the range reported internationally, supporting the relevance of systematic screening in Moroccan children and adolescents with T1D.

The strong association between T1D and CD can be explained by shared genetic and immunological mechanisms. Both diseases are strongly associated with HLA-DQ2 and HLA-DQ8 haplotypes and result from immune dysregulation occurring in genetically predisposed individuals. In addition to genetic susceptibility, environmental factors, intestinal microbiota alterations, and viral infections have been implicated in the pathogenesis of both conditions.

One of the most important findings of our study is that 77.5% of CD cases were diagnosed within the first five years following the diagnosis of T1D. This observation is in agreement with ISPAD and ADA recommendations, which emphasize the need for repeated screening during the first years after diabetes onset, even in asymptomatic patients. The ADA Standards of Care 2025 recommend screening for celiac disease at the time of type 1 diabetes diagnosis and repeating screening during follow-up, particularly within the first years after diabetes onset. These recommendations are supported by the observation that many patients remain asymptomatic despite positive serology and histological evidence of disease. Our finding that 77.5% of celiac disease cases were diagnosed within the first five years following T1D onset strongly supports these recommendations. The high frequency of CD diagnosis during this period supports the implementation of regular surveillance programs in pediatric diabetes clinics.

Another important finding concerns metabolic control. Most patients with coexisting T1D and CD did not achieve the recommended HbA1c target of 7%. However, because no comparison group of patients with isolated T1D was included, the direct effect of celiac disease on glycemic control could not be established. Nevertheless, these findings suggest challenges in maintaining optimal metabolic control. Indeed, only 14.1% of patients achieved optimal glycemic control, whereas 85.9% presented HbA1c levels exceeding recommended targets. These findings indicate that maintaining adequate metabolic control remains challenging in patients affected by both autoimmune disorders.

Several mechanisms may explain this observation. Recent clinical reviews have emphasized that the coexistence of T1D and celiac disease may increase glycemic variability through intestinal inflammation, altered nutrient absorption, and fluctuations in carbohydrate bioavailability. Furthermore, long-term management requires regular nutritional assessment, monitoring of growth parameters, and evaluation of adherence to a gluten-free diet to optimize both metabolic and clinical outcomes.

Although our study was not designed to evaluate the effect of a gluten-free diet, previous studies have suggested that strict adherence to a gluten-free diet may improve metabolic outcomes, reduce glycemic variability, and increase time spent within target glucose ranges. However, the benefits of dietary treatment depend not only on gluten exclusion but also on the nutritional quality of the diet, as several commercially available gluten-free products have a high glycemic index and may adversely affect postprandial glucose control.

The main strength of our study is the large cohort of children and adolescents with T1D followed over a 10-

year period in a tertiary referral center. Furthermore, systematic screening for CD allowed the identification of both symptomatic and asymptomatic patients.

However, several limitations should be acknowledged. First, the retrospective design may have resulted in missing or incomplete data. Second, the study was conducted in a single center, which may limit the generalizability of the findings. Third, detailed analyses of glycemic variability, continuous glucose monitoring metrics, and adherence to a gluten-free diet were not available. Furthermore, no comparison was performed between patients with isolated T1D and those with coexisting celiac disease, limiting the interpretation of the direct impact of celiac disease on glycemic control.

Despite these limitations, our study provides valuable epidemiological data regarding CD in children and adolescents with T1D and highlights the importance of systematic screening and multidisciplinary management in this high-risk population.

CONCLUSION

Celiac disease is the most frequent autoimmune comorbidity associated with type 1 diabetes mellitus in our cohort, with a prevalence of 4.1%. Most cases were diagnosed within the first five years following the onset of diabetes, supporting the recommendations for systematic and repeated screening in children and adolescents with T1D.

The high proportion of patients with suboptimal glycemic control highlights the challenges associated with the coexistence of these two autoimmune disorders. Early diagnosis of celiac disease and appropriate multidisciplinary management, including nutritional counseling and regular metabolic monitoring, are essential to optimize glycemic control, growth, and overall quality of life.

Further prospective multicenter studies are needed to better evaluate the long-term impact of celiac disease and gluten-free diet adherence on metabolic outcomes in children with T1D.

DECLARATIONS

Ethics Approval and Consent to Participate

This retrospective study was conducted in accordance with the principles of the Declaration of Helsinki. Patient confidentiality and data anonymity were strictly maintained throughout the study. According to local institutional policies, formal ethics committee approval was not required for this retrospective review of anonymized medical records.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Funding

The authors received no specific funding for this work.

Conflict of Interest

The authors declare that they have no competing interests.

Author Contributions

SK conceived the study, collected the data, performed the literature review, and drafted the manuscript. HB, SKA, SA, HL, AMA, and ZI contributed to data interpretation, critical revision of the manuscript, and final approval of the submitted version.

All authors read and approved the final manuscript.

ACKNOWLEDGMENTS

The authors would like to thank the medical and nursing staff of the pediatric endocrinology and diabetology unit for their contribution to patient care and data collection.

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