

## Type 1 Diabetes Incidence among School-Aged Children and Adolescents in Sana'a City, Yemen

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### ABSTRACT

Childhood diabetes, once uncommon and often fatal in the early 20th century, has seen a steady rise in incidence by the century's end. This study aimed to assess the prevalence of diabetes among school children and adolescents in Sana'a city, Yemen. Out of a total student population of 26,410 across four educational districts, 2,870 students underwent diabetes screening through urine glucose testing. Initial suspicion from urine testing led to confirmation through blood glucose testing.

**Results:** Glucosuria in 10 out of 2,870 students, indicating an overall crude prevalence of 0.35% among the investigated school children and adolescents. The diagnosis of type 1 diabetes was confirmed through plasma glucose and C-peptide level testing in both index patients and a control group. Compared to the control group, students with diabetes exhibited significantly higher mean fasting and 2-hour postprandial plasma glucose levels ( $P < 0.0001$ ) but significantly lower mean fasting serum C-peptide values ( $P < 0.0001$ ). The age-standardized prevalence rate for the age range of 5-19 years (Census 1994 population-adjusted rate) was determined as 0.36% (95% CI: 0.2-0.5%).

**Conclusion:** Pediatric-onset Type 1 diabetes demonstrates a relatively prevalent presence among school

children and adolescents in Yemen, with a slightly higher frequency among those aged  $\geq$  15 years, showing no significant difference based on gender.

**Keywords:** Type 1 Diabetes; Screening.

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## INTRODUCTION

"At the onset of the 20th century, childhood Type 1 Diabetes (T1D) was a rare and swiftly fatal condition. However, as the century progressed, a consistent increase in its incidence was observed globally. In 2019, the International Diabetes Federation (IDF) estimated that, among the global child and adolescent population of 2.58 billion aged below 20 years, approximately 1,110,000 individuals had prevalent (existing) cases of T1D. This corresponds to a prevalence rate of 0.043%, translating to 43 existing cases per 100,000 in the global child and adolescent population [1-5].

Significant regional and national variations exist in the prevalence of prevalent (existing) and incident (new) cases of T1D worldwide. In the Eastern Mediterranean region, limited population-based studies on the prevalence of childhood T1D have been conducted. To our knowledge, this study represents the first population-based research endeavor to determine the prevalence of childhood diabetes in Yemen. The primary objective was to assess the prevalence of T1D among school children and adolescents aged 5-19 years in the capital city, Sana'a, Yemen."

## METHODS

### Study Population and Sampling Technique

The study was conducted in the first half of 1996, targeting the estimated population of Sana'a city, Yemen, based on the 1994 Census. The city's total population was approximately 972,011, with children aged less than 20 years constituting about 50% of the total resident population. Specifically, children aged 5-19 years were identified from the four educational district registers in Sana'a during the study period.

A list of schools from each educational district was prepared, and a random sample selection of two schools from each district was made to represent both basic and secondary educational levels. A stratified random sampling technique was then employed, ensuring representation from each level of education, encompassing at least 10% of the total number of students within each level [6-8].

Out of the total student population of 26,410 (17,188 in basic education and 9,222 in secondary education) in the eight selected schools from the four educational districts, 2,870 students (1,885 males and 985 females), constituting 10.9% of the population, were enrolled in the study. Of these, 1,888 students came from basic education, while 982 students came from secondary education.

### Laboratory Investigations

All enrolled students underwent diabetes screening through urine glucose testing. Students were instructed to collect a midstream urine specimen at home upon waking, both fasting and two hours post-breakfast. Urine glucose levels were determined using the dip-and-read method with enzyme glucose

oxidase reagent strips. Urine test results were considered positive if the glucose level was  $> 5.6$  mmol/L (100 mg/dL). Additionally, urine acetone was tested using Ketostex strips.

Students with glucosuria on initial screening were considered cases and underwent further investigation of their blood glucose and C-peptide levels. A matched control group of students without glucosuria was also investigated for comparison. Fasting venous blood samples were collected to determine fasting blood glucose, serum creatinine, and C-peptide levels. Second blood samples were collected two hours post-breakfast to measure postprandial blood glucose levels.

The diagnosis of Type 1 Diabetes (T1D) in students positive for glucosuria was confirmed through laboratory findings, including elevated plasma glucose levels, low fasting serum C-peptide ( $< 166$  pmol/l), concurrently obtained fasting blood glucose  $> 4.0$  mmol/l, and normal kidney function [9].

### Statistical Analysis

Data analysis involved the use of statistical software packages, including EpiInfo (version 6.02) and Confidence Interval Analysis (CIA) version 1.0. Crude prevalence rates of diabetes were calculated as percentages with 95% confidence intervals (95% CI). Age-standardized prevalence rates were determined for the age range 5-19 years, using the world population as the standard.

Continuous variables were expressed as means (SD), analyzed using the two-tailed t-test for statistical significance. Categorical variables were presented as numbers and percentages. The level of significance was set at  $< 0.05$ .

## RESULTS

All students participating in the study underwent screening, involving urine testing in both the fasting state and 2 hours after a high-carbohydrate breakfast. The results revealed the following [10-16]:

### Glucosuria Prevalence

- Glucosuria, indicative of elevated glucose levels in urine, was identified in 10 out of the 2,870 students screened.
- The overall crude prevalence of glucosuria among the investigated school children and adolescents was 0.35%.
- A slight gender difference was observed, with a higher prevalence in females (0.41%) compared to males (0.32%).

### Confirmed Diabetes Cases

- Among the 10 students with glucosuria, four were found to have a confirmed diagnosis of diabetes with varying durations of the condition.
- Cases of diabetes were deemed valid only if diagnosed by a physician and if the students were currently receiving insulin treatment.

### Additional Measurements for Diabetes Cases

All students with either screen-detected or previously diagnosed diabetes underwent further assessments, including measurement of urine ketones, blood glucose, serum creatinine, and plasma C-peptide (Table 1).

### Age at Diagnosis

The median (IQR) age at the diagnosis of diabetes among the confirmed cases was 14 (5.3) years, with a peak age observed at 15 years.

### Biomarkers for Type 1 Diabetes (T1D)

- Biomarkers associated with Type 1 Diabetes (T1D) were evident among these students:
- High mean ( $\pm$  SD) values of fasting plasma glucose:  $10.5 \pm 1.9$  mmol/l.
- Elevated postprandial plasma glucose concentration:  $14.8 \pm 2.6$  mmol/l.
- Low mean fasting serum C-peptide level:  $110 \pm 23$  pmol/l.

### Control Group Comparison

- A control group without glucosuria showed significantly different profiles:
- Lower mean ( $\pm$  SD) values of fasting plasma glucose:  $4.6 \pm 0.4$  mmol/l.
- Lower postprandial plasma glucose concentrations:  $5.5 \pm 0.3$  mmol/l.
- Higher mean fasting serum C-peptide level:  $483 \pm 100$  pmol/l.
- Statistical analysis indicated significant differences ( $p < 0.0001$ ) for each parameter between the diabetes cases and the control group.

### Overall Crude Prevalence

- Among the whole student population screened, the overall crude prevalence of T1D is 0.35% (95% CI: 0.2-0.6%).
- Slightly higher frequency in females (0.41%, 95% CI: 0.12-1.0%) compared to males (0.32%, 95% CI: 0.12-0.7%).
- Age-Standardized Prevalence:
- The estimated age-standardized prevalence rate for a truncated age range of 5-19 years in Yemen is 0.36% (95% CI: 0.2-0.5%).
- Substantially higher frequency in males (0.39%, 95% CI: 0.2-0.7%) compared to females (0.3%, 95% CI: 0.14-0.53%).
- Age-Adjusted Prevalence Rate:
- The overall estimated age-adjusted prevalence rate of T1D in children and adolescents in Yemen is 360 cases per 100,000 children aged 5-19 years.

Higher in males (390 cases per 100,000) compared to females (300 cases per 100,000).

Age Group at Diagnosis	Educational Level	Number of Cases (Males)	Number of Cases (Females)	Crude Prevalence Rate
5-14 years	Basic	3	2	0.31% (Overall)
				0.31% (Males)
				0.32% (Females)
15-19 years	Secondary	3	2	0.39% (Overall)
				0.33% (Males)
				0.57% (Females)

**Table 1:** Prevalence Rates of Type 1 Diabetes (T1D) among School Children and Adolescents by Age at Diagnosis and Sex.

## DISCUSSION

### The Association of Glucosuria with Elevated Blood Glucose Levels

Glucosuria, the presence of glucose in the urine, is primarily indicative of elevated blood glucose levels and is rarely associated with intrinsic renal issues. In 1974, Japan enacted a school health law mandating urine glucose screening for all primary and junior high school students. The primary goal of this screening was to identify children with diabetes at an early stage (14). Since the implementation of this mandate, several studies have been conducted in Japan and Korea, focusing on urine glucose screening as a means of early detection for both type 1 and type 2 diabetes in school children (6, 13, 14, 15, 16). This proactive approach underscores the importance of early identification and intervention in managing diabetes among the younger population [17].

The prevalence rates of Type 1 Diabetes (T1D) provide valuable insights into the size of the affected population, shaped by the prior incidence of the disease (4). In Yemen, the reported prevalence rate of T1D among children aged 5-19 years at diagnosis suggests an incidence rate that predates the 1996 study period. Previous findings from a diabetic clinic in Sana'a revealed a T1D prevalence of approximately 10.5% of the total diabetic population, with an average age at diagnosis of 16 years (17). T1D is typically characterized by its incidence, especially in childhood, which explains the scarcity of population-based prevalence studies in the Middle East region (4).

The current study in Yemen identified an overall crude prevalence rate of T1D among school children and adolescents at 0.35%. The age-standardized population-adjusted prevalence rate (Census 1994) stood at 0.36%, equivalent to 360 cases per 100,000 children and adolescents aged 5-19 years. In comparison with other Middle Eastern countries, Yemen's prevalence rates appear relatively higher than those

reported in Libya, Kuwait, Saudi Arabia, Oman, and Turkey.

The age-specific prevalence rate analysis indicated a higher rate among individuals aged 15 years and above (0.39%) compared to those aged under 15 years (0.31%). This finding contrasts with a previous estimate suggesting a slightly higher prevalence in children under 15 years in Yemen (23). The age-specific prevalence trends vary across countries, such as in Turkey, Kuwait, and Saudi Arabia.

It is important to note the study's limitations, including the relatively small number of children with diabetes detected among the total student population screened. This initial study, conducted in 1996 when there was limited data on T1D epidemiology in Yemen, prompted the initiation of a registry-based cohort study currently underway. The ongoing study, involving around 500 children and adolescents with T1D, aims to provide a more comprehensive understanding of T1D incidence and prevalence rates in Yemen.

## CONCLUSION

The prevalence of T1D among school children and adolescents in Yemen, with a higher frequency observed in those aged 15 years and above, without a significant difference between genders. To better characterize T1D trends in Yemen, further research focusing on the annual incidence of pediatric-onset T1D is recommended.

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