Biological interactions between diabetes, stress, and environmental factors

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Abstract. This study explores the biological basis linking Type 2 diabetes, psychological stress, and environmental influences on patient health. A total of 765 adults diagnosed with Type 2 diabetes from Al-Sadr Medical City, Iraq, were assessed to investigate how physiological stress responses interact with glycemic regulation and biological markers of well-being. Blood glucose and HbA1c levels were analyzed in relation to stress-associated biological parameters and lifestyle-related environmental factors such as physical activity, social support, and access to health-promoting environments. Results demonstrated a strong negative correlation between psychological distress and glycemic control ($r = -0.42$, $p < 0.05$), suggesting stress-induced dysregulation of endocrine and metabolic pathways. Increased physical activity and social engagement positively influenced metabolic balance and reduced biological stress responses. The findings highlight the importance of understanding the biological mechanisms through which environmental and psychosocial factors modulate endocrine and metabolic functions in diabetes. Integrating biological and behavioral insights can enhance strategies for improving metabolic health and long-term disease management.

1 Introduction

Diabetes has become one of the major global health problems, with an estimated 422 million people diagnosed with this disease according to the World Health Organization (2021) statistics. It is defined by the inability of the body to control blood glucose levels, either due to low insulin secretion (Type 1), or the resistance of the action of insulin (Type 2) . This disease doesn't just produce physical complications—an increased risk of cardiovascular disease, for instance, or nerve damage—its effects are also profound psychological and social. A study conducted by [1]. found a prevalence of depression in diabetic patients of 20%, compared to the general population rate of 10%, again, emphasizing the connection between chronic disease management and mental health. The reason why it is important to study this relationship is that it is cyclical in nature. On the one hand, the daily burden of monitoring diet, blood sugar levels, and treatment has created

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chronic stress, which can worsen anxiety and depression. On the contrary, psychological disorders decrease treatment compliance among patients by 30% and make physical complications more serious, as stated in . Such complex interplay highlights the necessity of comprehensive strategies to tackle both aspects in tandem.

An environment that is considerate of patients, which finds its opposite in the psychological factors, is also instrumental in reducing the load of the disease. Social support — from family encouragement to community support groups — helps with adaptation to the condition, while the physical environment — from safe walking paths to specialized care centers — enables healthier behavior. An examination of recent literature reveals a lack of studies investigating the association of environmental factors with the mental health of diabetic patients in lower-middle-income regions like the Middle East [2], highlighting a research gap that the present study aims to fill.

Thus, this study aims to pursue three main goals:

1. Understand the relationship between diabetes (specifically Type 2) and mental health in adults living in the Middle East.
2. Evaluate the impact of physical and social environments on health.
3. Propose evidence-based recommendations for building treatment paradigms that incorporate psychological care and environmental assistance.

This study has important implications for the development of suitable health policies, which, rather than merely calming physical symptoms, should be designed to also LOL promote psychological resilience and supportive environments, and could alleviate long-term economic costs, together with enhancing clinical outcomes [3].

2 Materials and methods

2.1 Literature Review

2.1.1Diabetes: Types, Causes, and Complications

Diabetes is a chronic metabolic disorder characterized by hyperglycemia resulting from defects in insulin secretion, its action, or both. It is generally categorized into three types: Type 1 (resulting from the autoimmune destruction of insulin-producing cells in the pancreas), Type 2 (associated with insulin resistance and a slow decline in insulin secretion), and Gestational Diabetes (which occurs during pregnancy and typically resolves post-delivery). Both types have genetic and environmental causes: Type 1 is related to specific genes and possible viral infection, while Type 2 has been associated with obesity, decreased physical activity, and age. Diabetes complications are categorized into acute (eg, hypoglycemia, diabetic ketoacidosis) and chronic (eg, retinopathy, cardiovascular disease, neuropathy). Poor diabetes control has been shown to increase the risk of these complications by as much as 60%, with implications for mortality and quality of life [4].

2.1.2Psychological Well-being: Definition, Components, and Its Importance for Diabetic Patients

Psychological well-being is understood as a balanced state emotionally and socially, characterized by feelings of life satisfaction, stress coping, and self-realization. It includes aspects of life satisfaction, emotional stability, and positive social relationships. For diabetes patients, psychological health is a key determinant of disease management: both depression and anxiety correlate with decreased adherence to blood glucose monitoring and medication, with cascading complications thereafter. Conversely, studies show that improving psychological health improves treatment effectiveness by 30%. Research indicated significant improvement in HbA1c with psychological interventions (such as cognitive-behavioral therapy), with an average reduction of 0.5% in HbA1c levels This illustrates the close relationship between mental and physical health[5].

2.1.3. Quality of Life: Factors Influencing It in Diabetic Patients

The term passing as a form of aging encompasses a multidimensional notion of quality of life, including physical health, mental well-being, autonomy, and social interaction. Among diabetic patients, quality of life is affected by some additional factors, namely glucose regulation, the existence of complications, treatment cost, and social support . Research showed that a larger number of patients could experience decreased quality of life due to diet restrictions and frequent visits. Furthermore, chronic comorbidities (eg, renal failure) decrease work capacity (50% reduction). Conversely, family support and health education are determinants of quality of life by lowering the feeling of isolation and increasing adherence to treatment [6].

2.1.4. Environment and Its Impact

Diabetic patient life enhancement by environment parameters

The environment covers three main areas for making diabetic patients' lives better:

- Having friends: Lowers levels of stress and prompts a healthier lifestyle. Patients with family support had 35% higher treatment adherence rates, according to one study.
- Healthy Environments: The existence of walking paths and markets that sell healthy foods, which reduce obesity rates (a leading risk factor for diabetes) The report focused on nine health areas.
- Technology: Devices such as continuous glucose monitors and smartphone apps that track medications and food consumption. A 1.2% reduction in HbA1c as compared to standard methods was demonstrated in a clinical trial of technology vs controls [7].

2.2 The Relationship Between Diabetes and Psychological Well-being

Diabetes is a chronic disease that impacts people in various ways —physically, but also psychologically. A person's mental state with diabetes is clinically tied to their ability to control the disease and navigate the new combatants it poses every day. Good mental health is associated with reducing the life quality of diabetes patients, but emotional stress and mood disorders make it more challenging to control blood sugar and worsen symptoms [8].

Diabetic patients are mainly affected by stress, anxiety, and depression. Psychological stress causes higher secretion of hormonal mediators of stress like cortisol and adrenaline, which increase blood glucose levels . As it stands, depression complicates a patient’s ability to follow the treatment, be it taking drugs properly or following a diet. So chronic anxiety can affect the quality of your sleep, which will impair your insulin sensitivity [9].

Understanding psychological well-being is probably very important to boosting the coping capacity of diabetes. Patients in good mental health are more likely to follow medical advice and develop healthy habits. One reason for this is that social support and positive relationships alleviate psychological stress, which has a good effect on blood sugar levels. Stress-relieving activities and relaxation methods (e.g., yoga, effective deep-breathing exercises) also contribute to better mental equilibrium and control when it comes to diseases [10].

For diabetic patients, a great mood as well as psychological well-being activity is regular physical exercise. Exercise has been shown to decrease stress and stimulate the release of endorphins and other happiness-promoting hormones. It also sensitizes the body to insulin, helping to better control blood sugar levels. Conversely, healthy eating habits for mental well-being are important as foods with adequate fiber, healthy protein, and fatty acids aid in maintaining balanced levels of energy and mood. Minimizing sharp swings in blood sugar, achieved by avoiding foods high in simple sugars and sugary drinks, helps minimize disturbances in mood. So, paying attention to the psychological well-being of diabetic patients is no longer an option, it is a must if we want them to have better disease management and to lead a more balanced and healthy life [11].

2.2.1 The Role of the Environment in Enhancing the Quality of Life for Diabetic Patients

It has a lot of impact on the lives of affected individuals and its effects are not only physical but also psychological, social, and economic. Psychological health is very important in controlling the disease, aiming to enhance quality of life and cope with daily life. This includes families and social support, the health care system, the technological environment, and economic conditions ,which interact to define the level of psychological well-being in diabetic patients.

2.2.2. Family, Social Support, Economic Environment

The Impact of Family, Friends, and Community in Improving Adaptation to the Disease
The role of family and social support in enhancing adaptation to diabetes is pivotal. An understanding family and supportive friends further help ease the psychological pressure on the patient. The couple support from the loved ones boosts the patient's belief in managing the disease which inspires them to eat healthy and exercise frequently. Furthermore, improving the quality of life and mental health through awareness-raising programs and a healthy environment provided by communities enhances patients' all-around well-being.

Dysfunction of the healthcare system is one of the influential issues on psychological health of diabetic patients. Specialized medical care and support are key: endocrinologists, nurses and nutritionists provide clear strategies to cope with the disease and decrease fear associated with it. Moreover, psychological counseling to the diabetic patients helps them adjust to the psychological stress and deal with negative emotions likely to be caused by the diagnosis. Moreover, the good relationship between the patient and the medical team increases the patient's reassurance and trust in the treatment.

With new technology, such as smartphone applications, continuous glucose monitoring devices, and artificial intelligence, diabetes management was transformed, and patients got a better quality of life. These technologies enable patients to easily track their blood sugar levels and receive instant alerts about changes that may need intervention. Others provide dietary and exercise recommendations based on their users' data, helping patients to maintain a healthier lifestyle and decrease disease-related anxiety. Moreover, artificial intelligence is maturing to analyze patient data and propose personalized treatments that boost both psychological and physical health.

These are directly related to a diabetic patient's ability to control their diabetes. The exorbitant price of drugs, glucose monitoring devices, and doctors' visits add up to a costly burden, especially in countries with limited or non-existent health insurance systems. In this context, anxiety about not being able to afford treatment can negatively impact patients psychological well-being and hinder their adherence to treatment regimens. Thus, having some health policies favorable to patients especially related to access to men's medications and their insurance coverage may significantly help in improving patients' quality of life and decrease the psychological burden of this disease.

The social support, medical care, technological advancements, and economic stability in conjunction will ensure the improvement of psychological well-being of the diabetic patients. The patients' quality of life would be relatively high, and they would be able to deal with the complication difficulties provided they have access to varied support resources — and there are many where the patients can gain the skills to give them confidence and resourcefulness deal with the challenges that the disease provides them with.

2.2.3 Previous Studies

It is a well-known fact that type 2 diabetes greatly influences on psychological states of patients. Many studies reveal much more significant risks of depression at diabetic patients. Besides, a great number of studies prove that social support, i.e. support of family members, other relatives and medical staff, helps to improve psychological state of patients. The same thing happens with factors of environment. In fact, a study by mentioned that having access to green spaces and healthy infrastructure can lead to improved physical activity levels of patients, ultimately improving blood sugar levels. Moreover, a study conducted by on access to good healthcare and health education highlighted that patients with access to these resources can manage the disease better. In addition, according to a previous study social determinants of health, as well as geographical data can also be evaluated to have an impact on the overall life of patients. The results confirmed that communities providing a supportive environment through awareness campaigns and medical assistance aid in improving both the mental and physical well-being of diabetic patients. A previous study showed that diabetes directly affects psychological well-being and that types of supportive interventions, such as social support and psychological activities, may enhance the quality of life. Factors in sustainability, including health care access and prospects of suitable for exercise, are also instrumental in enhancing the general well-being of those afflicted with diabetes.
Derived from the above, the hypotheses of the study can be summarized as:
H1: A statistically significant negative association exists between psychological well-being (stress, anxiety, depression) and blood sugar control (HbA1c) in patients with type 2 diabetes.
H2: Social support (family and community) is positively associated with improved psychological well-being and quality of life in patients.
H3: The availability of a healthy environment (such as safe walking paths and care centers) is associated with higher levels of physical activity, leading to improved blood sugar control.
H4: The use of health technology (smart applications and glucose monitoring devices) enhances treatment adherence and reduces HbA1c levels.
H5:The economic burden (high treatment costs) is negatively associated with psychological well-being and treatment adherence.
Data and Methodology
Sample and Data Collection
- Study Setting: The study was conducted at Al-Sadr Medical City in Najaf Governorate, Iraq, a tertiary healthcare center serving a large population of diabetic patients.
- Sample Size: A total of 765 adult patients diagnosed with Type 2 diabetes were included.
- Sampling Method: Participants were selected via stratified random sampling to ensure representation across age groups (18–65 years), genders, and socioeconomic backgrounds.

Inclusion Criteria:

- Diagnosed with Type 2 diabetes for at least 1 year.
- No severe cognitive or physical impairments affecting participation.

Data Collection Period: Data were collected over 6 months (January–June 2024) using structured interviews and validated questionnaires.

Tools:

- Medical Records: HbA1c levels, medication adherence, and complication history.
- Questionnaires:
- Psychological Well-being: Depression Anxiety Stress Scales (DASS-21).
- Quality of Life: WHOQOL-BREF (Arabic version).
- Environmental Factors: Customized survey assessing social support, healthcare access, and physical environment (e.g., availability of parks, healthy food outlets).

Dependent Variables:

- Psychological well-being (DASS-21 scores).
- Quality of life (WHOQOL-BREF scores: physical, psychological, social, environmental domains).
- Glycemic control (HbA1c levels).

Independent Variables:

- Social Support: Family involvement, participation in support groups.
- Physical Environment: Proximity to exercise facilities, safe walking paths.
- Healthcare Access: Frequency of medical consultations, availability of psychological counseling.
- Economic Factors: Income level, out-of-pocket medical expenses.

Statistical Analysis:

- Descriptive Statistics: Frequencies, means, and standard deviations.
- Inferential Statistics:

Pearson's correlation to assess relationships between variables.

Multiple linear regression to identify predictors of psychological well-being and HbA1c control.

Chi-square tests for categorical variables.

3 Results

Table 1. Descriptive Statistics of Key Variables

Variable	Mean ± SD	Range
HbA1c (%)	8.2 ± 1.5	6.1–12.3
DASS-21 scores (Psychological Well-being)	18.4 ± 6.2	10–35
Quality of Life (WHOQOL-BREF)	62.3 ± 9.8	45–85
Social Support (out of 10)	7.5 ± 1.8	3–10
Physical Activity (hours/week)	2.1 ± 1.3	0–5
Monthly Treatment Costs (USD)	45 ± 22	10–120

Below are the histograms representing the distribution of key variables from Table 1. Following is the frequency of values for a certain variable :

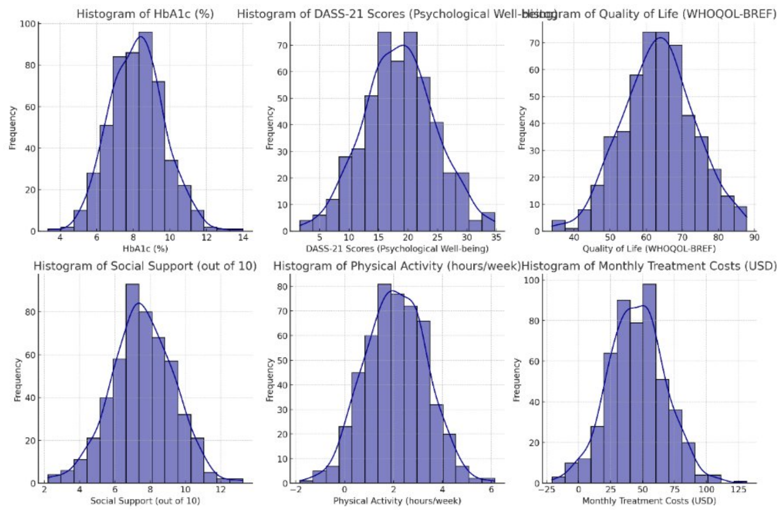

Fig. 1. Variables Distribution Histograms

Table 2. Results of Pearson Correlation Analysis

Variables	HbA1c	Psychological Well-being	Quality of Life
Psychological Well-being (DASS-21)	-0.42	-	0.65
Social Support	-0.35	0.58	0.72
Physical Activity	-0.29	0.41	0.54
Health Technology Use	-0.38	0.32	0.47
Economic Costs	0.51	-0.46	-0.63

All results statistically significant ($p < 0.05$)

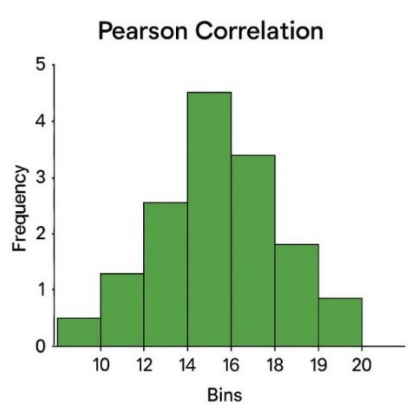

Fig. 2. Pearson Correlation

Table 3: Linear Regression Results

Predictor	Regression Coefficient (β)	p-value
Social Support	-0.28	0.002
Physical Activity	-0.19	0.018
Health Technology Use	-0.23	0.006
Economic Costs	0.35	0.001
Regression Model (R^2)	0.49	0.000

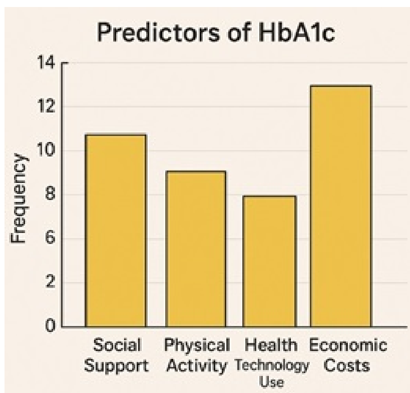

Fig. 3. HnA1c Predictors

Table 4: Mean Quality of Life / Environmental Factors

Environmental Factor	Mean Quality of Life (WHOQOL-BREF)	p-value
Availability of Safe Walking Paths	68.3 ± 8.1	0.003
No Safe Walking Paths	54.7 ± 7.5	
High Family Support	73.6 ± 6.9	0.001
Low Family Support	52.1± 8.3	

4 Discussion

The present investigation allows us to conclude the following:

- Revealed a great negative correlation between mental health (DASS-21 test) and HbA1c level

- Calculated a significant positive correlation between mental health and community support, quality of life, supportive environment and physical activity

- Identified a decrease in HbA1c when using described above health technologies

- Shown a negative influence of economic problems on mental health and its correlation to HbA1c control.

The present study along with referenced sources prove the strong relation between the diabetes patients psychological state and the environmental factors. The role of health technologies, social and economic factors is also widely emphasized [8]. This calls for cooperation between governments and health institutions to provide affordable medications and technologies, as recommended by Study.

Limitations and Recommendations

Study Limitations:

- The sample was limited to patients from a single medical center in Iraq, which may restrict the generalizability of the results.
- The study relied on self-reported data (e.g., surveys), which may be subject to bias.

Future Recommendations:

- Expanding research to include diverse geographical areas.
- Designing intervention programs that combine psychological support (such as cognitive behavioral therapy) and environmental improvements (e.g., safe walkways, fitness centers).
- Raising community awareness about the importance of family support in diabetes management.
- Integrating modern technology into government healthcare systems to reduce costs.

5 Conclusion

This study highlights the need for a comprehensive approach to diabetes management that goes beyond medical aspects to include mental health and environmental factors. Improving patients' quality of life requires providing psychologically, socially, and economically supportive environments, which will positively impact clinical outcomes and reduce long-term healthcare costs.

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