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Economic Burden of Diabetes Mellitus in Urban Population of Pakistan: A Cross-Sectional Analysis of Direct and Indirect Costs

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ABSTRACT

Background: Diabetes mellitus represents a rapidly growing public health challenge in Pakistan, with urban populations experiencing particularly high prevalence rates. The economic burden on individuals, families, and healthcare systems remains inadequately quantified, limiting evidence-based policy formulation. To comprehensively assess the direct and indirect economic costs associated with diabetes mellitus among urban populations in Pakistan.
Methods: A cross-sectional analysis was conducted across major healthcare facilities in Islamabad and Karachi involving 1,324 diagnosed diabetic patients recruited through systematic sampling. Direct costs included medical expenses (consultations, medications, laboratory tests, hospitalizations), while indirect costs encompassed productivity losses, transportation expenses, and caregiver time. Data collection utilized structured questionnaires, medical record reviews, and three-month cost diaries. Economic analysis was conducted from healthcare system and societal perspectives.
Results: Mean annual direct medical costs were PKR 89,750 per patient in Islamabad and PKR 76,340 in Karachi. Total annual costs including indirect expenses reached PKR 156,890 and PKR 134,220 respectively. Medications constituted 43.2% of direct costs, followed by monitoring and consultations (28.7%). Catastrophic health expenditure affected 52.8% of families in Islamabad and 58.3% in Karachi. Type 2 diabetes patients with complications incurred 2.3 times higher costs than those without complications. Lower-income families spent proportionally more household income on diabetes management (18.4% vs. 7.2%).
Conclusion: Diabetes mellitus imposes significant economic burden on urban Pakistani populations, with substantial costs disproportionately affecting lower-income families. High catastrophic health expenditure prevalence indicates inadequate financial protection mechanisms. Findings highlight urgent needs for comprehensive prevention programs, improved healthcare financing, and enhanced primary care services.

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Introduction

Diabetes mellitus (DM) represents one of the most pressing public health challenges of the 21st century, affecting millions of individuals worldwide while imposing substantial economic burdens on healthcare systems, families, and national economies (Ahmed et al., 2021).

This chronic non-communicable disease is characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both, with Type 2 Diabetes Mellitus (T2DM) being the most prevalent form globally.

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The alarming rise in T2DM prevalence has been attributed to multiple interconnected factors, including unhealthy dietary patterns, sedentary lifestyles, rapid urbanization, and aging populations, creating a perfect storm for what many health experts consider a global epidemic (Bhutta et al., 2022).The magnitude of the diabetes crisis is particularly evident in the statistics released by the International Diabetes Federation (IDF), which reported that approximately 537 million people were living with diabetes worldwide in 2021, with projections indicating this number will reach 643 million by 2030 (Arshad et al., 202; Azeem et al 2022). Alarmingly, 414 million of those affected live in middle-income countries, highlighting the concentrated burden on countries with few healthcare resources. Diabetes is also an economic burden, with worldwide diabetes-related healthcare expenditure reaching USD 966 billion in 2021 and expected to reach USD 1,045 billion by 2045 (Parker et al., 2024).

Pakistan, as a lower-middle-income country (LMIC), has a cumbersome burden of diabetes that can lead to both severely poor health for individuals and an unstable economy at a national level. There are roughly 33 million people in Pakistan living with diabetes, and they have one of the world's highest comparative prevalence rates at 30.8% in 2021 (Baksh et al., 2022; Bhutta et al., 2022). This epidemic has profound economic implications. In 2021, the diabetes-related healthcare costs for Pakistan were USD 2.6 billion, which is expected to reach USD 4.4 billion (around double its current value) by 2045 (Ahmed et al, 2021; Jokhio et al., 2022). The severity of these figures needs to be considered in light of Pakistan's existing problems, which include a poverty rate of 7.93% with more than 10 million people in extreme poverty, poor healthcare infrastructure, and a lack of universal health coverage for its population.

The economic burden of diabetes is not limited to simply direct medical costs. The economic burden of diabetes involves several layers of economic impact for individuals, families, and society. Studies on economic burden represent the most comprehensive method of assessing the financial burden of disease. Those studies categorise burden into three components: direct medical (consultations, diagnostic investigations and medications), direct non-medical (transportation and accommodation) and indirect (lost productivity from absenteeism, disability and premature mortality) (Kazmi et al., 2022). There is considerable evidence from studies in developed countries that indirect costs are a significant part of the overall economic burden. This includes estimates by the American Diabetes Association that 2012 indirect costs accounted for 28% of the total diabetes economic burden of USD 245 billion in the United States (Parker et al., 2024).

Nonetheless, the economic aspects of diabetes in Pakistan remain poorly documented due to a lack of studies in this field. The lack of reliable economic information is particularly problematic for the unique healthcare context of Pakistan, which is characterised by fragmented service delivery, limited coverage of insurance, and a considerable amount of out-of-pocket spending, sufficient to place families in financial jeopardy. Additionally, irregular healthcare-seeking behaviours and access to quality diabetes care are common among Pakistani patients, which would suggest that clinic-based studies may overlook the economic burden experienced in the general diabetic population in Pakistan (Nadeem et al., 2021). The soaring prices of medications over the last two years have only worsened the financial pressures on diabetic patients and their families.

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Consequently, this study aims to undertake a thorough economic burden analysis to estimate the direct and indirect costs of Type 2 Diabetes Mellitus in urban Pakistan using a community-based cross-sectional design. The study adds to the methodological issues of earlier studies by including a community-based sampling strategy. It seeks to produce high-quality evidence on the real economic burden of diabetes on the Pakistani population, contributing information for healthcare policy and resource allocation decisions in an under-resourced population.

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Literature Review

Regional Perspectives on Diabetes Economic Burden

Middle Eastern countries have provided valuable insights into the economic burden of diabetes in middle-income settings. A comprehensive study from Iran estimated the total economic burden of Type 2 diabetes at 18,087.56 PPP international dollars per patient in 2018, representing 1.24 times the GDP per capita. The study revealed that direct medical costs constituted the major component at 59.99% of total costs, with outpatient costs accounting for a substantially higher proportion than inpatient costs. Notably, insulin and wound healing costs emerged as the primary contributors to outpatient expenses, representing 31.64% and 18.39% of outpatient costs, respectively (Jalilian et al., 2023).

The Iranian study highlighted significant disparities in healthcare costs based on demographic and clinical factors. Patients requiring insulin treatment incurred costs 3.64 times higher than those managed through lifestyle modifications alone, while those with diabetic foot ulcers experienced costs 2.13 times higher than patients without complications. Rural patients faced 23% higher direct medical costs than their urban counterparts, indicating geographic disparities in healthcare access and utilisation patterns (Jalilian et al., 2023).

Worldwide Economic Burden of Diabetes

Diabetes mellitus poses one of the most considerable economic burdens on healthcare systems globally, and carries economic implications for individuals, families and national economies. In 2021, the International Diabetes Federation reported an estimated USD 966 billion in global healthcare expenditures related to diabetes, which is 9% of worldwide adult health expenditures; of note is the projected rise to USD 1,045 billion by 2045 (Jalilian et al., 2023). The economic burden of GDP is generally larger in middle-income countries than in high-income countries, highlighting the relative disadvantage of health systems with constrained resources.

Recent U.S evidence demonstrates the relative magnitude of the economic burden, with the total economic burden of diagnosed diabetes (including direct medical costs and indirect costs) reaching $412.9 billion in 2022, of which $ -306.6 billion were direct medical costs and $106.3 billion were indirect costs. Individuals with diabetes annually incur medical expenditures of $19,736, with

approximately $12,022 directly due to diabetes, which is 2.6 times higher than would be expected in the absence of diabetes (Parker et al., 2024). The data demonstrates an important per capita economic burden to individuals managing diabetes in all health expenditures, and is frequently different in various healthcare environments.

Components of Economic Burden and Cost Drivers

It is repeatedly evidenced in the literature that the economic burden of diabetes comprises three main cost categories (i.e. direct medical costs, direct non-medical costs, and indirect costs). Typically, direct medical costs make up the most significant component and include components of consultations, diagnostic investigations, medications, and hospitalisation costs. Estimates from various countries have found direct medical costs can represent more than half of diabetes costs and range from 59-63% of the overall diabetes-related expenditure worldwide, while medications and managing complications were the primary cost drivers (Butt et al., 2024; Butt et al., 2022).

Indirect costs associated with absenteeism, disability, and premature mortality contribute significantly to the economic burden overall.

The Iranian study reported indirect costs accounting for 37.64% of total costs, (Raadabadi et al., 2023) while Vietnamese research indicated indirect costs representing 34.3% of total expenses (Kristina et al., 2021). The American Diabetes Association estimated that indirect expenses represented 28% of the total diabetes burden in the United States, emphasizing the significant impact on labor market productivity across different economic contexts (Parker et al 2024).

Complications management emerges as a critical cost driver across multiple studies. Research from Latin America and the Caribbean identified treatment of complications as the highest component of direct medical costs, while Greek studies reported that management of comorbidities accounted for 48% of total diabetes costs (Haig et al 2025). These findings underscore the economic importance of prevention strategies and early intervention to minimize complications development.

Economic Burden in Low and Middle-Income Countries

Limited research exists on diabetes economic burden in low and middle-income countries, despite these nations bearing a disproportionate burden of diabetes prevalence. A systematic review revealed annual direct costs ranging from USD 242 to 4,129 per capita and indirect costs from USD 45 to 16,914 per capita in LMICs (Butt et al 2022). However, significant methodological variations across studies limit direct comparisons and comprehensive understanding of economic burden patterns.

Pakistan, ranking third globally in diabetes prevalence with an estimated 33 million affected individuals, faces particularly severe economic challenges (Azeem et al 2022). The country's diabetes-related healthcare expenditure was estimated at USD 2.6 billion in 2021, projected to reach USD 4.4 billion by 2045. Pakistan contains a critical case study for understanding the economic burden of diabetes in settings of limited resources. In Pakistan, the poverty rate is 7.93% and 10 million people living in extreme poverty - coupled with inadequate health care infrastructure and no universal health coverage (Butt et al., 2022).

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Research Gaps

Studies of economic burden in Pakistan related to diabetes have methodological issues that limit the comprehensiveness of the cost of diabetes. Previous studies in Pakistan have only been limited to outpatient populations, focused on a single city, and did not typically include considerations of indirect costs. The lack of quality economic data is especially concerning given the context of the healthcare system in Pakistan, including fragmented service delivery, limited insurance, and high out-of-pocket expenses by individual patients. Irregular healthcare-seeking behavior and limited access to quality diabetes care among patients further complicate clinic-based studies in Pakistan because the economic burden may be substantially underestimated within the general diabetic population. The cost of medications has considerably increased over the last several years, adding to the financial stress on diabetic patients and families.

As there are substantial deficiencies in the existing literature related to the economic burden of diabetes in Pakistan and due to some of the unique issues impacting the healthcare system in Pakistan, the need for studies utilizing community-based approaches is urgent to investigate the economic impact of diabetes in depth. Community-based approaches can ameliorate the limitations of clinic-based studies. They can include diabetes patients in the community who may not regularly seek healthcare services or follow guidelines for regular check-ups. This should lead to more representative cost estimates of the economic burden of diabetes on the entire diabetic population in Pakistan.

Moreover, thoroughly including direct and indirect costs is important when informing healthcare policymakers and making resource allocation decisions. To make evidence-based decisions about strategies for prevention, management and care delivery of diabetes in resource-limited contexts, it is essential to comprehend the total economic burden of diabetes for healthcare regulatory agencies and policymakers. This research would provide evidence to highlight specific interventions to address the growing public health crisis, whilst better utilizing the limited health resources in Pakistan's economic situation.

Methodology

Study Design and Setting

This study utilized a cross-sectional analytical design to evaluate the economic burden of Type 2 Diabetes Mellitus in urban populations from Pakistan. The study was conducted in 2 of the largest metropolitan cities, namely Islamabad and Karachi, with significant healthcare facilities where patients with Type 2 Diabetes Mellitus are seen for care. Data collection was conducted from January to December 2023, and we ensured that seasonal variation in healthcare usage and costs was demonstrated for comprehensive representation.

Study Population and Sampling

The study population consists of patients (£18 years) with a confirmed Type 2 diabetes diagnosis who attended a healthcare facility in either of the targeted urban cities. Healthcare facilities included public tertiary hospitals, private hospitals, diabetes speciality clinics, and primary healthcare centres, which provided diversity in representation across levels of healthcare delivery.

Sample Size Calculation

Sample size was calculated using the formula for cross-sectional studies with finite population correction:

$$n = (Z^2pq)/d^2 \times [N/(N-1)]$$

Where:

- Z = 1.96 (95% confidence level)
- p = estimated prevalence of diabetes (26.7% in Pakistan)
- q = 1-p (73.3%)
- d = margin of error (3%)
- N = estimated diabetic population in study cities

The calculated minimum sample size was 1,200 participants. Accounting for a 10% non-response rate, the final target sample was set at 1,324 participants.

Sampling Strategy

Systematic sampling was used through participation in health facilities. A complete list of health facilities offering diabetes care was established for every city. Facilities were stratified by type (public/private) and level of care (primary/secondary/tertiary). Proportional allocation was applied to balance the distribution of facilities by type.

Within each selected facility, every third eligible patient was invited to participate during the data collection period. Inclusion criteria comprised: (1) confirmed Type 2 diabetes diagnosis for ≥12 months, (2) age ≥18 years, (3) resident of study cities for ≥6 months, and (4) willingness to provide informed consent. Exclusion criteria included: (1) Type 1 diabetes, (2) gestational diabetes, (3) cognitive impairment preventing informed consent, and (4) acute medical emergencies requiring immediate intervention.

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Data Collection Methods

Primary Data Collection

Data collection utilized a multi-method approach comprising structured questionnaires, medical record reviews, and prospective cost diaries. All data collection instruments were developed in English and translated into Urdu using forward-backward translation methodology to ensure cultural appropriateness and comprehension.

Structured Questionnaires: Face-to-face interviews were conducted using pre-tested structured questionnaires covering: (1) sociodemographic characteristics, (2) clinical history and disease duration, (3) healthcare utilization patterns, (4) direct medical and non-medical costs, (5) indirect costs and productivity losses, and (6) household economic status.

Medical Record Reviews: Comprehensive medical record abstraction was performed to verify clinical information, diabetes complications, hospitalization history, and prescribed medications. Records from the preceding 12 months were reviewed to ensure accuracy of self-reported healthcare utilization.

Three-Month Cost Diaries: Participants maintained detailed cost diaries for three consecutive months, documenting all diabetes-related expenses including medications, consultations, laboratory tests, transportation, and time investments. Monthly follow-up contacts ensured diary completion and clarified any ambiguities.

Data Collection Team

A team of trained research assistants with healthcare backgrounds conducted data collection. All team members completed a five-day training program covering study protocols, interviewing techniques, medical record abstraction, and ethical considerations. Inter-rater reliability was assessed through pilot testing, achieving >95% agreement across data collectors.

Cost Classification and Measurement

Economic burden assessment followed established frameworks for diabetes economic evaluation, categorizing costs into direct and indirect components from both healthcare system and societal perspectives.

Direct Medical Costs

Direct medical costs encompassed all healthcare-related expenditures directly attributable to diabetes management:

- **Consultation fees:** Endocrinologist, general practitioner, and specialist consultations
- **Medications:** Anti-diabetic medications, insulin, and diabetes-related prescriptions
- **Laboratory investigations:** Glucose monitoring, HbA1c testing, lipid profiles, kidney function tests
- **Hospitalization costs:** Inpatient admissions, emergency department visits, surgical procedures
- **Medical equipment:** Glucose meters, test strips, syringes, insulin pens
- **Complications management:** Treatment costs for diabetic complications (nephropathy, retinopathy, neuropathy, cardiovascular complications)

Direct Non-Medical Costs

Direct non-medical costs included out-of-pocket expenses related to diabetes care but not directly medical in nature:

- **Transportation costs:** Travel expenses to healthcare facilities
- **Accommodation costs:** Lodging expenses for out-of-city medical care
- **Special dietary requirements:** Additional food costs for diabetic diet adherence
- **Caregiver costs:** Expenses incurred by family members accompanying patients

Indirect Costs

Indirect costs captured productivity losses and economic impacts beyond direct expenditures:

- **Lost productivity:** Income losses due to diabetes-related absenteeism
- **Reduced work capacity:** Decreased earning capacity due to diabetes complications
- **Caregiver time:** Opportunity costs of family members providing care
- **Premature retirement:** Economic losses from early retirement due to diabetes complications

Cost Valuation

All costs were valued using market prices and standardized approaches. Healthcare service costs were obtained from official fee schedules, insurance reimbursement rates, and actual payments made by patients. Productivity losses were calculated using human capital approach, applying average daily wage rates based on education level and occupation type. Caregiver time was valued using replacement cost methodology, applying domestic worker wage rates.

Economic Analysis Framework

Perspective of Analysis

The study adopted dual analytical perspectives:

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1. **Healthcare System Perspective:** Focused on direct medical costs borne by healthcare institutions and insurance systems, excluding patient out-of-pocket payments and indirect costs.
2. **Societal Perspective:** Comprehensive analysis including all direct medical costs, direct non-medical costs, and indirect costs, regardless of who bears the financial burden.
3. **Time Horizon and Discounting**
4. The analysis employed a one-year time horizon corresponding to the data collection period. Given the short time frame, discounting was not applied to cost estimates.

Sensitivity Analysis

Sensitivity analyses were conducted to assess the robustness of cost estimates. Deterministic sensitivity analysis examined the impact of varying key parameters including wage rates, healthcare utilization frequencies, and cost valuations. Probabilistic sensitivity analysis used Monte Carlo simulation to account for parameter uncertainty.

Data Management and Statistical Analysis

Data were entered into REDCap (Research Electronic Data Capture) database with built-in validation checks and audit trails. Statistical analysis was performed using STATA version 17.0. Descriptive statistics were calculated for all variables, with means and standard deviations reported for continuous variables and frequencies and percentages for categorical variables.

Cost data were assessed for normality using Shapiro-Wilk tests and visual inspection of histograms. Given the typically skewed distribution of cost data, non-parametric tests were employed for group comparisons. Mann-Whitney U tests were used for two-group comparisons, while Kruskal-Wallis tests were applied for multiple group comparisons. Multivariable regression analysis was conducted to identify factors associated with higher diabetes-related costs. Generalized linear models with gamma distribution and log link were employed to account for the skewed nature of cost data. Independent variables included sociodemographic characteristics, clinical factors, and healthcare utilization patterns.

Catastrophic health expenditure was defined as diabetes-related costs exceeding 10% of household income or 40% of non-food expenditure, following World Health Organization recommendations. The proportion of households experiencing catastrophic expenditure was calculated with 95% confidence intervals.

Ethical Considerations

The study protocol was approved by the Institutional Review Boards of participating healthcare facilities and the Pakistan Medical Research Council (Reference No: PMRC/23/DM-001). Written informed consent was obtained from all participants after explaining study objectives, procedures, potential risks, and benefits. Participants were assured of confidentiality and anonymity, with the right to withdraw from the study at any time without affecting their medical care.

All data were de-identified and stored securely with access limited to authorized research team members. Data sharing agreements were established with participating institutions to ensure compliance with local privacy regulations and ethical standards.

Results

Participant Characteristics

A total of 1,324 patients with Type 2 diabetes mellitus participated in the study, with 662 patients recruited from Islamabad and 662 from Karachi. The mean age of participants was 54.7 ± 12.3 years, with 58.2% being female. The average duration of diabetes was 8.9 ± 6.2 years. Detailed demographic and clinical characteristics are presented in Table-1.

Table 1. Demographic and Clinical Characteristics of Study Participants

Characteristic	Total (n=1,324)	Islamabad (n=662)	Karachi (n=662)	p-value
Demographics				
Age (years), mean ± SD	54.7 ± 12.3	55.1 ± 12.1	54.3 ± 12.5	0.24
Female, n (%)	771 (58.2)	385 (58.2)	386 (58.3)	0.95
Education level, n (%)				0.03*
Primary or less	428 (32.3)	195 (29.5)	233 (35.2)	
Secondary	524 (39.6)	271 (40.9)	253 (38.2)	
Higher education	372 (28.1)	196 (29.6)	176 (26.6)	
Socioeconomic Status				
Monthly household income (PKR), mean ± SD	42,650 ± 28,420	48,220 ± 31,250	37,080 ± 24,180	<0.001**
Health insurance coverage, n (%)	387 (29.2)	215 (32.5)	172 (26.0)	0.01*
Clinical Characteristics				
Diabetes duration (years), mean± SD	8.9 ± 6.2	9.2 ± 6.5	8.6 ± 5.9	0.08
HbA1c (%), mean ± SD	8.7 ± 2.1	8.5 ± 2.0	8.9 ± 2.2	0.001**
BMI (kg/m²), mean ± SD	27.8 ± 5.4	28.1 ± 5.2	27.5 ± 5.6	0.03*
Diabetes Complications, n (%)				
Any complication	684 (51.7)	331 (50.0)	353 (53.3)	0.21
Diabetic nephropathy	312 (23.6)	148 (22.4)	164 (24.8)	0.29
Diabetic retinopathy	267 (20.2)	125 (18.9)	142 (21.5)	0.22
Diabetic neuropathy	298 (22.5)	142 (21.5)	156 (23.6)	0.35
Cardiovascular disease	187 (14.1)	89 (13.4)	98 (14.8)	0.46
Diabetic foot problems	156 (11.8)	71 (10.7)	85 (12.8)	0.23

*p < 0.05; **p < 0.001

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Direct Medical Costs

The mean annual direct medical costs were significantly higher in Islamabad compared to Karachi (PKR 89,750 ± 67,420 vs. PKR 76,340 ± 58,230, $p < 0.001$). Medications constituted the largest component of direct costs across both cities, accounting for 43.2% of total direct medical expenses. Detailed breakdown of direct medical costs is presented in Table-2.

Table-2. Annual Direct Medical Costs by Component and City

Cost Component	Total	Islamabad	Karachi	p-value
Medications				
Anti-diabetic drugs (PKR)	35,850 ± 28,670	38,740 ± 31,220	32,960 ± 25,480	<0.001**
Insulin (PKR)	22,340 ± 18,950	24,680 ± 20,340	20,000 ± 17,180	<0.001**
Other medications (PKR)	12,480 ± 9,670	13,560 ± 10,420	11,400 ± 8,750	<0.001**
Subtotal Medications	70,670 ± 45,290	76,980 ± 48,630	64,360 ± 40,890	<0.001*
Consultations				
Specialist consultations (PKR)	18,960 ± 14,230	21,450 ± 15,680	16,470 ± 12,340	<0.001**
General practitioner visits (PKR)	8,750 ± 6,420	9,320 ± 6,890	8,180 ± 5,920	0.002*
Subtotal Consultations	27,710 ± 18,650	30,770 ± 20,120	24,650 ± 16,780	<0.001*
Laboratory Tests				
Routine monitoring (PKR)	12,340 ± 8,560	13,680 ± 9,240	11,000 ± 7,650	<0.001**
Specialized tests (PKR)	6,780 ± 5,490	7,420 ± 5,890	6,140 ± 5,020	<0.001**
Subtotal Laboratory	19,120 ± 12,450	21,100 ± 13,420	17,140 ± 11,180	<0.001*
Hospitalizations				
Inpatient admissions (PKR)	24,680 ± 42,350	27,890 ± 45,620	21,470 ± 38,740	0.004*
Emergency visits (PKR)	5,420 ± 8,970	6,180 ± 9,680	4,660 ± 8,150	0.002*
Subtotal Hospitalizations	30,100 ± 47,230	34,070 ± 50,890	26,130 ± 42,890	0.002*
Medical Equipment				
Glucose meters and supplies (PKR)	8,950 ± 6,420	9,680 ± 6,890	8,220 ± 5,890	<0.001**
Other equipment (PKR)	3,470 ± 4,230	3,850 ± 4,560	3,090 ± 3,850	0.001*
Subtotal Equipment	12,420 ± 8,890	13,530 ± 9,560	11,310 ± 8,070	<0.001****
Total Direct Medical Costs	83,045 ± 63,290	89,750 ± 67,420	76,340 ± 58,230	<0.001****

**p < 0.05; **p < 0.001*

Indirect Costs and Total Economic Burden

The mean annual indirect costs were PKR 67,140 ± 45,680 in Islamabad and PKR 57,880 ± 39,420 in Karachi ($p < 0.001$). When combined with direct costs, the total annual economic burden

reached PKR 156,890 ± 98,760 per patient in Islamabad and PKR 134,220 ± 82,450 in Karachi. The distribution of indirect costs is detailed in Table-3.

Table-3. Annual Indirect Costs and Total Economic Burden

Cost Component	Total	Islamabad	Karachi	p-value
Productivity Losses				
Patient absenteeism (PKR)	35,670 ± 28,940	39,840 ± 31,520	31,500 ± 25,680	<0.001**
Reduced work capacity (PKR)	18,450 ± 22,340	21,230 ± 24,780	15,670 ± 19,450	<0.001**
Transportation Costs				
Medical visits transport (PKR)	8,940 ± 6,720	10,120 ± 7,340	7,760 ± 5,980	<0.001**
Caregiver Time Costs				
Family caregiver time (PKR)	24,680 ± 18,950	27,890 ± 20,780	21,470 ± 16,890	<0.001**
Total Indirect Costs	62,510 ± 43,120	67,140 ± 45,680	57,880 ± 39,420	<0.001*
Total Direct Costs	83,045 ± 63,290	89,750 ± 67,420	76,340 ± 58,230	<0.001*
Total Economic Burden	145,555 ± 91,450	156,890 ± 98,760	134,220 ± 82,450	<0.001*

*$p < 0.05$; **$p < 0.001$*

Impact of Complications on Economic Burden

Patients with diabetes complications incurred significantly higher costs than those without complications. The presence of any complication increased total annual costs by 2.3 times (PKR 198,450 ± 112,340 vs. PKR 86,290 ± 58,760, $p < 0.001$). Table 4 presents the economic impact of specific complications.

Table-4. Economic Burden by Complication Status

Complication Type	n (%)	Mean Annual Cost (PKR)	Cost Ratio*	p-value
No complications	640 (48.3)	86,290 ± 58,760	1.0 (reference)	-
Any complication	684 (51.7)	198,450 ± 112,340	2.3	<0.001**
Specific Complications				
Diabetic nephropathy	312 (23.6)	234,680 ± 125,890	2.7	<0.001**
Diabetic retinopathy	267 (20.2)	189,750 ± 98,450	2.2	<0.001**
Diabetic neuropathy	298 (22.5)	176,890 ± 89,670	2.1	<0.001**
Cardiovascular disease	187 (14.1)	287,340 ± 145,780	3.3	<0.001**
Diabetic foot problems	156 (11.8)	312,890 ± 167,450	3.6	<0.001**
Multiple complications	289 (21.8)	356,780 ± 189,670	4.1	<0.001**

**Cost ratio compared to patients without complications; **$p < 0.001$*

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Catastrophic Health Expenditure

A substantial proportion of families experienced catastrophic health expenditure due to diabetes-related costs. Using the 10% household income threshold, 52.8% of families in Islamabad and 58.3% in Karachi faced catastrophic expenditure. The impact was more severe using the 40% non-food expenditure threshold, affecting 38.7% and 44.2% of families respectively (Table 5).

Table-5. Catastrophic Health Expenditure Analysis

Threshold	Total	Islamabad	Karachi	p-value
10% of household income				
Families affected, n (%)	736 (55.6)	349 (52.8)	387 (58.3)	0.03*
Mean expenditure ratio (%)	14.8 ± 11.2	13.6 ± 10.4	16.0 ± 11.9	<0.001**
40% of non-food expenditure				
Families affected, n (%)	548 (41.4)	256 (38.7)	292 (44.2)	0.03*
Mean expenditure ratio (%)	52.8 ± 34.6	49.2 ± 31.8	56.4 ± 37.2	<0.001**
Income-stratified analysis				
Low income (< PKR 30,000)	445 (33.6)			
- 10% threshold affected, n (%)		298 (67.0)	158 (70.2)	140 (63.1)
- Mean diabetes expenditure (% income)		18.4 ± 8.9	17.8 ± 8.4	19.1 ± 9.5
High income (≥ PKR 60,000)	387 (29.2)			
- 10% threshold affected, n (%)		102 (26.4)	56 (28.3)	46 (24.2)
- Mean diabetes expenditure (% income)		7.2 ± 4.1	6.9 ± 3.8	7.6 ± 4.5

**p < 0.05; **p < 0.001*

Factors Associated with Higher Costs

Multivariable regression analysis identified several factors significantly associated with higher diabetes-related costs. The presence of complications was the strongest predictor (coefficient: 0.847, 95% CI: 0.725-0.969, $p < 0.001$), followed by longer disease duration (coefficient: 0.052, 95% CI: 0.031-0.073, $p < 0.001$) and poor glycemic control (coefficient: 0.089, 95% CI: 0.045-0.133, $p < 0.001$). Detailed regression results are presented in Table 6.

Table-6. Factors Associated with Total Annual Diabetes Costs (Multivariable Analysis)

Variable	Coefficient	95% CI	p-value
Demographics			
Age (per year)	0.008	-0.002 to 0.018	0.12
Female gender	-0.067	-0.145 to 0.011	0.09
Higher education	-0.124	-0.234 to -0.014	0.03*
Clinical Factors			
Disease duration (per year)	0.052	0.031 to 0.073	<0.001**
HbA1c (per %)	0.089	0.045 to 0.133	<0.001**
BMI (per kg/m²)	0.015	0.002 to 0.028	0.02*
Any complication (vs. none)	0.847	0.725 to 0.969	<0.001**
Healthcare Access			
Health insurance coverage	-0.156	-0.287 to -0.025	0.02*
Private facility use	0.234	0.123 to 0.345	<0.001**
Socioeconomic			
Household income (log-transformed)	-0.089	-0.145 to -0.033	0.002*
Geographic			
Karachi (vs. Islamabad)	-0.178	-0.267 to -0.089	<0.001**

*Model $R^2 = 0.624$; *p < 0.05; **p < 0.001*

Discussion

This comprehensive cross-sectional analysis of 1,324 diabetic patients across Pakistan's two major urban centers reveals a substantial economic burden that extends far beyond direct medical expenditures, with profound implications for individual families and the broader healthcare system. The mean annual direct medical costs of PKR 89,750 in Islamabad and PKR 76,340 in Karachi represent significant financial obligations for Pakistani families, particularly when contextualized against the average monthly household income of PKR 42,650 observed in our study population (Nasim et al 2022). These findings underscore the substantial economic impact of diabetes management in a resource-constrained healthcare environment where out-of-pocket expenditures predominate and universal health coverage remains absent (Shaikh et al., 2024).

The discovery that medications account for 43.2% of direct medical costs demonstrates integration with the previous studies from other low-middle-income countries (Butt et al. 2024), but represents a proportionally greater burden compared to developed healthcare systems (Parker et al., 2024). Nonetheless, the remainder of direct medical costs will also reflect the limited availability of generic medications, the lack of insurance coverage for drug expenditure, and the ongoing nature of diabetes requiring ongoing medication adherence (Mir & Ayub, 2021).The substantial medication costs,

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totaling PKR 70,670 annually per patient, present a particularly challenging burden for lower-income families who must prioritize diabetes management against other essential household expenditures (Arshad et al., 2024). Our finding that lower-income families spend 18.4% of their household income on diabetes management compared to 7.2% for higher-income families demonstrates the regressive nature of diabetes-related healthcare costs and highlights significant equity concerns in healthcare access and affordability (World Health Organization, 2022).

The identification of complications as the strongest predictor of increased costs, with patients experiencing any complication incurring 2.3 times higher annual expenses, emphasizes the critical importance of prevention strategies and early intervention in diabetes management (Mir & Ayub, 2021). Patients with diabetic foot problems faced the highest economic burden at PKR 312,890 annually, representing more than seven times the average annual household income in our study population. The geographic disparities observed between Islamabad and Karachi merit careful consideration in healthcare policy development. The consistently higher costs in Islamabad across all categories may reflect differences in healthcare infrastructure, pricing structures, and availability of specialized services between the capital city and the commercial hub (Khalid et al., 2021). These disparities suggest that standardized national pricing policies and equitable distribution of healthcare resources could help reduce geographic inequities in diabetes care costs. Additionally, the finding that rural-origin patients accessing urban healthcare facilities face higher transportation and accommodation costs highlights the need for strengthening diabetes care capacity in secondary cities and rural areas to reduce the burden of medical migration for chronic disease management (Mseke et al., 2024).

The catastrophic health expenditure rates of 52.8% and 58.3% in Islamabad and Karachi respectively represent a public health emergency requiring immediate policy attention. These rates substantially exceed the World Health Organization's sustainable development goal targets and indicate that diabetes management is pushing a majority of affected families into financial hardship (WHO: Global monitoring report on financial protection 2021). The higher rates observed in Karachi, despite lower absolute costs, likely reflect the lower average household incomes in this population, emphasizing how diabetes disproportionately affects economically vulnerable communities (Mustafa et al., 2021). The finding that nearly two-thirds of low-income families experience catastrophic expenditure related to diabetes management suggests that current healthcare financing mechanisms are inadequate to protect vulnerable populations from the economic consequences of chronic disease.

Our multivariable analysis revealing that health insurance coverage significantly reduces diabetes-related costs provides evidence for expanding insurance coverage as a policy intervention (Eze et al., 2023). However, the relatively modest protective effect observed suggests that current insurance schemes may have limited coverage for diabetes management or high out-of-pocket requirements that diminish their effectiveness (Mir & Ayub, 2021)). The association between private facility use and higher costs indicates that patients may be seeking private care due to inadequate public sector capacity, highlighting the need for strengthening public healthcare infrastructure for diabetes management while ensuring quality care delivery (Khalid et al., 2021).

The substantial indirect costs identified in our study, representing approximately 43% of total economic burden, highlight an often-overlooked component of diabetes impact that has significant implications for national productivity and economic growth (Ahmed & Anwer, 2023). The annual productivity losses of PKR 35,670 per patient due to absenteeism, combined with reduced work capacity losses of PKR 18,450, suggest that diabetes imposes substantial macroeconomic costs beyond healthcare sector expenditures (O'Keef & Haldane, 2024). These findings support the economic argument for diabetes prevention and management programs from a broader societal perspective, as investments in diabetes care may yield returns through maintained workforce productivity and reduced economic dependency.

The methodology employed in this study addresses several limitations of previous Pakistani diabetes economic burden research by adopting a community-based approach that captures patients across different healthcare utilization patterns and includes comprehensive indirect cost measurement. The use of three-month cost diaries enhanced the accuracy of cost estimates compared to recall-based methods, while the multi-city design improved generalizability to Pakistan's urban population. However, several limitations warrant acknowledgment. The focus on urban populations may limit generalizability to rural areas where healthcare access patterns and costs may differ substantially. The cross-sectional design captures costs at a specific time point and may not reflect the longitudinal progression of diabetes-related expenses as complications develop or management strategies change.

The study's reliance on patient-reported cost data, despite verification through medical records where possible, may introduce recall bias or social desirability bias in reporting healthcare expenditures. Additionally, the exclusion of patients with cognitive impairment or acute medical conditions may have led to underestimation of costs among the most severely affected diabetes patients. The one-year time horizon, while appropriate for capturing annual cost patterns, may not fully reflect the lifetime economic burden of diabetes or the long-term cost-effectiveness of different management strategies.

The findings have important implications for healthcare policy development in Pakistan and similar resource-constrained settings. The high medication costs suggest that negotiating better pharmaceutical pricing, expanding local generic drug production, and implementing medicine subsidy programs could substantially reduce patient financial burden. The significant impact of complications on costs supports investing in diabetes prevention programs, improving access to routine monitoring, and strengthening primary healthcare capacity for early diabetes management. The catastrophic expenditure rates indicate an urgent need for healthcare financing reform, potentially including expansion of health insurance coverage specifically for chronic diseases and implementation of financial protection mechanisms for vulnerable populations.

Our results also highlight the importance of addressing diabetes management from a health systems perspective rather than focusing solely on clinical interventions. The geographic disparities observed suggest that strengthening secondary and tertiary healthcare capacity outside major metropolitan areas could reduce patient travel costs while improving access to specialized care. The substantial caregiver time costs identified indicate that family-centered care approaches and community-

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based support systems could help reduce the informal care burden while maintaining quality diabetes management.

From a broader policy perspective, these findings support the economic argument for comprehensive diabetes prevention strategies targeting population-level risk factors such as dietary patterns, physical activity, and obesity prevention. The substantial economic burden identified suggests that investments in diabetes prevention and management programs could yield significant returns through reduced healthcare costs, maintained workforce productivity, and improved population health outcomes. The regressive nature of diabetes costs observed in our study emphasizes the importance of ensuring that prevention and treatment interventions are accessible to economically vulnerable populations who bear disproportionate disease burden.

The substantial economic burden documented in this study reflects broader challenges facing Pakistan's healthcare system in addressing the growing burden of non-communicable diseases. The findings suggest that addressing diabetes economic burden requires coordinated action across multiple sectors, including healthcare delivery system strengthening, pharmaceutical policy reform, health insurance expansion, and social protection enhancement. The evidence provided by this study should inform ongoing healthcare sector reforms and contribute to evidence-based policy development for chronic disease management in Pakistan and similar settings.

Conclusion

This study reveals that diabetes mellitus imposes a substantial economic burden on Pakistani families, with annual costs of PKR 156,890 in Islamabad and PKR 134,220 in Karachi. Over half of affected families experience catastrophic health expenditure, with lower-income households spending 18.4% of their income on diabetes management compared to 7.2% for higher-income families. Complications increase costs by 2.3-fold, while medications constitute 43.2% of direct medical expenses. These findings highlight urgent needs for healthcare financing reform, insurance expansion, and pharmaceutical policy interventions to ensure diabetes management becomes economically sustainable for Pakistani families and the healthcare system.

Author's Contribution

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