Original Article

Risk Factors Associated with Type 1 Diabetes Mellitus among Children and Adolescents in Multan Division, Pakistan - A Population-Based Case-Control Study

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Abstract

Background: Type 1 diabetes mellitus (T1DM) is a significant public health issue in the global community and its morbidity is growing in children and adolescents. Nonetheless, there is limited epidemiological evidence on risk factors, as well as clinical features of T1DM in developing countries like Pakistan.

Objective: The current study aimed to identify factors related to T1DM in children and adolescents in Multan Division of Pakistan.

Methods: A population-based case-control study was performed on a population of 614 participants [case (n=221) and control (n=393)]. A structured and validated questionnaire was used to collect data related to demographic characteristics, clinical and psychosocial variables. Descriptive statistics was used to summarize characteristics of the participants. Chi-square tests and logistic regression analysis were conducted to assess the association between potential factors and T1DM at $p < 0.05$ significant level.

Results: The current study revealed that Multan city had a higher rate of T1DM cases (42.9%; 95% CI: 37.7–48.1) compared to Jalalpur Pir Wala (27.4%; 95% CI: 21.0–34.6) and Shujabad (25.9%; 95% CI: 17.4–36.4). there was a significant relationship between age at diagnosis and T1DM with children diagnosed aged below 5 years showing more odds than those diagnosed between 6-10 years (OR = 0.44) and 11-15 years (OR = 0.12). Clinical indicators of the severity of the disease were almost universal insulin dependence (99.5%) and inadequate glycemic control with HbA1c levels between 9–10% (OR = 170.0) and >10% (OR = 29.0). Several diabetes-related complications were also significantly related to T1DM cases such as diabetic ketoacidosis (OR = 219.0), weight loss (OR = 22.6), visual problems (OR = 30.67), and hypoglycemic episodes (OR = 104.14). Children with T1DM had significant psychosocial challenges including social discrimination (OR = 104.14), negative community experiences (OR = 119.67), and substantial impacts on mental health (OR = 39.0).

Conclusion: The current study revealed that several demographic, clinical and psychosocial variables were associated with T1DM in children and adolescents. Therefore, there is need to enhance early detection, diabetes education/awareness programs, and further strengthen healthcare support systems to enhance disease management and patient wellbeing.

Keywords: Type 1 Diabetes Mellitus; case-control study; risk factors; children; adolescents

Introduction

Type 1 Diabetes Mellitus (T1DM) accounts for approximately 5-10% of all diabetic cases with an estimation of 8.8% of adults. To date, it has been estimated that more than 1.2 million children and adolescents worldwide have T1DM.[1] The incidence rate of T1DM is rising steadily in both developed and developing countries, presenting a growing public health challenge in the absence of a definitive cure.[2] It is a chronic autoimmune disease characterized by the progressive destruction of pancreatic β-cells, leading to absolute insulin deficiency and hyperglycemia. T1DM can be diagnosed at any age; however, its incidence rate peaks during adolescence, and most

available evidence on associated risk factors is derived from investigations on children and adolescents.[3] Globally, the incidence of T1DM has been on the rise with a varied rate of increase across regions and time periods. Most continents experienced an average annual rise of 2%–5% among children during the 1990s, a trend that has persisted in recent years. In some countries, however, this upward trend appears to have stabilized since around 2005. An annual increase of 2%–5% equates to a doubling of incidence approximately every 15–40 years.[1] Such rapid changes cannot be explained by shifts in the prevalence of genetic susceptibility within populations, indicating that unknown risk factors are likely driving this trend. The T1DM has now become the third most prevalent chronic disease of childhood in the United States. It is leading cause of nephropathy, retinopathy, neuropathy, and coronary and peripheral vascular disease and represents an enormous public health burden.[3] The incidence of T1DM in children is increasing, and knowledge of the temporal trends and the geographic, demographic, and biologic differences in incidence is necessary in elucidating the multifactorial cause of the disease.

In Pakistan, T1DM accounts for less than 2% of the diabetes burden, with an estimated annual incidence of 1.02 per 100,000 people.[4] Despite this, the epidemiological studies conducted in Pakistan are scarce, particularly in children and adolescents. It can be explained by the fact that effective infrastructure is not developed in the area and there are no research works devoted to the epidemiology of diabetes in the country. This is very threatening especially in the southern part of Punjab where these facilities are not available in the region. The Multan Division has more than one million inhabitants, and the area is not well in terms of infrastructure as compared to the occurrence of T1DM among the pediatric and adolescent population in the Multan division. The distribution of T1DM cases among the pediatric and adolescent population in the country has not been properly addressed because of the absence of a well-developed infrastructure in the area and the absence of the studies devoted to the distribution of T1DM cases among the pediatric and adolescent population in the country.[5,6] The given study, therefore, seeks to emphasize the distribution of T1DM cases within the pediatric and adolescent demographic within the Multan Division of the country and the risk factors of

the disease within the area, including the quality of care that the patients have obtained, as well as the availability of the healthcare system, within the country.

Methods

Before conducting this case-control study, a pilot study was conducted over a period of 8 weeks in the districts of Multan to validate research methodology and study design. For this purpose, a total of 58 participants, including TIDM cases and healthy controls, were selected through pediatric endocrineology departments and clinics. The semi-structured questionnaire was validated with the help of an expert review panel, including pediatric endocrineologists, epidemiologists, and diabetes educators. The validation was done on the basis of achieving excellent test-retest reliability with kappa values of 0.78-0.92 for categorical variables and intraclass correlation coefficients of 0.85-0.94 for continuous variables, thus validating the feasibility of the proposed methodology for this study. A case-control study was conducted on a total of 614 adolescents and children in the districts of Multan Division, Pakistan, between December 2023 and February 2024, with a total of 221 cases and 393 controls between the ages of 2 and 20 years. The cases for the study were defined as people who had T1DM during the time the research was conducted, had a confirmed laboratory test for the condition, had a medical record, and had been to healthcare facilities for treatment and routine follow-up. Sample size calculation for the study was conducted based on epidemiological principles for a case-control study design with the assumption of a known proportion for T1DM as 2%, a margin of error of ±0.5%, a confidence level of 95%, a design effect of 1.5 to account for clustering effects in the data, and a non-response rate of 15%. The specific formula used for the calculation was based on the following:

$$n = ((Z_{1-\alpha/2} + Z_{1-\beta})^2 * [p_1 * (1 - p_1) + p_2 * (1 - p_2)] / (p_1 - p_2)^2)$$

where $Z_{1-\alpha/2}$ is equal to 1.96 for a confidence level of 95%, $Z_{1-\beta}$ is equal to 0.84 for a power level of 80%, p_1 is the proportion in the cases, and p_2 is the proportion in the controls. In addition to this, the sample size was validated for the matched case-control design using the Pitman efficiency assumption for the sample size

estimation for a matched pair design. The calculated sample size for the research was a minimum of 580 participants, while the actual sample for the study comprised 614 participants, with 221 cases and 393 controls.

The primary cases were defined as children and adolescents between the ages of 2 and 19 years with a clinically confirmed diagnosis of T1DM. They were included if diagnosed with T1DM by a qualified physician, had HbA1c levels of ≥6.5% or fasting plasma glucose ≥126 mg/dL, were on insulin therapy, were diagnosed before the age of 19 years, and were residents of the Multan division for at least six months. Exclusion criteria for the cases included Type 2 diabetes mellitus, secondary diabetes resulting from pancreatic disease, maturity-onset diabetes of the young, drug-induced diabetes, and gestational diabetes among adolescent females. Controls were defined as age-matched healthy children and adolescents without diabetes who had no history of diabetes mellitus of any type, normal fasting glucose levels below 100 mg/dL, no first-degree family history of T1DM, met the same geographic residence requirements as cases, and were willing to participate in blood glucose testing. Cases were recruited through multiple channels including hospital-based recruitment from pediatric endocrinology clinics in major hospitals, community health centers serving as primary healthcare facilities for the division, existing diabetes registries and patient databases from healthcare providers and physician referrals from private practice endocrinologists and pediatricians. Controls were recruited using community-based sampling through random household surveys in the same geographic areas as cases, school-based recruitment of students from schools serving case neighborhoods, health facility recruitment of children attending for routine check-ups, and snowball sampling through referrals from participating families. The informed consent was obtained by assurance of the participants that their information was confidential and anonymous. An elaborate, well-designed questionnaire had been formulated and well tested in different stages of testing and reviewing. The questionnaire was split into important sections, such as demographic information, medical history, family history, presentation, management of diabetes, and assessment of the psychosocial impact, among others. To guarantee data quality and integrity, a double data entry system was embraced, as well as consistency checks. Questionnaires that were not completely filled and those that were not filled at all were not to be subjected to final analysis. Ethical concerns and privacy of the participants led to anonymization. Data entry involved the substitution of personal identifiers by participant codes thereby preserving confidentiality. To address data quality, a number of measures were applied, such as standardized work with written record of all the activities, data entry twice, range and consistency checks that were automated with automated validation, field work supervision through weekly field visit monitoring and external control through monthly independent quality evaluation. For the descriptive analysis, univariate analysis for both continuous and categorical variables was conducted using IBM SPSS version 22.0 software (IBM Corporation, Armonk, NY, USA) for primary data for secondary data analysis. Bivariate analysis included the use of the chi-square test for categorical variables. The level for significance was set to $p < 0.05$.

Results

A total of 614 participants were included in the study, comprising 221 cases and 393 controls. Multan city had the highest proportion of case (42.9%, 95% CI: 37.7-48.1%, p<0.001). Age was significantly associated with case status, with a higher proportion of cases observed among children younger than 5 years and adolescents (χ^2=77.146, p<0.001). Unemployed individuals having a greater proportion of case (62.2%, 95% CI: 52.9-70.9%) compared to individuals with occupation (χ^2=80.417, p<0.001) (Table 1). Among the clinical characteristics of cases, most participants were diagnosed at an early age year (95% CI: 80.0-90.4%, p<0.001) and nearly all required insulin therapy (95% CI: 97.4-99.9%, p<0.001). Poor glycemic control was evident among cases, with 99.4% having HbA1c levels 9-10% and 96.7% exceeding 10% (p<0.001). Several diabetes-related complications were frequently reported among cases including diabetic ketoacidosis (99.5%, 95% CI: 97.4-99.9%), hospitalization due to T1D complications (99.5%, 95% CI: 97.4-99.9%), hyperglycemia (99.5%, 95% CI: 97.4-99.9%), and hypoglycemia (99.1%, 95% CI: 95.2-99.9%) (all p<0.001). Psychosocial challenges were also notable with a high proportion of participants reporting negative social experiences (99.2%), feeling of discrimination (99.1%) and adve-

rse impacts on mental health (97.5%) (Table 1). Logistic regression analysis identified several factors significantly associated with T1DM. Compared to Multan city, Jalalpur Pir Wala City (OR=0.504, 95% CI: 0.363-0.700, p<0.001) and Shujabad City (OR=0.481, 95% CI: 0.295-0.784, p=0.003) showed lower odds of T1DM (Table 2). Age groups 6-10 years (OR=0.443, 95% CI: 0.270-0.728, p=0.001) and 11-15 years (OR=0.118, 95% CI: 0.068-0.205, p<0.001) showed significantly lower odds compared to <5

years. Family history of T1D showed high odds (OR=6.438, 95% CI: 2.831-14.645, p<0.001) with insulin intake (OR=219.000, 95% CI: 70.735-678.391, p<0.001) and rapid-long acting insulin type (OR=218.000, 95% CI: 43.921-1082.082, p<0.001). Clinically, all HbA1c levels >6% showed significantly higher odds of T1DM cases compared to <6% (p<0.001). Detailed regression results are presented in Table 2.

Table 1: *Socio-Demographic, Economic and Clinical Characteristics of Participants*

Variables	Case (n)	Control (n)	Total (n)	Percentage	95% C.I	χ^2	*p*-value
Location							
Multan City	150	200	350	42.9	37.7-48.1	16.71	<0.001*
Jalalpur Pir Wala City	49	130	179	27.4	21.0-34.6		
Shujabad City	22	63	85	25.9	17.4-36.4		
Gender							
Male	117	220	337	34.7	29.7-40.0	11.72	<0.001*
Female	104	173	277	37.5	31.9-43.5		
Age in years							
<5 years	39	25	64	60.9	48.8-72.2	77.15	<0.001*
6-10 years	79	114	193	40.9	34.1-48.0		
11-15 years	40	201	241	16.6	12.2-21.9		
16-20 years	63	53	116	54.3	45.0-63.4		
Education level							
Primary Level	125	150	275	45.5	39.3-51.7	19.28	<0.001*
Secondary Level	17	35	52	32.7	20.8-46.6		
Uneducated	79	208	287	27.5	22.5-33.0		
Marital status							
Single	215	378	593	36.3	32.4-40.3	3.92	0.048*
Married	6	15	21	28.6	11.6-52.2		
Designation							
Student	122	185	307	39.7	34.3-45.4	80.42	<0.001*
Business/Employed	2	4	6	33.3	4.3-77.7		
Labor	23	159	182	12.6	8.3-18.4		
Unemployed	74	45	119	62.2	52.9-70.9		
Type-1 Diabetes Diagnosis							
Yes	220	1	221	99.5	97.4-99.9	605.35	<0.001*
No	1	392	393	0.5	0.01-1.4		
Experience in Social Settings							
Positive	95	110	205	46.3	39.6-53.2	362.93	<0.001*
Negative	120	1	121	99.2	95.4-99.9		
Mixed	6	282	288	2.1	0.8-4.4		
Feeling of Discrimination							
Yes	115	1	116	99.1	95.2-99.9	246.06	<0.001*
No	106	392	498	21.3	17.8-25.2		
Impact on Mental Health and Wellbeing							
Positive	1	4	5	20.0	0.5-71.6	145.17	<0.001*
Negative	39	1	40	97.5	86.8-99.9		
Mixed	50	11	61	82.0	70.0-90.6		
No Impact	131	377	508	25.8	22.1-29.8		
Age of T1D Diagnosis							
<5 years	151	25	176	85.8	80.0-90.4	271.62	<0.001*
6-10 years	40	153	193	20.7	15.3-27.2		

11-15 years	24	114	138	17.4	11.6-24.8		
16-20 years	6	101	107	5.6	2.1-11.7		
Family History of T1D							
Yes	28	8	36	77.8	61.9-89.2	28.98	<0.001*
No	193	385	578	33.4	29.6-37.4		
Insulin Intake							
Yes	220	1	221	99.5	97.4-99.9	605.35	<0.001*
No	1	392	393	0.3	0.01-1.4		
Type of Insulin							
Rapid-Long acting	219	1	220	99.5	97.4-99.9	603.17	<0.001*
Short-acting	1	1	2	50.0	1.3-98.7		
Other/None	1	391	392	0.3	0.01-1.4		
Diabetic Ketoacidosis Experience							
Yes	220	1	221	99.5	97.4-99.9	605.35	<0.001*
No	1	392	393	0.3	0.01-1.4		
Hospitalized due to T1D Complications							
Yes	211	1	212	99.5	97.4-99.9	567.35	<0.001*
No	10	392	402	2.5	1.2-4.5		
Hyperglycemia Experience							
Yes	215	1	216	99.5	97.4-99.9	584.03	<0.001*
No	6	392	398	1.5	0.6-3.2		
Latest HbA1c Value							
<6%	1	390	391	0.3	0.01-1.4	597.03	<0.001*
6-8%	20	1	21	95.2	76.2-99.9		
9-10%	171	1	172	99.4	96.8-99.9		
>10%	29	1	30	96.7	82.8-99.9		
Diabetes Management Education							
Yes	207	26	233	88.8	84.4-92.4	551.01	<0.001*
No	14	367	381	3.7	2.0-6.1		
Clinical Visit Frequency							
Monthly	217	1	218	99.5	97.5-99.9	598.116	<0.001*
Every 3 months	1	1	2	50.0	1.3-98.7		
Every 6 months	1	1	2	50.0	1.3-98.7		
Annually	1	2	3	33.3	0.8-90.6		
Other	1	388	389	0.3	0.01-1.4		
Ever Skipped/Missed Insulin Dose							
Yes	193	1	194	99.5	97.0-99.9	495.09	<0.001*
No	28	392	420	6.7	4.5-9.5		
Specific Diet Intake							
Yes	220	3	223	98.7	96.2-99.7	596.82	<0.001*
No	1	390	391	0.3	0.01-1.4		
Weight Loss							
Yes	114	5	119	95.8	90.5-98.6	229.16	<0.001*
No	107	388	495	21.6	18.1-25.5		
Impact on Eyesight							
Yes	31	1	32	96.9	83.8-99.9	54.32	<0.001*
No	190	392	582	32.6	28.9-36.6		
Numbness/Heat in Hands/Feet							
Yes	66	2	68	97.1	89.8-99.6	123.77	<0.001*
No	155	391	546	28.4	24.7-32.4		
UTI Problems							
Yes	7	3	10	70.0	34.8-93.3	5.11	0.024*
No	214	390	604	35.4	31.7-39.3		
Hypoglycemia Experience							
Yes	115	1	116	99.1	95.2-99.9	246.06	<0.001*
No	106	392	498	21.3	17.8-25.2		

Abbreviations; n: number of participants, C.I: confidence interval. *: significant association (p<0.05)

Table 2: *Regression Analysis for Socio-demographic, Economic and Clinical Characteristics of Participants*

Variable	β Coefficient	SE	Odds Ratio (OR)	95%CI (OR)	Z-value	p-value
Location						
Multan City				(Ref)		
Jalalpur Pir Wala City	-0.684	0.167	0.50	0.36-0.70	-4.095	<0.001*
Shujabad City	-0.733	0.250	0.48	0.29-0.78	-2.932	0.003*
Gender						
Male				(Ref)		
Female	0.122	0.156	1.13	0.83-1.53	0.782	0.434NS
Age in years						
<5 years				(Ref)		
6-10 years	-0.816	0.253	0.44	0.27-0.72	-3.225	0.001*
11-15 years	-2.134	0.283	0.11	0.06-0.20	-7.543	<0.001*
16-20 years	0.271	0.302	1.31	0.72-2.37	0.897	0.370
Education level						
Primary Level				(Ref)		
Secondary Level	-0.547	0.282	0.57	0.33-1.00	-1.940	0.052*
Uneducated	-0.776	0.164	0.46	0.33-0.63	-4.732	<0.001*
Marital status						
Single				(Ref)		
Married	-0.351	0.445	0.70	0.29-1.68	-0.789	0.430NS
Designation						
Student				(Ref)		
Business/Employed	-0.268	0.816	0.76	0.15-3.79	-0.328	0.743NS
Labor	-1.710	0.238	0.18	0.11-0.28	-7.185	<0.001*
Unemployed	0.913	0.213	2.49	1.64-3.78	4.285	<0.001*
Type-1 Diabetes Diagnosis						
No				(Ref)		
Yes	5.393	0.577	219.00	70.73-678.39	9.347	<0.001*
Experience in Social Settings						
Positive				(Ref)		
Negative	4.787	0.577	119.66	38.66-370.55	8.295	<0.001*
Mixed	-3.850	0.577	0.02	0.007-0.06	-6.672	<0.001*
Feeling of Discrimination						
No				(Ref)		
Yes	4.647	0.577	104.14	33.65-322.28	8.053	<0.001*
Impact on Mental Health and Wellbeing						
No Impact				(Ref)		
Positive	-1.371	1.155	0.25	0.02-2.44	-1.187	0.235NS
Negative	3.664	0.577	39.00	12.61-120.64	6.351	<0.001*
Mixed	1.520	0.354	4.57	2.28-9.14	4.293	<0.001*
Age of T1D Diagnosis						
<5 years				(Ref)		
6-10 years	-1.827	0.229	0.16	0.10-0.25	-7.982	<0.001*
11-15 years	-1.953	0.262	0.14	0.08-0.23	-7.454	<0.001*
16-20 years	-2.849	0.448	0.05	0.02-0.13	-6.359	<0.001*
Family History of T1D						
No				(Ref)		
Yes	1.862	0.419	6.43	2.83-14.64	4.445	<0.001*
Insulin Intake						
No				(Ref)		
Yes	5.393	0.577	219.00	70.73-678.39	9.347	<0.001*
Type of Insulin						
Other/None				(Ref)		

Rapid-Long acting	5.389	0.816	218.00	43.92-108.08	6.604	<0.001*
Short-acting	0.693	1.414	2.00	0.12-31.74	0.490	0.624NS
Diabetic Ketoacidosis Experience						
No	(Ref)					
Yes	5.393	0.577	219.00	70.73-678.39	9.347	<0.001*
Hospitalized due to T1D Complications						
No	(Ref)					
Yes	5.340	0.577	208.10	67.23-644.35	9.256	<0.001*
Hyperglycemia Experience						
No	(Ref)					
Yes	5.364	0.577	214.16	69.19-662.75	9.298	<0.001*
Latest HbA1c Value						
<6%	(Ref)					
6-8%	2.996	0.577	20.00	6.46-61.87	5.193	<0.001*
9-10%	5.135	0.577	170.00	54.95-526.09	8.900	<0.001*
>10%	3.367	0.577	29.00	9.37-89.77	5.835	<0.001*
Diabetes Management Education						
No	(Ref)					
Yes	3.002	0.213	20.11	13.24-30.54	14.095	<0.001*
Clinical Visit Frequency						
Other	(Ref)					
Monthly	5.375	0.816	216.00	43.52-1071.42	6.587	<0.001*
Every 3 months	0.693	1.414	2.00	0.12-31.74	0.490	0.624NS
Every 6 months	0.693	1.414	2.00	0.12-31.74	0.490	0.624NS
Annually	0.405	1.225	1.50	0.13-16.41	0.331	0.741NS
Ever Skipped/Missed Insulin Dose						
No	(Ref)					
Yes	5.258	0.577	192.00	62.07-594.28	9.115	<0.001*
Specific Diet Intake						
No	(Ref)					
Yes	5.298	0.577	200.00	64.63-618.85	9.184	<0.001*
Weight Loss						
No	(Ref)					
Yes	3.117	0.258	22.60	13.63-37.47	12.083	<0.001*
Impact on Eyesight						
No	(Ref)					
Yes	3.434	0.577	30.66	9.91-94.80	5.953	<0.001*
Numbness/Heat in Hands/Feet						
No	(Ref)					
Yes	3.481	0.408	32.50	14.62-72.22	8.532	<0.001*
UTI Problems						
No	(Ref)					
Yes	0.847	0.707	2.33	0.58-9.33	1.198	0.231NS
Hypoglycemia Experience						
No	(Ref)					
Yes	4.647	0.577	104.14	33.6-322.28	8.053	<0.001*

*: significant association (p<0.05), NS: non-significant (p>0.05)

Discussion

The presented study highlighted a definite contrast to established continuous surveillance of T1DM, its management and clinical outcomes in Pakistan. While Pakistan has been identified as having the third largest diabetes population however most of research has focused predominantly on T2DM, [5,6] with many patients suffering from T1DM going undiagnosed and making the actual prevalence much higher than officially reported.[7] Our study revealed that the majority of children with T1DM presented with diabetic ketoacidosis (DKA) at diagnosis, demonstrating a concerning pattern of diagnostic delay that persists throughout the region. This finding is consistent with previous research

from Pakistan and other low- and middle-income countries, where inadequate public awareness, insufficient screening protocols, and limited access to specialized pediatric endocrinology services collectively contribute to delayed diagnosis and late clinical presentation.[8,9] The higher distribution of T1DM cases in Multan city compared with other cities suggests urban–rural or regional differences in detection and disease occurrence. This geographic clustering may be explained by the superior diagnostic capabilities of the population of Multan city, which might result in a higher detection rate of T1DM, the environmental triggers of T1DM that might be more common in the urban setting, or genetic factors such as founder effects.[10] Further, the earlier studies have also emphasized that the geographic clustering of T1DM might be explained by the differences in healthcare facilities, awareness drives, and socioeconomic factors of the population of the urban countries of the region as compared to the rural areas.[11,12] Thus, the inclusion of early screening of high-risk children, such as children with a family history of T1DM or autoimmune conditions, might result in the early diagnosis of T1DM, reduce the incidence of DKA, and consequently T1DM.[13] The bimodal distribution of T1DM with a peak incidence of the condition among children younger than 5 years of age (60.9%) and among adolescents aged 16-20 years (54.3%) is consistent with the global distribution of T1DM. However, the very early onset of T1DM, i.e., before the age of 5 years, is very high among the children of the region.[14] This might be explained by the genetic predisposition of the South Asian population to very early onset of T1DM, with HLA associations with T1DM, the triggers of T1DM that might be more common in the region, or diagnostic bias whereby only the most severe cases are being detected.[15] The current study revealed a significant relationship between T1DM cases and younger patient age, lower socioeconomic status, and lack of diabetes education. This study supports the research by Talbo et al.[16] that identified that children from socioeconomically disadvantaged backgrounds are at a higher risk of T1DM by a substantial factor. This disparity arises from healthcare access barriers that exist due to differences in healthcare systems. In this study, most patients were found to exhibit hyperglycemia. Some patients also experienced repeated episodes of hypoglycemia. Hypoglycemia

among children with T1DM often arises from the complicated relationship between carbohydrate and insulin dosing protocols. This phenomenon is perhaps the most persistent challenge that arises in managing diabetes among children.[17] The current study revealed that children with longer disease duration experienced higher rates of severe hypoglycemia. This phenomenon aligns with previous research that identified that increased complexity of insulin dosing regimens and inconsistent glucose monitoring protocols increase the risk of hypoglycemia among children. This phenomenon indicates that children are experiencing T1DM as an acute problem rather than a chronic disease.

The overwhelming nature of these negative social experiences and discrimination is an indication of the high stigmatization that is associated with diabetes in this culture. This could be a factor that contributes to the disease burden because it could discourage people from discussing their condition, adhering to treatment, or receiving support from their communities.[18-20] The impact of the social effects that were found in this study, although consistent with the previous research on diabetes stigmatization in the South Asian culture, was found to be of a higher magnitude.[21,22] The findings of the current study indicate that there are systemic failures in the healthcare system in the management of T1DM. This includes the lack of an insulin supply chain, lack of education resources for the patients, and lack of social support systems. The most interesting findings in the current study are those that indicate a paradox in the relationship between healthcare engagement and outcomes. This is because, despite high healthcare engagement in that 99.5% of the population maintaining regular visits with their healthcare providers, as well as 88.8% receiving diabetes education, the results indicate that there are other factors at play. This could include the fact that the patients are expected to procure their insulin at their own expense, thus causing treatment discontinuation despite regular visits to the healthcare facilities. It could also be because the diabetes education that is provided may not be appropriate in this culture.[23,24]

Conclusion

The present study has generated baseline data with regard to the burden of T1DM among children and adolescence. These results highlight the importance

of implementing targeted interventions in the community setting. These results highlight the importance of implementing cultural-specific awareness programs, developing comprehensive education initiatives in the school system with regard to the symptoms of diabetes, and developing a strong system of healthcare referral.

Ethical Approval: The Institutional Review Board, MNS University of Agriculture, Multan approved this study vide No: IRB/MNSUAM/703-024.

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Authors' Contribution:

MA: Conception and design, acquisition of data, analysis and interpretation, manuscript writing, final approval of the version to be published

AB, NS, ZP, MSI, GM: Acquisition of data, analysis and interpretation, manuscript writing, final approval of the version to be published

MAR: Drafting of article, critical revisions for important intellectual content, final approval of the version to be published

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