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A Retrospective Study on the Prevalence of Type 1 and Type 2 Diabetes Mellitus

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ABSTRACT

Diabetes mellitus is a major and rapidly growing health burden in Pakistan, yet contemporary district-level information on the relative distribution of type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) remains limited. This retrospective cross-sectional study described the case mix of T1DM and T2DM and examined age- and sex-related patterns among patients with laboratory-confirmed diabetes in District Dera Ismail Khan. Records from four private diagnostic laboratories were reviewed for the period 1 January to 31 December 2025. A total of 804 eligible patients were included. Diabetes status was supported by fasting blood glucose or glycated hemoglobin results, whereas diabetes type was taken from the physician diagnosis documented in the laboratory record. Descriptive statistics and Pearson chi-square tests were used. T2DM accounted for 792 of 804 cases (98.5%), while T1DM accounted for 12 (1.5%). Males represented 57.2% of patients and females 42.8%. Diabetes type was not associated with sex (χ^2=0.006, p=.937). Age showed a strong association with diabetes type (χ^2=457.123, p<.001): all six patients aged 0–17 years had T1DM, whereas among those aged 18–34 years, 6 had T1DM and 34 had T2DM; all patients aged 35 years or older had T2DM. The 50–64-year group was the largest age category (41.0%). These findings show a pronounced predominance of T2DM among diagnosed patients attending private laboratories and a clear age-related separation of diabetes type. Because the sampling frame contained diabetic patients only, the reported percentages represent the distribution of diabetes types within the clinical sample and should not be interpreted as population prevalence estimates.

Keywords: Type 1 Diabetes Mellitus; Type 2 Diabetes Mellitus; Age Distribution; Retrospective Study.

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INTRODUCTION

Diabetes mellitus is a heterogeneous group of metabolic disorders characterized by persistent hyperglycemia resulting from impaired insulin secretion, impaired insulin action, or both. Although hyperglycemia is the shared biochemical feature, the major forms of diabetes differ substantially in their pathophysiology, age distribution, treatment requirements, and long-term clinical course. Type 1 diabetes mellitus is most commonly caused by autoimmune destruction of pancreatic beta cells and usually produces an absolute requirement for insulin. Type 2 diabetes mellitus, in contrast, develops through a combination of insulin resistance and progressive loss of adequate beta-cell insulin secretion. Current clinical guidance emphasizes that correct classification matters because management, education, monitoring, and the risk of acute metabolic complications can differ by diabetes type (American Diabetes Association Professional Practice Committee for Diabetes, 2026).

The global burden of diabetes has expanded rapidly over the past three decades. The Global Burden of Disease 2021 analysis estimated that approximately 529 million people were living with diabetes in 2021 and projected that the number could exceed 1.31 billion by 2050 if present demographic and epidemiologic trends continue (GBD 2021 Diabetes Collaborators, 2023). A later pooled analysis of population-representative studies estimated 828 million adults with diabetes in 2022, while the International Diabetes Federation (IDF) estimated 588.7 million adults aged 20–79 years were living with diabetes in 2024 (NCD Risk Factor Collaboration [NCD-RisC], 2024; International Diabetes Federation [IDF], 2025). These estimates are not directly interchangeable because they use different age ranges, datasets, and modeling methods, but they converge on the same conclusion: diabetes has become a major and growing public-health challenge.

Pakistan is particularly affected by this transition. The IDF Diabetes Atlas 11th edition estimated approximately 34.5 million adults aged 20–79 years with diabetes in Pakistan in 2024, placing the country among those with the largest absolute number of affected adults worldwide (IDF, 2025). Earlier national field data also demonstrated a substantial burden. In the Diabetes Prevalence Survey of Pakistan (DPS-PAK), Aamir *et al*. (2019) reported a type 2 diabetes prevalence of 16.98% among 18,856 adults aged 20 years and older using glycated hemoglobin (HbA1c) as the principal screening method. The same study showed strong associations between diabetes and increasing age, adiposity, family history, and blood pressure. More recent global analyses have similarly identified Pakistan as one of the countries with very high age-standardized diabetes prevalence (NCD-RisC, 2024).

The public-health meaning of "diabetes prevalence," however, depends on the denominator from which the estimate is calculated. A population prevalence estimate requires a defined source population that includes both people with and without diabetes. A dataset composed only of patients already diagnosed with diabetes can instead describe the proportion of different diabetes types, demographic composition, and other patterns within the diagnosed sample. This distinction is important for district-level retrospective laboratory studies, where available records may be valuable for understanding the local clinical case-mix but do not necessarily represent the entire population. In the present article, therefore, the term distribution is used for the study's main outcomes rather than population prevalence.

District Dera Ismail Khan, located in southern Khyber Pakhtunkhwa, includes urban and rural communities and receives patients from a broad surrounding catchment. Regional evidence indicates that diabetes is an important local health concern. Abbas *et al*. (2023), in a study of 600 participants from different tehsils of District Dera Ismail Khan, reported an overall diabetes prevalence of 38% and found that the largest proportion of diabetic participants

were in the 41–60-year age range. Their study also identified physical inactivity, hypertension, obesity, and high cholesterol as common risk factors among affected individuals. Although that work documented the broad burden of diabetes in the district, it focused mainly on type 2 diabetes and related complications. District-level information directly comparing the documented occurrence of T1DM and T2DM across age and sex groups remains limited.

The distinction between T1DM and T2DM is epidemiologically relevant. T1DM is less common in absolute numbers but has major implications for lifelong insulin therapy and often appears earlier in life. A systematic review covering 55 countries found substantial international variation in childhood and adolescent T1DM incidence, with the highest rates generally reported in higher-income regions (Hormazabal-Aguayo *et al*., 2024). At the same time, adult-onset T1DM is increasingly recognized, meaning that age alone cannot be used as a definitive diagnostic classifier. T2DM remains the dominant form globally and is strongly related to population aging, adiposity, physical inactivity, diet, and genetic susceptibility. The relative frequency of the two types within a district's diagnostic services can therefore provide useful information for planning insulin availability, laboratory services, screening strategies, and referral pathways.

The present study used routinely collected diagnostic-laboratory records from 2025 to describe the distribution of T1DM and T2DM among diagnosed diabetic patients in District Dera Ismail Khan. The specific objectives were to determine the proportion of diagnosed patients classified as T1DM or T2DM, examine the sex distribution within each diabetes type, describe age-group patterns, and test whether diabetes type was statistically associated with sex and age. The study also provides an updated local clinical profile that can be compared with national and international evidence while explicitly recognizing the limitations of a retrospective, laboratory-based convenience sample.

LITERATURE REVIEW

Globally, diabetes epidemiology is shaped by a combination of demographic change, urbanization, obesity, dietary transition, socioeconomic conditions, access to diagnosis, and survival after diagnosis. The GBD 2021 analysis showed that the worldwide burden is increasing in nearly every region and projected a particularly large future increase in low- and middle-income countries (GBD 2021 Diabetes Collaborators, 2023). NCD-RisC (2024), using 1,108 population-representative studies with measured fasting glucose or HbA1c, estimated that global age-standardized diabetes prevalence in 2022 was approximately 14% in both women and men. The analysis also found that treatment coverage had not increased sufficiently in many lower-income settings, including parts of South Asia. These findings place district-level surveillance in Pakistan within a broader context of rapidly expanding chronic disease burden and unequal access to effective detection and treatment.

T1DM represents a smaller fraction of all diabetes but is clinically distinctive. Autoimmune destruction of pancreatic beta cells leads to progressive insulin deficiency, and the disease can develop from childhood through adulthood. Staging models recognize presymptomatic autoimmune phases characterized by persistent islet autoantibodies before clinical hyperglycemia becomes evident (Insel *et al*., 2015). Contemporary pediatric guidelines also emphasize that T1DM should be considered across a spectrum of ages and that appropriate classification may require clinical features, autoantibodies, C-peptide, genetic testing, or follow-up when the phenotype is uncertain (Haller *et al*., 2024). The strong concentration of T1DM in younger patients remains epidemiologically important, but age should not be treated as an absolute rule.

International surveillance demonstrates large geographic variation in T1DM incidence. Hormazabal-Aguayo *et al*. (2024) pooled evidence from 126 studies across 55 countries and reported marked between-region differences among people younger than 20 years. The highest incidence rates were observed in Finland and other high-income regions, while many low- and middle-income settings had lower recorded rates. Lower observed incidence in resource-limited settings can reflect a true epidemiologic difference, but it may also be influenced by underdiagnosis, limited surveillance, early mortality, or incomplete case registration. These factors are particularly relevant when interpreting small numbers of T1DM in laboratory-based datasets.

T2DM is the predominant form of diabetes worldwide. Its pathophysiology involves insulin resistance in key metabolic tissues together with progressive beta-cell dysfunction and inadequate insulin secretion. DeFronzo (2009) described the multifactorial nature of T2DM, emphasizing that hyperglycemia emerges from interacting abnormalities in insulin secretion, hepatic glucose production, peripheral glucose uptake, adipose-tissue metabolism, incretin function, glucagon regulation, and renal glucose handling. Population-level T2DM risk is strongly influenced by age, obesity, physical inactivity, dietary patterns, family history, and social and environmental determinants. Because these determinants have become increasingly common in rapidly urbanizing societies, T2DM now contributes to the overwhelming majority of diagnosed diabetes cases in most adult populations.

Pakistan's diabetes burden has been documented through national surveys and meta-analyses, although estimates vary by diagnostic method and study population. The DPS-PAK survey used a multistage sampling design and HbA1c testing and reported T2DM in 16.98% of adults aged 20 years and older (Aamir *et al*., 2019). National estimates based on other diagnostic methods have produced different values, demonstrating the sensitivity of prevalence estimates to sampling and diagnostic criteria. In 2024, the IDF estimated 34.5 million adults aged 20–79 years with diabetes in Pakistan, while NCD-RisC placed Pakistan among countries with the highest age-standardized prevalence (IDF, 2025; NCD-RisC, 2024). These contemporary sources reinforce the importance of local data to guide service planning.

Within Khyber Pakhtunkhwa, diabetes patterns may vary across urban and rural settings because of differences in lifestyle, socioeconomic conditions, access to diagnosis, and health-seeking behavior. The DPS-PAK included sites from Khyber Pakhtunkhwa as part of its national sample and demonstrated significant variation in diabetes prevalence across demographic groups (Aamir *et al*., 2019). District-level investigations are therefore useful complements to national data, particularly where they can identify the age groups and clinical categories most frequently appearing in local services. Dera Ismail Khan has been the subject of several diabetes-related investigations. Abbas *et al*. (2023) sampled 600 participants across Dera Ismail Khan, Paroa, and Paharpur and reported 228 diabetic participants, corresponding to 38% of the sampled population. They observed substantial variation by tehsil and found that the 41–60-year age group carried the greatest burden. Their findings are consistent with the well-established age gradient in T2DM and with the influence of modifiable cardiometabolic risk factors. Importantly, however, that study was designed to estimate broad diabetes prevalence and complications rather than to examine the relative distribution of T1DM and T2DM among diagnosed patients.

The existing evidence therefore leaves a specific local gap. Health services need to know not only how much diabetes exists in the population, but also what types of diabetes are being encountered in clinical practice and at what ages. T1DM and T2DM differ in insulin dependence, education needs, monitoring strategies, risk of ketoacidosis, and long-term treatment pathways. A laboratory-record review can help characterize this service-

level case-mix. It cannot substitute for a population-based prevalence survey, but it can provide a practical snapshot of the diagnosed patients who interacted with local diagnostic services during a defined time period. The present study was undertaken to provide that snapshot for District Dera Ismail Khan using 2025 records.

MATERIALS AND METHODS

Study Area and Design

The study was conducted in District Dera Ismail Khan, a southern district of Khyber Pakhtunkhwa, Pakistan, located along the western bank of the Indus River. The district includes a mixture of urban and rural communities and several tehsils, including Dera Ismail Khan, Paharpur, Paroa, and Kulachi. A retrospective cross-sectional design was used. The source material consisted of diagnostic-laboratory records rather than prospectively recruited participants.

Study Period and Data Sources

Records were reviewed for the one-year period from 1 January 2025 through 31 December 2025. Data were obtained from four private diagnostic laboratories in District Dera Ismail Khan after permission from the relevant laboratory management. Laboratory information systems and manual registers were used as source records. Patient identifiers were excluded from the analytical dataset.

Study Population and Sample Size

The study population consisted of patients with a documented diagnosis of diabetes mellitus who had attended the selected laboratories during the study period. A total of 804 eligible patient records were available and were included in the analysis. The sample was therefore based on the availability of complete eligible records rather than on a population probability-sampling frame.

Eligibility Criteria

Records were eligible when the patient had a documented diagnosis of T1DM or T2DM, had a laboratory-supported diabetes diagnosis based on fasting blood glucose or HbA1c, and had complete information on age and sex. Both males and females and all age groups were eligible. Records were excluded if they were incomplete, lacked confirmation of diabetes, represented duplicate entries, lacked essential demographic information, or related to pregnancy/gestational diabetes.

Variables and Diabetes Classification

The extracted variables were age in completed years, sex as recorded in the laboratory record, diabetes type, and the diagnostic test supporting the diagnosis. Patients were classified as T1DM or T2DM according to the physician diagnosis recorded in the laboratory report. Fasting blood glucose and HbA1c were used to support the presence of diabetes, not to infer the diabetes type. This distinction is important because glucose and HbA1c establish chronic hyperglycemia but do not, by themselves, reliably distinguish autoimmune T1DM from T2DM. Current ADA criteria recognize A1C ≥6.5% or fasting plasma glucose ≥126 mg/dL, among other criteria, as diagnostic thresholds for diabetes in nonpregnant individuals (American Diabetes Association Professional Practice Committee for Diabetes, 2026).

Age Grouping

For analysis, age was categorized into five groups: 0–17, 18–34, 35–49, 50–64, and 65–92 years. These categories were retained from the thesis dataset so that the manuscript remained fully traceable to the original statistical output.

Statistical Analysis

Data were analyzed using Microsoft Excel and SPSS version 25.0 in the original study. Frequencies and percentages were calculated for diabetes type, sex, and age group. Cross-tabulations were constructed to examine diabetes type by sex and age. Pearson chi-square tests were used to test the association between sex and diabetes type, age group and diabetes type, and age group and sex. Statistical significance was defined as $p<.05$. For reporting, values originally shown as $p=.000$ are expressed as $p<.001$, consistent with standard statistical practice. Cramer's V was calculated from the reported chi-square values to provide an interpretable measure of association strength. Because the T1DM count was small and several expected cell counts in the age-by-type table were below five, the age-by-type chi-square result should be interpreted with caution; the very large observed separation nevertheless indicates a pronounced age pattern.

Interpretation of Percentages

All 804 records represented patients already diagnosed with diabetes. Accordingly, the percentages reported in this study represent the proportion of diabetes and demographic categories among diagnosed patients attending the selected laboratories. They are not estimates of diabetes prevalence in the general population of District Dera Ismail Khan.

Ethical Considerations

Ethical approval was obtained from the relevant institutional ethical review committee, and patient confidentiality was maintained by excluding names, addresses, and contact details from the analytical dataset.

Diagnostic Criteria and Classification of Diabetes Mellitus

Diabetes mellitus was identified using laboratory findings documented in the available diagnostic records, including fasting blood glucose and glycated hemoglobin (HbA1c) measurements. Classification into Type 1 diabetes mellitus (T1DM) and Type 2 diabetes mellitus (T2DM) was based on the clinical diagnoses recorded by the attending physicians. As the investigation was retrospective, the classification process depended on previously documented clinical information rather than independent diagnostic reassessment. Additional investigations, including C-peptide measurement and pancreatic islet autoantibody testing, were not systematically available in the laboratory records. Consequently, the recorded diabetes categories were retained for analysis, while the potential for diagnostic misclassification was considered when interpreting the findings.

RESULTS AND FINDINGS

Overall Profile of the Study Sample

The analytical sample comprised 804 patients with a documented diabetes diagnosis. Of these, 460 were male (57.2%), and 344 were female (42.8%). The age distribution was concentrated in middle and later adulthood: 330 patients (41.0%) were aged 50–64 years, 222 (27.6%) were aged 35–49 years, and 206 (25.6%) were aged 65–92 years. Younger patients represented a small fraction of the laboratory case-mix, with 40 patients (5.0%) aged 18–34 years and six (0.7%) aged 0–17 years. This profile is consistent with the dominant contribution of T2DM to adult clinical

services, but it also reflects the specific sampling frame of private diagnostic laboratories rather than a population census.

Table 1

Demographic Characteristics of Diagnosed Diabetic Patients (N=804)

Characteristic	Category	n	%
Sex	Male	460	57.2
	Female	344	42.8
Age group (years)	0–17	6	0.7
	18–34	40	5.0
	35–49	222	27.6
	50–64	330	41.0
	65–92	206	25.6

Percentages Are Calculated Within the Total Study Sample.

Distribution of Type 1 and Type 2 Diabetes

T2DM was overwhelmingly predominant in the study sample. Of 804 diagnosed patients, 792 were classified as T2DM (98.5%) and 12 as T1DM (1.5%). Figure 1 illustrates this marked difference. The result should be interpreted as the clinical distribution of diabetes among patients using the selected laboratories. It does not mean that 98.5% of residents of Dera Ismail Khan have T2DM, nor does it provide a district population prevalence estimate.

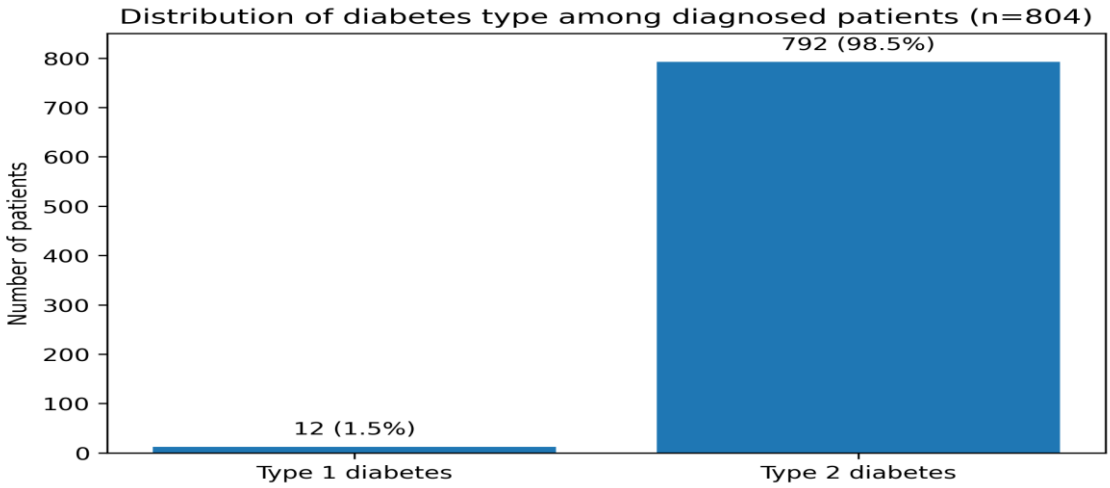


Figure 1

Distribution of Documented Diabetes Type Among Diagnosed Patients (N=804). Figure Generated from the Study Dataset for This Manuscript.

The dominance of T2DM is consistent with global evidence showing that T2DM accounts for the vast majority of diabetes cases. The GBD 2021 analysis estimated that approximately 96% of diabetes globally in 2021 was T2DM (GBD 2021 Diabetes Collaborators, 2023). The 98.5% proportion observed here is somewhat higher, which may reflect the demographic structure of the patients, the selection of private diagnostic laboratories, differences in

referral patterns, or underrepresentation of young people and patients with T1DM. The present data cannot determine which of these mechanisms contributed most strongly. Nevertheless, the finding confirms that these diagnostic services encounter T2DM as the principal form of diabetes. From a service-planning perspective, a high T2DM caseload implies sustained demand for glycemic monitoring, cardiovascular-risk assessment, kidney and eye screening, medication follow-up, and lifestyle counseling. At the same time, the relatively small number of T1DM cases should not be interpreted as a low clinical priority. T1DM requires uninterrupted insulin access and carries a substantial risk of acute metabolic decompensation when insulin is interrupted. A service system designed around the numerical dominance of T2DM must therefore still preserve rapid recognition and appropriate management pathways for T1DM.

Diabetes Type and Sex

Among males, 7 of 460 patients had T1DM and 453 had T2DM. Among females, 5 of 344 had T1DM and 339 had T2DM. The sex composition was therefore almost identical across the two diabetes types: males represented 58.3% of T1DM and 57.2% of T2DM cases, whereas females represented 41.7% and 42.8%, respectively. Pearson's chi-square test showed no evidence of association between sex and diabetes type ($\chi^2(1)=0.006$, p=.937). Cramer's V was approximately .003, indicating a negligible association in this dataset.

Table 2

Diabetes Type by Sex

Sex	Type 1, n	Type 2, n	Total, n	Type 1 within sex, %
Male	7	453	460	1.5
Female	5	339	344	1.5
Total	12	792	804	1.5

Pearson $\chi^2(1)=0.006$, p=.937; Cramer's V≈.003.

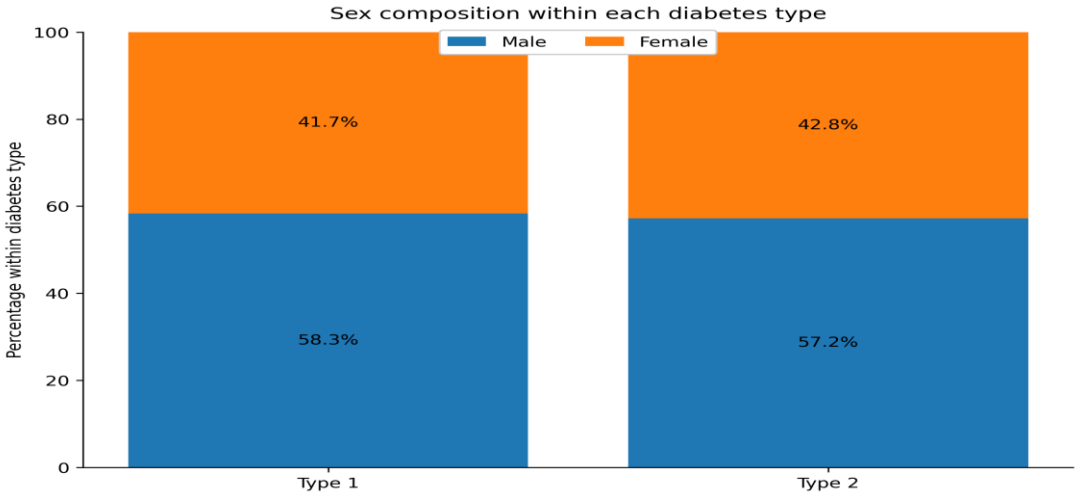


Figure 2

Sex Composition Within Type 1 And Type 2 Diabetes. Percentages are Calculated Within Each Diabetes Type.

The absence of a statistical association should be separated from the observation that more male than female records were present overall. A greater number of male records can arise from many factors unrelated to biologic susceptibility, including differential use of private laboratories, referral patterns, employment-related health testing, household decision-making, or other features of healthcare access. Because the study did not sample the general population, the male-to-female ratio in the laboratory records cannot be interpreted as a sex-specific population prevalence ratio. This distinction is especially important because population-based studies in Pakistan have not consistently shown higher diabetes prevalence in men. For example, DPS-PAK reported significant differences by sex in a nationally sampled adult population, but the direction and magnitude of those differences depend on the population and method used (Aamir et al., 2019).

Diabetes Type and Age

Age was the most striking demographic correlate of diabetes type in the present dataset. All six patients aged 0–17 years were classified as T1DM. In the 18–34-year group, six patients had T1DM and 34 had T2DM. No T1DM cases were recorded in the 35–49, 50–64, or 65–92-year groups; all 758 patients in these three older categories were classified as T2DM. Pearson's chi-square test showed a very strong association between age group and diabetes type ($\chi^2(4)=457.123$, $p<.001$). Cramer's V was approximately .754, consistent with a large association. Because several expected T1DM cell counts were small, the chi-square approximation should be interpreted cautiously, but the descriptive pattern itself is unequivocal: T1DM was confined to the two youngest groups in this laboratory sample, while T2DM dominated from age 35 years onward.

Table 3

Diabetes Type by Age Group

Age group (years)	Type 1, n	Type 2, n	Total, n	Type 1 within age group, %
0–17	6	0	6	100.0
18–34	6	34	40	15.0
35–49	0	222	222	0.0
50–64	0	330	330	0.0
65–92	0	206	206	0.0
Total	12	792	804	1.5

Pearson $\chi^2(4)=457.123$, $p<.001$; Cramer's $V\approx.754$. Sparse expected counts in the Type 1 column warrant cautious interpretation of the asymptotic chi-square p-value.

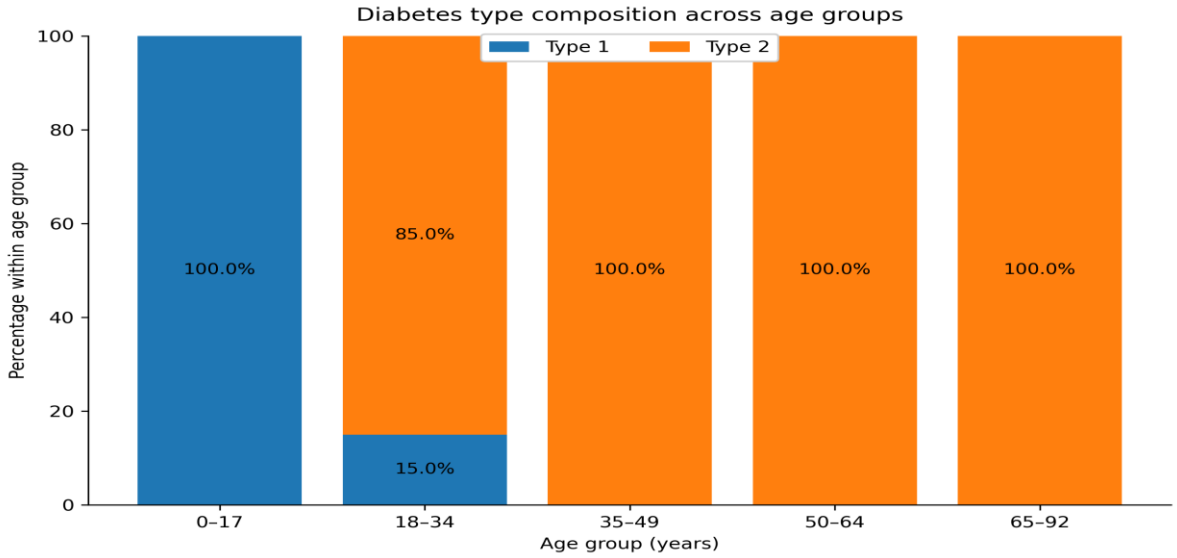


Figure 3

Composition of Diabetes Type Within Each Age Group. Type 1 Diabetes Was Documented Only in Patients Younger Than 35 Years in this Dataset.

The age pattern is clinically plausible and broadly consistent with the recognized epidemiology of the two major diabetes types. T1DM is commonly presents in childhood and adolescence, although it can be diagnosed at any age. Hormazabal-Aguayo et al. (2024) documented a substantial global incidence of T1DM in people younger than 20 years, and current clinical guidance emphasizes the need to recognize autoimmune diabetes across the life course. Conversely, T2DM risk rises strongly with age as a consequence of cumulative exposure to metabolic risk factors, changes in body composition, declining beta-cell reserve, and the increasing prevalence of insulin resistance. The present findings therefore fit the expected broad age gradient while also illustrating the limitations of using age alone to classify diabetes.

The emergence of 34 T2DM cases in the 18–34-year group is notable. T2DM was historically labeled adult-onset diabetes, but its occurrence in younger adults and adolescents has become increasingly recognized in settings with rising obesity and metabolic risk. The current dataset cannot identify the specific risk factors responsible because body mass index, diet, physical activity, family history, and socioeconomic variables were not available in the extracted records. Nevertheless, the presence of T2DM in early adulthood supports the value of risk-based screening and prevention before middle age, particularly in a high-burden national context.

The largest age category was 50–64 years, containing 330 patients (41.0%). This broadly resembles the local pattern reported by Abbas *et al*. (2023), who observed the greatest burden among participants aged 41–60 years in District Dera Ismail Khan. It also aligns with the national DPS-PAK observation that diabetes prevalence rose with age and was particularly high in later middle adulthood (Aamir *et al*., 2019). The consistency across datasets strengthens the interpretation that middle-aged adults constitute a critical target group for screening and long-term management in the district.

Age Group and Sex

A secondary analysis examined whether the sex distribution differed across age groups. The age-by-sex table contained 3 males and 3 females at 0–17 years; 18 males and 22 females at 18–34 years; 144 males and 78 females at 35–49 years; 186 males and 144 females at 50–64 years; and 109 males and 97 females at 65–92 years. Pearson's chi-square test was statistically significant at the conventional threshold ($\chi^2(4)=9.528$, p=.049), but the effect size was small (Cramer's V≈.109). This result should therefore not be overinterpreted. It indicates modest variation in the sex composition across age categories in the laboratory sample rather than a strong demographic effect.

DISCUSSION

The present laboratory-based study of 804 diabetic patients in District Dera Ismail Khan demonstrates that Type 2 diabetes accounts for nearly 99% of cases, while Type 1 diabetes is rare (1.5%). This distribution aligns closely with global estimates in which T2DM constitutes >90–95% of diabetes (GBD 2021; NCD-RisC, 2024) and with Pakistani national and provincial patterns (Aamir *et al*., 2019). The extremely low proportion of T1DM may reflect both true epidemiology in this population and possible under-ascertainment of childhood/adolescent cases that present acutely to tertiary hospitals rather than private diagnostic laboratories.

Males were modestly over-represented (57.2%), consistent with several local observations in Dera Ismail Khan tehsils (Abbas *et al*., 2023). However, the absence of a significant gender–type association (p = 0.937) indicates that the relative burden of T1DM versus T2DM does not differ meaningfully by sex in this cohort. Lifestyle factors (occupational patterns, smoking, dietary habits) may contribute to the slight male excess overall, yet they do not appear to alter type distribution.

Age emerged as the dominant demographic correlate. Nearly two-thirds of patients were aged 35–64 years, with the peak in the 50–64 band (41%). This mirrors the age pattern reported by Abbas *et al*. (2023) (majority 41–60 years) and broader South Asian epidemiology, where T2DM onset often occurs a decade earlier than in European populations. The highly significant age–type association (p < 0.001) and the complete confinement of T1DM to individuals under 35 years reinforce classic clinical understanding: autoimmune T1DM predominantly affects younger persons, whereas progressive insulin resistance and β-cell decline drive T2DM in mid- and later life. The modest but significant age–gender interaction (p = 0.049) suggests shifting sex ratios across the life course and warrants further exploration in larger prospective samples.

The study's most important contribution is not a new population prevalence estimate; rather, it is a contemporary description of the diagnosed diabetes case-mix in a district for which direct type-specific service data are limited. This distinction helps reconcile the present results with population-based studies. Abbas et al. (2023) reported 38% diabetes prevalence in their sampled district population because their denominator included both diabetic and non-diabetic participants. In contrast, the present dataset included only diabetic patients and therefore yields a 98.5% T2DM proportion among diagnosed cases. Both findings can be valid simultaneously because they answer different questions.

The same principle applies when comparing the current data with national estimates. Aamir et al. (2019) estimated T2DM prevalence in a representative national adult sample using HbA1c, while IDF (2025) and NCD-RisC (2024) produced modeled national estimates from multiple data sources. The present study, by contrast, describes records generated through routine healthcare use in four private laboratories. The value of this design lies in its immediacy

and local specificity, but its inference is narrower. It can inform service demand and stimulate more rigorous district surveillance, but it cannot quantify the probability that a randomly selected resident of Dera Ismail Khan has diabetes or a particular diabetes type.

The overwhelming dominance of T2DM is nevertheless expected in a setting where national diabetes burden is high and where the sample is composed primarily of adults. GBD 2021 estimated T2DM to represent the large majority of diabetes globally, and Pakistan's current diabetes burden is substantial by both IDF and NCD-RisC estimates (GBD 2021 Diabetes Collaborators, 2023; IDF, 2025; NCD-RisC, 2024). The present district-level case mix therefore fits a wider epidemiologic transition in which metabolic disease is increasingly concentrated in middle-aged and older adults while also appearing earlier in life.

Several practical implications follow from these findings. First, the concentration of patients in the 35–92-year range, especially the 50–64-year group, supports prioritizing accessible screening and follow-up for middle-aged adults. Community outreach, primary-care risk assessment, and laboratory monitoring may be particularly valuable in this age range. Second, the presence of T2DM among adults aged 18–34 years indicates that prevention should begin before middle age and should address modifiable cardiometabolic risks when they are still amenable to change. Third, the small number of recorded T1DM cases should prompt attention to referral and insulin continuity rather than complacency. Young patients with T1DM require dependable access to insulin, glucose monitoring, education on sick-day management, and rapid evaluation when acute symptoms occur.

At the health-system level, routine laboratory databases could be developed into stronger surveillance resources if diagnostic coding is standardized and linked with a minimal set of clinical variables. Recording the basis for diabetes classification, age at diagnosis, treatment status, body mass index, family history, and key comorbidities would make future retrospective analyses more informative. Linkage with public hospitals and pediatric services would also reduce the risk that private-laboratory data systematically underrepresent some patient groups.

Diagnostic Classification Limitations

An important limitation of the present investigation concerns the classification of diabetes mellitus using previously documented clinical diagnoses. Although laboratory measurements were available to support the identification of diabetes, distinguishing between T1DM and T2DM relied primarily on physician-recorded diagnoses. In the absence of systematically documented C-peptide concentrations and pancreatic islet autoantibody profiles, the possibility of diagnostic misclassification cannot be completely excluded. This limitation is particularly relevant to adult-onset autoimmune diabetes, including latent autoimmune diabetes in adults (LADA), which may initially resemble T2DM in routine clinical practice. Similarly, certain secondary forms of diabetes may not have been consistently distinguished from T2DM in the available records. Therefore, the observed distribution of diabetes types should be interpreted in the context of the diagnostic information available at the time of data collection. Future investigations incorporating detailed clinical histories, pancreatic beta-cell function assessments, and autoimmune markers may provide a more precise understanding of diabetes classification in the study population.

Selection Bias Associated with Private Diagnostic Laboratories

Another limitation relates to the selection of participants from four private diagnostic laboratories in District Dera Ismail Khan. Patients seeking diagnostic services at private healthcare facilities may differ from those attending public hospitals, basic health units, and rural healthcare centers in terms of socioeconomic circumstances, healthcare

accessibility, and health-seeking behavior. Consequently, the study population may not adequately represent all individuals living with diabetes in the district, particularly those residing in underserved rural communities or experiencing financial barriers to diagnostic services. Furthermore, the retrospective laboratory-based sampling approach did not provide a population-based denominator, limiting the ability to estimate the actual prevalence of diabetes mellitus in the general population. The findings therefore describe the relative distribution of documented diabetes types among the selected laboratory patients rather than the population-wide prevalence of T1DM and T2DM. Future population-based studies involving both public and private healthcare facilities would improve the representativeness of regional epidemiological estimates.

The findings of the present study indicate several priorities for future research and healthcare planning in District Dera Ismail Khan. Broader epidemiological investigations involving urban and rural populations are needed to establish representative estimates of diabetes prevalence and evaluate potential differences in disease distribution across demographic and socioeconomic groups. Future studies should consider standardized diagnostic approaches, including appropriate biochemical and autoimmune investigations where clinically indicated, to improve differentiation between diabetes types. From a public health perspective, strengthening primary healthcare services, expanding access to diabetes screening, and promoting awareness of modifiable risk factors may contribute to earlier identification and improved management of T2DM. In addition, maintaining accessible insulin treatment and glucose-monitoring services is particularly important for individuals with T1DM. Collaboration between public healthcare institutions, private diagnostic facilities, and community health programs may support more comprehensive diabetes surveillance and improve the planning of regional healthcare services.

CONCLUSION

The present retrospective study provides an overview of the distribution of Type 1 and Type 2 diabetes mellitus among 804 patients attending four private diagnostic laboratories in District Dera Ismail Khan, Pakistan, during 2025. The findings revealed a substantial predominance of T2DM (98.5%) compared with T1DM (1.5%), indicating that T2DM accounted for the majority of documented diabetes cases within the selected laboratory population. An age-related difference was observed between the two diabetes categories, with all recorded T1DM cases occurring among individuals younger than 35 years, while no statistically significant association was identified between diabetes type and sex.

These findings emphasize the importance of strengthening diabetes prevention, early detection, and clinical management services at the district level. Community-based awareness initiatives, accessible blood glucose screening, and lifestyle modification programs may support the identification and management of individuals at increased risk of T2DM. At the same time, reliable access to insulin, appropriate glucose-monitoring facilities, and continued clinical follow-up remain essential components of care for individuals living with T1DM.

Nevertheless, the retrospective design, reliance on physician-recorded diabetes classifications, and exclusive inclusion of private laboratory records limit the generalizability of the findings. The results should therefore be interpreted as the distribution of diabetes types within the investigated patient population rather than as estimates of diabetes prevalence in District Dera Ismail Khan. Further multicenter and population-based investigations incorporating public and private healthcare facilities, standardized diagnostic procedures, and broader demographic representation are recommended to establish more reliable regional estimates and inform evidence-based diabetes prevention and management strategies.

DECLARATION

Ethical Considerations: This study strictly adhered to the Declaration of Helsinki and relevant national and institutional ethical guidelines. All procedures performed in this study were consistent with the ethical standards of the Declaration of Helsinki. The study was conducted according to ethical and clinical standards for research.

Conflict of Interest: The authors have no conflicts of interest.

Consent for Publication: Consent was obtained according to the aims and process of the research.

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Authors' Contributions: S.K done research; I.U.R and M.S.R helps in analysis of data, software, and manuscript editing; Q.H.S done overall supervision.

Data Availability: The de-identified data supporting the findings may be made available by the corresponding author subject to institutional and ethical restrictions.

Use of Artificial Intelligence (AI)- Assisted Technology for Manuscript Preparation: No AI tools were used for data extraction, statistical analysis, result interpretation, or the generation of original scientific content. All analyses were conducted by the authors, and they take full responsibility for the integrity and accuracy of the manuscript; however, we used AI for our questionnaire alignments, yet no AI was involved in conducting the test for the analysis.

Similarity Index/ Plagiarism: The similarity index was checked, and it is well below the threshold value of 19%, whereas each source is less > 5%.

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